Transportation Research Board – Airport Cooperative Research Program (TRB-ACRP)

Project Number 03-03 – Enhancing Airport Land Use Compatibility

This annotated bibliography contains over 300 entries which have relevance to airport land use compatibility. The references relate to a number of topics which include airport land use compatibility planning, military air installation compatibility planning, aircraft noise, hazards and third party risk, land use regulations, economic considerations and environmental considerations. These entries have been divided into each of these eight categories as found below.

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AIRPORT LAND USE COMPATIBILITY PLANNING

Airport Compatibility Guidelines: Compatibility Planning, Height Hazard Zoning, and Compatible Land Use Zones for Texas Airports. Texas Department of Transportation, Division of Aviation. 1992.

This guidelines document discusses a variety of approaches to airport land use compatibility, with most of the focus on zoning regulations. The document makes a distinction between "hazard zoning", which it states is intended to protect the airport from surrounding uses, and "airport compatible zoning", which it states is intended to protect adjacent property from the airport. The maximum area that may be zoned for airport compatibility is described, as well as procedures and recommendations for writing and adopting airport zoning regulations. A model of a zoning ordinance is included in the appendix.

Boyer, Phil. Statement to the United States House of Representatives, Subcommittee on Aviation, Committee on Transportation & Infrastructure, June 26, 2001.

Phil Boyer, President, AOPA states "our objective as an association is to promote the interest of those who contribute to our economy by taking advantage of general aviation aircraft to fulfill their business and personal transportation needs." AOPA volunteered services including the use of the company aircraft N4GA to the Federal Emergency Management Agency and also served as an adjunct part of the FAA utilizing the 800 phone lines and website to assist pilots and the nation after the tragic events of 9/11.

Also stated by Phil Boyer, "General aviation operates at more than 5,300 public use airports of which airlines service is available at only 650. The number of general aviation hours flown each year is almost 30 million – 60 percent of the total number of hours flown. More than 92 percent of the roughly 225,000 civilian aircraft registered in the United States are general aviation aircraft. And of the Nation's 635,000 pilots, an estimated 500,000+ fly general aviation airplanes. Of these, more than 374,000 of them are member of the Aircraft Owners and Pilots Association."

He asked the Subcommittee to reject a "one-size fits all" approach to both airport security and airspace access. He mentioned that a large number of these aircraft operate from rural or sparsely populated areas.

Caves, Robert E., and Geoffrey D. Gosling. *Strategic Airport Planning*. Oxford: Elsevier Science, Limited, 1999.

The book provides an overview of airport systems planning from a global perspective and addresses how the concept of strategic system planning can be applied to planning airports and airport systems. The authors examine the evolving context of airport planning, including environmental concerns and economic considerations, as well as institutional issues. One chapter is devoted to community response to aircraft noise. The book describes both the regional and national airport system planning process and presents a wide range of case studies from the United States, Canada, Europe, Brazil, and Japan. The chapter on the community response to aircraft noise provides a brief review of selected literature on the effect of aircraft noise on property values and discusses some of the implications for noise mitigation measures, including sound-proofing homes and compensation. However, there is little discussion of the role of land use planning.

Clarion Associates. *Airport Land Use Compatibility Manual*. Minnesota Department of Transportation. Office of Aeronautics. 2006.

This manual is a comprehensive look at airport land use in Minnesota. The authors document the state of airport land use compatibility planning in Minnesota and identify problems and challenges – both functional and legal – with the existing system. The document explains the noise- and risk-based rational for airport land use compatibility and sets out a compatible land use table for the

airport influence zones. The authors identify both preventive and corrective strategies for airport land use compatibility. A detailed guide for adopting zoning regulations and a model airport zoning ordinance are also included.

Mead & Hunt. Ionia County Airport Zoning Ordinance: 2001, revised 2004.

The Ordinance establishes regulations on land within a ten-mile radius of the Ionia County Airport. This Ordinance establishes a sizeable air bowl within a minimum height limitation of 25 feet above ground at some locations in the approaches to the runways immediately adjacent to the airport increasing to a maximum height limitation of 500 feet above the established elevations of the airports as the distance from the airport is increased.

This Ordinance does not affect existing structures, the height of which exceeded the limits imposed by this Ordinance at the time it becomes effective. New construction and construction that increases the heights of existing structures within the airport area must conform to the provisions on height. The Ordinance also restricts such uses of land within the vicinity of the airport that would unreasonably interfere with radio communication systems and other navigational aids or devices used by the airport and aircraft. It also restricts those used that reduce visibility, create confusing lights, or result in undesirable effects that may be caused by the operation of aircraft.

Mead & Hunt. Jackson County Airport, Airport Zoning Manual: 2001.

The manual provides a guidance tool for communities within Jackson County who are responsible for implementing and enforcing the Jackson County Airport – Reynolds Field Zoning Ordinance.

Mead & Hunt. Land Use Survey, National Association of State Aviation Officials: 2004.

The National Association of State Aviation Officials (NASAO) teamed with the firm of Mead & Hunt, a national leader in aviation planning and land use issues, to conduct a survey of state aviation agencies to assess their perceptions on land use issues. During the development of other land use guides, such as the 2004 Wisconsin Airport Land Use Guidebook and the Oregon Airport Land Use Compatibility Guidebook, Mead & Hunt uncovered the extent of land use issues facing airports. Those results helped shape the NASAO survey instrument.

The results of the 2004 National Association of State Aviation Officials Land Use Survey offers a wide variety of comments on the issue of land use compatibility around airports and available land use tools and legislation. Survey questions encompassed topics such as the level of concern over incompatible land uses, the types of regulations available, and the use and availability of land use resources. State officials were also asked about the role that federal agencies, state agencies, and NASAO should play in addressing incoming incompatible land use issues.

Mead & Hunt. Livingston County Airport, Airport Zoning Plan Update: 2000.

This manual provides a guidance tool for Livingston County's community planning departments and the governmental agencies responsible for implementing and enforcing the Livingston County Airport Zoning Ordinance.

Mead & Hunt, and Satre Associates. Oregon Department of Aviation, Oregon Airport Land Use Compatibility Guidebook: 2003.

"The document is intended to be a resource for planners, local officials and citizens, regarding airport land use compatibility issues. In an effort to provide a comprehensive picture of the issues surrounding land use compatibility topics, brief summaries of the various federal and state regulations related to airport planning are included. Discussion of environmental and noise related

issues is also included, along with methods of implementation for various preventive and corrective actions, as well as sample agreements, plans and programs."

"Incompatible land uses and their impact on airport development are a continuing threat to airports nationwide. As the population of the State of Oregon continues to grow, so does the demand for space and, with it, the potential for incompatible land uses near airports. Consequently, it is important to provide a document for the preservation of the state aviation system, and ultimately, the economic vitality of the state. This document serves as a statewide planning tool providing the basis for future land use decisions regarding compatibility within airport planning areas."

Mead & Hunt. Wisconsin Department of Transportation, Bureau of Aeronautics, A Guide for Land Use Planning Around Airports in Wisconsin: 2004.

This document serves as a resource for planners, local officials, state agencies, developers, and citizens. It contains summaries of federal and state laws related to airport planning. In addition it contains implementation methods for various preventative, corrective, and mitigation actions. Sample agreements and existing plans and programs are also included for reference.

US Code. Title 49, Transportation, Subtitle VII Aviation Programs, Grant Assurances, Airport and Airway Improvements Act of 1982.

As amended, grant assurances are required as part of a project application from the sponsors (airports or communities) who are requesting funds. Upon acceptance of the grant money, these assurances are incorporated into and become part of the grant agreement that obligates the airport owners to operate and maintain the airport and comply with specific assurances, including maintaining compatible land use surrounding the airport. The numbers of assurances that apply to planning related projects are limited compared to other projects and have stipulations that are outlined in the grant agreement documents.

Some of the planning assurances include:

- Compliance with all applicable federal laws, regulations, executive orders, policies, guidelines, and requirements as they relate to the project.
- Responsibility and authority of the sponsor to carry out the proposed project.
- Availability of the local share of funds for the proposed project.
- Preservation of the rights and powers of the sponsor and airport.
- Consistency with local plans.
- Creation of an accurate accounting, auditing, and recordkeeping process.
- Public access to project information and planning processes.
- Compliance with civil rights issues.
- Provision of engineering and design services.
- Compliance with current policies, standards, and specifications.

US Code. Title 49, Transportation, Subtitle VII Aviation Programs, Part B, Chapter 471 Airport Development, January 3, 2006.

This document entitles the Federal Aviation Administration (FAA) the ability to protect the public's freedom of airspace transit given to all airspace users, including national defense, commercial and general aviation, and space operations. The FAA is also charged with the task of ensuring the safety of aircraft, its efficiency, and the preservation of navigable airspace as it relates to the public interest.

US Code. Title 49, Transportation, Subtitle VII Aviation Programs, Part B, Chapter 471 Airport Development, Subchapter I Airport Improvements, Section 47101 (a) General (8), January 3, 2006.

This code describes policy that regulates navigable airspace. It states that: "It is the policy of the United States…to ensure that nonaviation usage of the navigable airspace be accommodated but not allowed to decrease the safety and capacity of the airspace and airport system."

US Code. Title 49, Transportation, Subtitle VII Aviation Programs, Part B, Chapter 471 Airport Development, Subchapter I Airport Improvements, Section 47107 (a) General (7), January 3, 2006.

This code describes policy that regulates navigable airspace. It states that: "It is the policy of the United States… that airport construction and improvement projects that increase the capacity of facilities to accommodate passenger and cargo traffic be undertaken to the maximum feasible extent so that safety and efficiency increase and delays decrease."

US Code. Title 49, Transportation, Subtitle VII Aviation Programs, Part B, Chapter 471 Airport Development, Subchapter I Airport Improvements, Section 47107 (a) General (10), January 3, 2006.

This code describes policy that regulates navigable airspace. It states that: "It is the policy of the United States…that special emphasis should be placed on converting appropriate former military air bases to civil use and identifying and improving additional joint-use facilities."

US Code. Title 49, Transportation, Subtitle VII Aviation Programs, Part B, Chapter 471 Airport Development, Subchapter I Airport Improvements, Section 47107 (a) General (9), January 3, 2006.

This code describes policy that regulates navigable airspace. It states that: "It is the policy of the United States…that artificial restrictions on airport capacity:

- Are not in the public interest;
- Should be imposed to alleviate air traffic delays only after other reasonably available and less burdensome alternatives have been tried; and
- Should not discriminate unjustly between categories and classes of aircraft."

United States Department of Transportation, Federal Aviation Administration, Airports Division, Southern Region. "Land Use Compatibility and Airports, a Guide for Effective Land Use Planning." 1998.

This document states that its intent is "…to guide incompatible land uses away from the airport environs and to encourage compatible uses to locate around airport facilities." While making mention of other compatibility issues, the document focuses primarily on noise compatibility. The authors summarize key federal regulations and federal funding sources. The document gives recommendations for airport master planning and noise compatibility planning. It also details how airport land use planning considerations can be incorporated into a variety of local land use planning tools.

United States Department of Transportation, Federal Aviation Administration. Advisory Circular 70/7460-1K Change 2, "Obstruction Marking and Lighting," February 1, 2007.

This AC works within the requirements of FAR Part 77. A sponsor proposing any type of construction or alteration of a structure that may affect the National Airspace System (NAS) is required to submit FAA Form 7460-1 Notice of Proposed Construction or Alteration. This form should then be sent to the Obstruction Evaluation Service (OES).

United States Department of Transportation, Federal Aviation Administration. Advisory Circular 70/7460-2K, "Proposed Construction or Alteration of Objects that May Affect the Navigable Airspace," March 1, 2000.

This AC provides information regarding the erection or alteration of an object on or near an airport that may affect the navigable airspace as required in FAR Part 77. In addition, this AC explains the process by which to petition for discretionary review, thereby providing the FAA the opportunity to:

- Recognize potential hazards and minimize the effects to aviation.
- Revise published data and/or issue a Notice to Airmen (NOTAM).
- Recommend appropriate marking and lighting to make objects visible.
- Depict obstacles on aeronautical charts.

United States Department of Transportation, Federal Aviation Administration. Advisory Circular 150/5050-6, "Airport Land Use Compatibility Planning," 1977.

This document offers guidance on compatibility plan formation to protect airport environs from development that could present a risk to the airport's operations. It specifically addresses land use and noise issues.

United States Department of Transportation, Federal Aviation Administration. Advisory Circular 150/5070-6B, "Airport Master Plans," July 29, 2005.

This document outlines the development of airport master plans. The guiding principle of the airport planning process is to develop a safe and efficient airport through the use of acceptable planning standards. While there are many steps in the planning process, none of the steps should be treated in a piecemeal manner. Where possible, the airside and landside issues must be evaluated equally to create a plan that provides compatible airport and community development. This AC provides a detailed outline for the development of an acceptable airport master plan.

United States Department of Transportation, Federal Aviation Administration. Advisory Circular 150/5070-7, "The Airport System Planning Process," November 11, 2004.

This document outlines the development of effective airport system planning. Developing an airport system plan provides guidance and establishes a balanced integrated system of public-use airports. The airport system planning process should be consistent with state or regional goals that involve examining the relationship between airports and aviation user requirements. Once these relationships are established, the airport system planning process should result in the identification, preservation, and enhancement of both the current and future aviation demand. This AC provides a detailed outline for the development of an acceptable airport system plan.

United States Department of Transportation, Federal Aviation Administration. Advisory Circular 150/5190-4A, "A Model Zoning Ordinance to Limit Height of Objects Around Airports," December 14, 1987.

This AC allows the adoption of zoning ordinances to control the height of objects. It is based upon the surfaces described in Subpart C of FAR Part 77, Objects Affecting Navigable Airspace, current edition. This document provides sample language and model ordinances for use by local airports.

United States Department of Transportation, Federal Aviation Administration. Advisory Circular 150/5300-13 Change 10, "Airport Design," September 29, 2006.

This AC provides the basic standards and recommendations for airport design. It also consolidates five previous documents pertaining to airport design. The update containing Change 10 provides expanded information regarding new approach procedures for Runway Protection Zones, threshold-siting criteria, and new instrument approach categories. The specific criteria related to land use compatibility are the primary spatial standards for on-airport development which include:

- Runway Protection Zones (RPZ)
- Runway Safety Areas (RSA)
- Runway Object Free Areas (OFA)

These zones and areas fulfill safety-related functions for the airport and for aircraft using the airport. The RSA and OFA are almost always contained within airport property. The RPZ, however, can extend beyond airport property. Therefore, from an off-airport land use compatibility planning perspective, the critical safety zone, identified by the design standards, is the RPZ. The FAA recommends that, whenever possible, the entire RPZ be owned by the airport and be clear of all obstructions if practicable.

United States Department of Transportation, Federal Aviation Administration. Executive Order 13175, "Consultation and Coordination with Indian Tribal Governments," November 6, 2000.

This order establishes regular consultation and collaboration with tribal officials that strengthen government-to-government relationships with Indian tribes. Set forth within the constitution of the United States, Indian tribes have the right to self-government. Indian tribes exercise the sovereign powers over their members and territory, and also strive to meet the responsibilities that arise between Federal Government and Indian Tribal Governments.

United States Department of Transportation, Federal Aviation Administration. FAR Part 77 "Surfaces, Objects Affecting Navigable Airspace," CFR Title 14, January 1, 2007.

This regulation provides for a study of obstructions to be conducted to determine the effects on the safe and efficient use of airspace, establishing standards for determining the obstructions in the navigable airspace, and setting forth requirements for the construction or alteration of structures, such as buildings, towers, etc. It provides for public hearings regarding the obstructions and makes provisions for the creation of antenna farm areas. It also establishes methods of identifying surfaces that must be free from penetration by obstructions, such as buildings, cranes, cell towers, etc.

Implementation and enforcement of FAR Part 77 is a cooperative effort between the FAA and the individual state aviation agencies. The FAR Part 77 surfaces are often based upon the type of approaches established for each runway end.

United States Department of Transportation, Federal Aviation Administration. FAR Part 157, "Notice of Construction, Alteration, Activation, and Deactivation of Airports," July 24, 1991.

This federal regulation provides guidelines, procedures, and standards that shall be used in determining what effect construction, alteration, activation, or deactivation of an airport will have on the safe and efficient use of the navigable airspace by aircraft.

United States Department of Transportation, Federal Aviation Administration. FAR Part 161, "Notice and Approval of Airport Noise and Access Restrictions," CFR Title 14, September 25, 1991.

This regulation established the implementation of the Airport Noise and Capacity Act of 1990 (Title 49, US Code App. 2153, 2154, 2155 and 2156), which requires notification and creation of procedures for the operation of Stage 2 and Stage 3 aircraft noise restrictions. This regulation defines requirements and procedures for airport proprietors to follow when implementing Stage 3 aircraft noise and access restrictions. Under this regulation, airport proprietors can impose limitations on Stage 2 or 3 aircraft used by commercial carriers, for the purpose of controlling airport noise. These restrictions include, but are not limited to:

- Limiting noise generated on either a single-event or cumulative basis.
- Limiting the total number of Stage 2 or Stage 3 aircraft operations, implementing a noise budget or noise allocation program that includes Stage 2 or Stage 3 aircraft.
- Limiting the number of hours of Stage 2 or Stage 3 aircraft operations and implementing a program of airport use charges, which has the direct or indirect effect of controlling airport noise.
- Before these restrictions are adopted, the airport sponsor must inform the public of the proposed restriction, its anticipated or actual costs and benefits, an alternative restriction, and a comparison of the two. The sponsor must allow the public to comment on the proposed restriction. The airport sponsor must then submit an application to the FAA for approval of the proposed noise or access restrictions. A written agreement between the airport sponsor and the commercial operators affected by the proposed restriction must be in effect 180 days prior to the date of the proposed restriction. FAR Part 161 provides for improved airport land use compatibility by permitting the airport sponsor to implement noise and access restrictions at the airport.

Additionally, FAA FAR Part 36 provides guidelines on the retirement of various categories of aircraft based upon noise emissions. Aircraft are categorized by the level of noise they generate. The categories are referred to as: Stage 1 (the loudest), Stage 2, and Stage 3 (the quietest). Those aircraft that meet Stage 1 noise levels are already retired and no longer operate in the United States' commercial fleet. By 2006, all aircraft being built must meet newly established Stage 4 criteria.

United States Department of Transportation, Federal Aviation Administration. Form 7460-1, "Proposed Construction of Alteration of Objects that may affect the Navigable Airspace," February 1999 & FAA Form 7460-2, "Supplemental Notice of Actual Construction or Alteration," July 1998.

Forms 7460-1 and 7460-2 are required at all federally obligated airports to assess each proposed or temporary construction in the vicinity of the airport. The FAA conducts an aeronautical study and issues a determination to the airport sponsor. The determination identifies whether or not the proposed development is a hazard to airspace. It is imperative that local planners be aware of the various critical safety considerations when developing around airports. Notice is required for the following:

- Form must be submitted at least 30 days prior to the date the construction or alteration is to begin.
- On or before the date an application for a construction permit is filed with the Federal Communication Commission (FCC), well in advance of the 30 day period.

United States Department of Transportation, Federal Aviation Administration. Form 7480-1, "Notice of Landing Area Proposal," January 1993.

This form works in conjunction with FAR Part 157 which requires a 90-day notification prior to any construction, alteration, deactivation, or change to the use of an airport.

Notice is required for the following:

- Construct or otherwise establish a new airport or activate an airport.

- Construct, realign, alter, or activate any runway, or other aircraft landing or takeoff area of an airport.
- Construct realign, alter, or activate a taxiway associated with a landing or takeoff area on a public-use airport.
- Deactivate, discontinue using, or abandon an airport or any landing or takeoff area for a period of one year or more.
- Deactivate, abandon, or discontinue using, a taxiway associated with a landing or takeoff area on a public-use airport.
- Change to status of an airport from private use to an airport open to public or from public-use to another status.
- Change status from IFR to VFR or VFR to IFR.
- Establish or change any traffic patterns or traffic pattern altitude or direction.

United States Department of Transportation, Federal Aviation Administration. Order 5190.6A, "Airport Compliance Requirements," October 2, 1989.

The Airport Compliance Program monitors the performance of airport owners to maintain a high degree of safety and efficiency in airport design, construction, operation, and maintenance.

United States Department of Transportation, Federal Aviation Administration. Order 7400.2F, "Procedures for Handling Airspace Matters," February 16, 2005

This order specifies procedures in the joint administration of the airspace program. Actions associated with airspace allocation and utilization, obstruction evaluation, obstruction marking and lighting, airport airspace analysis, and the management of air navigation aids.

United States Department of Transportation, Federal Aviation Administration. Order 8260.3 B Change 19 through 20, "United States Standard for Terminal Instrument Procedures, TERPS," December 7, 2007.

This document contains standards for establishing and designing Terminal Instrument Flight Procedures (TERPS). The criteria are applicable at any location over which the United States has jurisdiction. TERPS are similar to FAR Part 77 in that there are constraints placed on the airspace in the vicinity of the airport that may have an impact on the land uses allowable beneath those surfaces.

MILITARY COMPATIBILITY PLANNING

Air Force Center for Engineering and the Environment, Brooks City-Base, San Antonio, Texas. http://www.afcee.brooks.af.mil/AFnewsRedirect.asp.

The web site contains documentation, publications, and information regarding Air Installation Compatible Use Zone Programs, USAF publications on noise, noise effects, and noise modeling, as well as NOISEMAP and other environmental noise models. Additional web links to the FAA Office of Aviation, Noise Abatement policy, INM Homepage, Interagency Committee on Aircraft Noise, and AICUZ staff contact information is provided.

Department of Defense. "Air Installations Compatible Use Zones." Number 4165.57, November 8, 1977. http://www.dtic.mil/whs/directives/corres/text/i416557p.txt.

This document defines the Department of Defense (DoD) policy to achieve compatible land uses of public and private lands near military airfields while maintaining operational effectiveness. Incompatible land is defined as areas that may obstruct the airspace or as areas exposed to health, safety, or welfare hazards of aircraft operations. The DoD's first priority is to take all "reasonable,

economical and practical measures to reduce and/or control the generation of noise from flying and flying related activities." The DoD recommends that facilities be sited and traffic patterns be routed of away from built-up areas and working with local agencies to control and regulate land uses. After all reasonable noise source control measures are taken, the DOD recognizes that significant land areas will remain exposed to noise that is incompatible with certain uses. Therefore the DoD developed guidelines for compatible land uses within three zones: the Clear Zone, the Accident Potential Zone, and the Noise Zone.

In 1964, the DOD defined aircraft noise exposure in terms of Composite Noise Rating (CNR). Several years later it began using Noise Exposure Forecast (NEF). In 1974, the DOD followed the Environmental Protection Agency's guidelines of Day-Night Average Sound Level (Ldn or DNL) as the noise descriptor and developed conversion guidelines for CNR and NEF. Essentially, the DOD follows other federal guidelines. All land uses are incompatible above DNL 75 dB and most land uses are compatible below DNL 65 dB. In fact, the DOD does not require noise contour plots for less than DNL 65 dB or more than DNL 80 dB.

Department of Defense. Joint Land Use Study (JLUS), Program Guidance Manual, August 2002.

The purpose of the JLUS is to encourage cooperative land use planning between military installations and surrounding communities in order to accommodate future compatible growth of both. Areas affected by accident potential or above DNL 65 dB (defined as unacceptable noise levels) should participate in the study. The government will fund a study to develop local jurisdictional development guidelines for accident potential zones and noise exposure zones above DNL 65 dB that will include limits on tall structures, on-base measures to mitigate community impacts, and peripheral land uses that adversely impact installation operations. Communities are asked to put forth a good faith commitment that the study recommendations, which may include comprehensive planning, zoning ordinances, subdivision regulations, and building codes, will be accepted and incorporated into local land development planning and decision-making. Additionally, the study recommendations may be controversial to some citizens with development aspirations, but community officials must consider the broad public health, welfare, and safety prior to beginning this study. Further, this study is a partnership between the military and the local community. Therefore, at least 50 percent non-federal funding must be provided by the local community, with no less than 20 percent contributed in cash. Finally, JLUS recommends implementation through a permanent advisory board comprised of military and community stakeholders in order to uphold the JLUS recommendations and offer peer support for politically sensitive land use controls.

Department of Defense. Unified Facilities Criteria 3-260-01, "Airfield and Heliport Planning and Design". Air Force Civil Engineer Support Agency (Preparing Activity), U.S. Army Corp of Engineers, Naval Facilities Engineering, Washington, DC, May 19, 2006. http://www.wbdg.org/ccb/DOD/UFC/ufc_3_260_01.pdf.

The 357 page document provides technical planning, design, and construction criteria for all U.S. military airfields and heliports. It outlines the airfield protections zones, airfield and helipad approach surfaces, aircraft parking apron criteria, and land side facility setbacks required for military airfield operations. The UFC is to be used for all DO
D projects and work for other customers when appropriate.

Grabow, Steven H., Mark Hilliker, and Joseph Moskal. "Comprehensive Planning and Citizen Participation." University of Wisconsin-Extension Community, Natural Resource and Economic Development Programs. 2004.

Wisconsin's Comprehensive Planning and Smart Growth Law of 1999 requires all communities in the State to develop a comprehensive plan by January 1, 2010 if they intend to make any decisions affecting land use within their jurisdiction.

This publication has three primary purposes that include: 1) help local elected officials better understand comprehensive planning; 2) help local elected officials ensure purposeful citizen participation throughout the comprehensive planning process; and 3) provide a detailed guide about how to get started with comprehensive planning. To that end, this publication lays out specific responses to the requirements of the Comprehensive Planning and Smart Growth Law. It also provides a framework for local elected officials to help guide their communities through a comprehensive planning process.

This publication is intended to help community leaders across the State of Wisconsin address the requirements of Wisconsin's Comprehensive Planning and Smart Growth Law. It is intended to provide a basic understanding of an effective citizen participation plan.

Office of Economic Adjustments. "Joint Land Use Study Program Guidance Manual." Arlington, Virginia, Office of the Secretary of Defense, August 2002.

This document is guidance for military and surrounding local communities to address joint land use studies and it authorizes military departments to enter into agreements with states, political subdivisions, and private conservation entities (conservators).

The Joint Land Use Study program was developed in 1985 and is intended to encourage land use planning between the military installations and surrounding communities to ensure that future growth is compatible with the training and operational needs of the military. It encourages the use of open forums to consider both the community and military installation requirements. As an incentive, the Office of Economic Adjustments can offer matching grants for joint planning processes. Recommendations are used to guide local jurisdictions with the development and implementation of land use controls.

Office of Economic Adjustments. "Practical Guide to Compatible Civilian Development Near Military Installations." In cooperation with the National Governors Association Center for Best Practices, Arlington, Virginia, Office of the Secretary of Defense, July 2005. http://www.oea.gov and http://www.nga.org/.

This 544 page guide offers an extensive look at "best practices" to land use planning and is specific to areas that are used or influenced by the military. The guide addresses a variety of strategies and approaches to encroachment prevention and is categorized by local, state, and federal approaches. The goal of the guide is to encourage local, state, and federal government coordination of encroachment prevention by use of a combination of approaches and tools to include the:

- Department of Defense (DoD) Air Installation Compatibility Use Zones (AICUZ)
- US Air Force and US Navy Air Installation Compatible Use Zones (AICUZ)
- US Navy Range Air Installation Compatibility Use Zone (RAICUZ)
- US Army Operational Noise Management Program (ONMP) general plans and zoning codes
- DoD Joint Land Use Study program
- DoD Conservation Partnering Authority
- State growth and development policies
- State legislation to prevent encroachment
- State and local capital expenditure policies

- DoD financial and planning assistance

United States Air Force. "AICUZ Program Managers Guide," Air Force Handbook 32-7064, Washington, DC, March 1, 1999. http://www.e-publishing.af.mil.

This instruction identifies the requirements to develop, implement, and maintain the Air Installation Compatible Use Zone (AICUZ) program. It also implements Department of Defense (DoD) Instruction 4165.57, Air Installations Compatible Use Zones, November 8, 1977. It applies to all Air Force installations with active runways located in the United States and its territories, including government-owned, contractor-operated facilities, except those installations exempted under this instruction. The Air Force may apply the AICUZ program, in whole or part, to overseas installations according to host country agreements or specific requests.

United States Air Force. "Air Installation Compatible Use Zone Program," Air Force Instruction 32-7063, Washington, DC, September 13, 2005. http://www.e-publishing.af.mil.

This handbook provides military commanders and managers an overview of the Air Force's Air Installation Compatible Use Zone (AICUZ) Program. The AICUZ Program Manager's provides specific guidance concerning the organizational tasks and procedures necessary to implement the AICUZ program. It is written in a "how to" format to guide a person through the five phases of an AICUZ study. It also includes a generic AICUZ Study Report, Citizen Brochure, and a Implementation and Maintenance Plan. The guide summarizes the data collection steps and procedures for developing USAF-approved noise contours. The AICUZ is similar to the FAA noise abatement programs.

United States Army. "Environmental Protection and Enhancement," Army Regulation 200-1, Washington, DC, February 21, 1997.

This regulation provides a brief overview of environmental programs and requirements. It does not provide a complete listing of requirements or detailed guidance on complying with environmental laws and regulations. In addressing environmental issues, readers must consult the applicable laws, regulations, and guidance documents referenced in this regulation. This regulation supplements federal, state, and local environmental laws for preserving, protecting, and restoring the quality of the environment. It also integrates pollution prevention, natural and cultural resources, and the National Environmental Policy Act (NEPA) into the Army Environmental Program. The goals of the Army's Environmental Noise Management Program are to control environmental noise to protect the health and welfare of people, on- and off-post and reduce community annoyance from environmental noise to the extent feasible.

United States Army Environmental Command. Army Compatible Use Buffers (ACUB). http://aec.army.mil/usaec/acub/acub00.html.

This local Army commander's outreach program is designed to avoid or limit civilian encroachment and provide for long-term range sustainability for Army installations and test and training ranges. It focuses on executing agreements between an installation and an "eligible entity" to address land use or potential development that could infringe upon the mission capability. Eligible entities include state and local governments and private conservation organizations. A cooperative agreement is the vehicle used to obligate Department of Defense (DoD) funds to acquire less than fee simple interest in property in partnership with other eligible entities. The program is based on a willing seller and a willing buyer. Partners receive financial support from the Army for land conservation, including endangered species and habitat protection and other uses consistent with the authority under 10 U.S.C. § 2684a.
The objective of the ACUB program is to provide the best training and maneuver range infrastructure and capabilities based on land availability, military mission, and doctrinal requirements. The U.S. Army Assistant Chief of Staff for Installation Management, Director of Environmental Programs, manages the ACUB program. The program supports each installation

and the identification of lands that may have the potential to meet multiple public purposes, including conservation, while sustaining range capabilities.

US Code. Title 32, Code of Federal Regulation, Part 256, Air Installation Compatible Use Zones, revised July 1, 2002

This Code of Federal Regulation authorizes and directs the Air Installation Compatible Use Zone requirements for the Department of Defense. The law is the foundation and support for authorizing federal funding and actions to address and resolve land uses in and around military airfields.

United States Marine Corps.

The Marine Corps exercises the authority to acquire real property restrictive easements by participating in Conservation Forums led by states or nongovernmental organizations. These forums are open to all interested Federal and State agencies and non-governmental organizations and individuals. Though not required, a charter agreed to by all participants usually governs the forums. The primary purpose of these forums is to identify criteria agreeable to all participants for identifying land desirable for acquisition, identifying land available for acquisition, developing a real estate process that meets all participants' legal requirements for property acquisition, and bringing together interested members of the forum to conduct the transaction.

United States Navy. Encroachment Partnering (EP) Program.

The Navy is particularly susceptible to a broad range of encroachment issues since many of its installations are located in ecologically important and high-growth urban areas. The objective of the Navy's Encroachment Partnering Program is to acquire real property interests, such as conservation easements, development rights, or water rights, which will address current or potential encroachment threats to the Navy's mission.
In order to ensure that the Encroachment Partnering (EP) program is effective, an installation or range must be aware of all of its encroachment threats. The Navy will develop an Encroachment Action Plan (EAP) that captures the results of identification, quantification, and mitigation of the potential encroachment threats to an installation or range. An EAP delineates a short-, mid-, and long-term strategy to address encroachment threats, including potential Encroachment Prevention partnerships. In addition, the Navy is using its Theater Assessment Program (TAP) to capture all encroachment threats at its training ranges through the development of Range Complex Management Plans (RCMP). Results of the RCMP will be used to develop potential EP projects.

United States Navy and Headquarters, United States Marine Corps. "Air Installation Compatible Use Zone (AICUZ) Program," OPNAV Instruction 11010.36B, Washington, DC, December 19, 2002.

The purpose of the Air Installation Compatible Land Use (AICUZ) instruction is to achieve compatibility between air installations and neighboring communities by protecting the health, safety, and welfare of civilians and military personnel by encouraging land use which is compatible with aircraft operations; protecting Navy and Marine Corps installation investment and operational capabilities; reducing noise impacts caused by aircraft operations and informing the public about the AICUZ program and seeking cooperative by promoting compatible development in the vicinity of military air installations.

United States Navy and Headquarters, United States Marine Corps. "Joint Land Use Studies (JLUS) Program," OPNAV Instruction 3030.3, Washington, DC, July 6, 2004.

This Navy instruction implements policies, assigns responsibilities, and prescribes procedures for executing the Joint Land Use Study (JLUS) Program as administered by the Department of Defense, Office of Economic Adjustment (OEA).

United States Navy and Headquarters, United States Marine Corps. "Range Air Installations Compatible Use Zones (RAICUZ) Program," OPNAV Instruction 3550.1, Washington, DC, August 7, 1998.

The Department of the Navy's Range Air Installation Compatible Use Zone (RAICUZ) program is designed to protect public health, safety, and welfare, and to prevent encroachment from degrading the operational capability of air-to-ground ranges. The RAICUZ program includes range safety and noise analysis, and provides land use recommendations which will be compatible with range safety zones and noise levels associated with military range operations.

COMMUNITY RESPONSE TO AIRCRAFT NOISE

Airport Noise Compatibility Planning (ANCP) Toolkit. Washington DC, May 1999. http://www.aee.faa.gov/noise/LUPItoolkit.htm..

The Airport Noise Compatibility Planning Toolkit was designed for FAA regional offices to help them assist local jurisdictions interested in compatible land use planning. The Toolkit provides information on Federal legislation, FAA policy, regulations, programs and funding, and sample state legislation and programs for addressing airport land use compatibility. The roles and responsibilities of twelve stakeholder groups are discussed. The Toolkit encourages: "cooperative planning, zoning, subdivision regulations, disclosure and open communication;" working with all parties to develop a balanced airport noise compatibility plan; and mitigating existing incompatible uses through sound insulation, easements, and voluntary acquisitions.

American National Standards Institute. *Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools.* ANSI S12.60-2002.

Document provided Abstract: This Standard provides acoustical performance criteria, design requirements, and design guidelines for new school classrooms and other learning spaces. The standard may be applied when practicable to the major renovation of existing classrooms. These criteria, requirements, and guidelines are keyed to the acoustical qualities needed to achieve a high degree of speech intelligibility in learning spaces. Design guidelines in informative annexes are intended to aid in conforming to the performance and design requirements, but do not guarantee conformance. Test procedures are provided in an annex when conformance to this standard is to be verified.

Summary Guidance: This Standard identifies levels of background noise, in terms of maximum one hour A- and C-weighted background levels and maximum reverberation times that, if achieved, "…will improve the quality of education by eliminating acoustical barriers for all students and teachers, including those with communication disabilities." Criteria for maximum A-weighted steady background levels are given as a function of classroom size. Additionally, when the noisiest hour is dominated by varying sound levels produced by transportation noise (such as aircraft), the criteria plus 5 dB should not be exceeded for more than 10 percent of the time. For example, for a core learning space of not more than 20,000 ft^3, (e.g. 20 feet by 40 feet by 10 feet high ceiling), a level produced by aircraft intruding noise should not exceed 40 dBA for more than 10 percent of the time. Outdoor-to-indoor sound reductions must, of course, be considered.

Andersson, H. *Noise charges in railway infrastructure.* VTI 26A-2006.

This paper evaluates the marginal social costs of and noise charges for railways in Sweden. Costs are identified as resource costs (medical, insurance, out of pocket, etc.), opportunity costs (lost productivity, lost leisure), and disutility costs (disturbance, annoyance, anxiety). Noise is measured both at an average level ("equivalent level") and maximum level. The cost function is only defined for dB levels above 50. Important influences on the marginal costs include volume,

train type, distance from tracks, ground conditions, and number of persons exposed. Freight trains have higher social costs than high-speed and commuter trains largely because of greater train length and source volume. Traffic levels are found to be less important than number of persons exposed to increased noise levels.

Moving away from the tracks, exposure to noise decreases, however the total number of persons exposed increases, which also increases the marginal costs. An additional factor is time of day. The social costs of noise are characterized as a function of traffic levels, distance to source, or other factors influencing noise (ground barriers, etc.). The paper uses both an equivalent level (average) and maximum level (for sleep disturbance) as measures.

Aviation and the Environment: FAA's Role in Major Noise Programs, GAO/RCED-00-98. Washington DC, April 2000. http://www.flypdx.com/PDFPOP/Noise_Mgmt_GAO_FAA_Role.pdf.

The Subcommittee on Aviation, House Committee on Transportation and Infrastructure asked Government Accountability Office (GAO) to determine the types of projects that are eligible for federal funding to reduce or mitigate airport-related noise, the differences in the major methods for measuring the impact of airport-related noise, FAA's current noise standards for turbojets, and the status of FAA's Land Use Planning Initiative. Most funds used for noise related projects have been used to acquire land and to soundproof buildings. The Land Use Planning Initiative is intended to assist state and local governments to prevent future incompatible land uses near airports. Under this Initiative, FAA announced in May 1999 five short-term actions it would undertake: (1) develop an information package on land use planning, (2) develop an information package on land use statutes, (3) establish an information clearinghouse, (4) develop procedures to rapidly respond to inquiries from local communities and airports, and (5) clarify the actions it will consider when noise levels begin to rise in certain areas. The initiative has highlighted some key questions about how best to address airport-related noise:

- Should FAA's role in land use planning be more proactive or should it focus its limited resources on activities over which it has direct jurisdiction?
- Should the noise exposure level defining compatible land use be lowered or retained at 65 decibels using the Day-Night Sound Level method?
- Should the use of supplemental information, such as single event noise measures, be required when measuring noise impacts for environmental impact analyses of airport development projects? and,
- How should federally authorized investment in the growth of airport capacity be directed in view of the noise and physical expansion constraints facing so many of the nation's airports?

Babisch, W. *Transportation Noise and Cardiovascular Risk*. January 2006. http://www.umweltdaten.de/publikationen/fpdf-l/2997.pdf.

Dr. Wolfgang Babisch of the Federal Environmental Agency in Germany reviewed epidemiological studies of transportation noise, including airport noise and the risk to cardiovascular functions. His report includes research up to 2005. The studies found that at higher noise levels there are higher risks, but a statistical significance is not found.

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

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

Although different measures of noise are employed, there are not major differences in the impact based as a result of these different metrics. An important contribution of the paper is the finding that the impact of noise differs significantly based upon whether the ambient environment of a

geographic area is quiet (i.e., non-urban) or noisy (urban). The impacts of noise are greater for quieter regions (0.60 percent/dB versus 0.20 percent/dB).

The paper suggests that GIS be integrated into similar analyses.

Basner, M., et al. *Effects of Nocturnal Aircraft Noise, Vol. 1, Executive Summary*. German Aerospace Center (DLR), Institute of Aerospace Medicine, Flightphysiology Department, Linder Hoehe, 51147 Cologne, Germany, July 2004.

This study reports the results of laboratory (128 subjects, 13 consecutive nights) and in-home (64 volunteers, 9 consecutive nights) sleep studies. The in-home study locations were chosen to be sites with high aircraft noise and low levels of other noise. The in-home results differed considerably from the laboratory results, with subjects being much less inclined to awaken from aircraft noise in their homes. Sound levels were measured outdoors and at the sleeper's ear, and were recorded (WAV files) when the level outside exceeded the L90 by 4 dB for later use in identifying the source of the noise. Many variables were recorded, such as sleep stage, heart rate, respiratory movements, and general body movements (motility). The aircraft noise was quantified in terms of the maximum A-weighted sound level at the sleeper's ear. The subject was considered to be awakened if the sleep stage changed from a deeper sleep stage to the lightest sleep stage (called S1) or to awake. An awakening was to be the result of an aircraft, if awakening occurred within a 90 second "window" after an aircraft noise event, and no other noise occurred in that time period. The study attempted to determine the percentage of awakenings that are induced by aircraft noise beyond the awakenings that normally (spontaneously) occur. In general, aircraft levels must exceed 35 dBA at the sleeper's ear before any awakenings more than spontaneous ones, are likely to occur. When accounting for spontaneous awakenings, aircraft maximum levels of up to approximately 75 dBA are likely to produce 10 percent additional awakenings.

Berglund, B., T. Lindvall, D.H. Schwela, Ed.s, "Guidelines for Community Noise," World Health Organization, Geneva, 1999

Since 1980, the World Health Organization (WHO) has addressed the problem of community noise. Health-based guidelines on community noise can serve as the basis for deriving noise standards within a framework of noise management. Key issues of noise management include abatement options; models for forecasting and for assessing source control action; setting noise emission standards for existing and planned sources; noise exposure assessment; and testing the compliance of noise exposure with noise immission standards. In 1992, the WHO Regional Office for Europe convened a task force meeting which set up guidelines for community noise. A preliminary publication of the Karolinska Institute, Stockholm, on behalf of WHO, appeared in 1995. This publication served as the basis for the globally applicable *Guidelines for Community Noise* presented in this document. An expert task force meeting was convened by WHO in March 1999 in London, United Kingdom, to finalize the guidelines.

Brink, M., K. Wirth, and C. Schierz. *Effects of Early Morning Aircraft Overflights on Sleep and Implications for Policy Making*. Euronoise 2006, Tempere, Finland, May-June 2006.

This paper reports on a study of 60 subjects over 30 consecutive nights when recorded aircraft arrivals and departures were played in sleeper's bedrooms. "Awakening" was determined by "motility reactions," that is, by increased movement of the sleeper. The findings were that 1) the subjects were awakened more readily by aircraft noise events in the early morning (closer to rising time) than by the same events in the evening (the time closer to retiring); 2) that the first aircraft noise events in the early morning are more disturbing (greater motility) than succeeding events or than events in the evening; and 3) that the amount of motility is affected by the time history of the noise event – events like arrivals that quickly rise and fall, produce higher levels of motility than do the slower rising and falling levels of departures, despite having equal maximum levels.

Bronzaft, Arline L. *United States Aviation Transportation Policies Ignore the Hazards of Airport-Related Noise*. World Transport Policy & Practice 9, no. 1 (2003): 37–40. http://www.eco-logica.co.uk/.

This article reviews recent literature on the adverse health effects of aircraft noise and argues that greater efforts are needed to reduce the number of people exposed to harmful levels of aircraft noise. However, the article is silent on what levels of noise exposure are likely to result in the harmful effects identified in the article, beyond noting that many agencies involved in setting noise standards have adopted a threshold criterion of 55 dB for defining noise impacts in urban residential areas, whereas the Federal Aviation Administration and the Department of Defense have adopted a criterion of 65 dB. The article suggests that growth in aviation activity is increasing the number of people exposed to aircraft noise, although no data are presented to quantify this assertion. The article makes no mention of land use planning strategies as a way to reduce the exposure of residential areas to aircraft noise, nor how these strategies might interact with urban growth patterns. Many of the points made in the article are self-evident to anyone who has studied airport noise issues, but the article fails to acknowledge or address the inherent trade-offs involved in reducing the exposure to aircraft noise while meeting other social goals, such as achieving economic use of land around airports or keeping the cost of air transportation as low as possible.

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

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

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

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

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

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

Coffman Associates, Lincoln, NE. Airports Part 150, Appendix E, Support Documentation for Land Use Regulations Within and Below 65 DNL, Table A, 2000.

This study was a brief review of tools used by various jurisdictions to regulate land use within and below DNL 65 dB. Specifically, the study concluded that Lincoln Airport, the City of Lincoln and Lancaster County, NE should strengthen their land use regulations because the airport receives regular military training activity and has the possibility of attracting future cargo service. Below is a summary table of the findings sorted by extent of noise mitigation and then by DNL contour. Follow-up with some of these jurisdictions is warranted since these all have various requirements applicable to levels less than DNL 65 dB.

Name of Jurisdiction	Regulating Tool	Noise Boundaries Established	Description of Regulation
Cleveland, OH	NA	DNL 60 dB	City of Cleveland mitigating noise impacts down to DNL 60 through sound insulation to existing noise sensitive development. The area within DNL 60 is fully developed.
Minneapolis, MN	NA	DNL 60 dB	City of Minneapolis is mitigating noise impacts down to DNL 60 through sound insulation to existing noise sensitive development. The area within DNL 60 is fully developed.
Naples, FL	Comprehensive Plan and Zoning Ordinance	squared off DNL 70, 75, 65 and 60 contours; Airport Overlay District; School Impact Area;	Plan requires City Council approval of any development within DNL 60 dB: Zoning Ordinance prohibits residential uses, nursing homes and schools within DNL 60 dB; Churches, Libraries and hospitals are conditional uses within DNL 60 dB; School Impact Area is 5 miles x 2,500 feet from runway centerline and prohibits school development within this area; Avigation easements required for all new development or redevelopment within DNL 60 dB; Noise impacted area maps shall be published 3 times in newspapers with general county circulation; DNL contours are squared off in coordination with parcels boundary lines;
Adams County, CO	Comprehensive Plan and Zoning Ordinance	DNL 60 dB	Residential development is prohibited within 60 DNL contour; commercial and industrial development must incorporate sound attenuation measures.
Boise, Idaho	Comprehensive Plan and Zoning Ordinance	DNL 65 to 60 dB	Plan's highest priority is airport protection from non-compatible encroachment & promotes non-residential land uses within these areas; Zoning Ordinance prohibits residential development above DNL 65 dB; allows residential and school development between DNL 65 to 60 dB but, requires sound insulation required; Airport Noise Transition Zone requires maximum lot coverage for all land uses
Loudon County, VA	Zoning Ordinance	DNL 65 to 60 dB and area extending 1 mile beyond DNL 60 dB boundary	Residential development is prohibited above DNL 65 dB; Residential development between DNL 65 to 60 dB requires sound insulation, avigation easements, and full disclosure statements; Full

Name of Jurisdiction	Regulating Tool	Noise Boundaries Established	Description of Regulation
			disclosure statements for all areas within 1mile of DNL 60 dB;
Mesa, AZ	General Plan and Zoning Ordinance	DNL 65 to 60 dB; overflight areas	Plan prohibits residential development within DNL 65 dB; Zoning Ordinance allows Residential development between DNL 75 to 65 dB but, requires sound insulation, avigation easements and design review; Residential development between DNL 65 to 60 dB requires sound insulation and avigation easement; Residential development within designated overflight areas requires sound insulation
Truckee, CA	General Plan, Zoning Ordinance and Subdivision Regulations	CNEL 80 to 55 dB	Plan declares hospitals, schools, residential uses, and other noise sensitive uses are unacceptable above CNEL 75 through CNEL 65 but, are conditionally acceptable between CNEL 65 to 60 dB; Zoning Ordinance requires an acoustical analysis for all noise sensitive development within CNEL 55 dB and sound insulation to achieve an indoor sound level of CNEL 45 dB; prohibits residences, schools, places of worship, etc within CNEL 65 dB; requires sound insulation of commercial development within CNEL 65 dB; Subdivision regulations require an avigation easement for all development within CNEL 55 dB;
Durham, NC	Zoning Ordinance	DNL 65 to 60 dB	Noise sensitive development including residential uses is prohibited within DNL 65 dB; Residential development within DNL 60 dB requires sound insulation and fair disclosure

Federal Interagency Committee on Noise (FICON). "Federal Agency Review of Selected Airport Noise Analysis Issues," August 1992.

The Federal Interagency Committee on Noise, FICON, was formed to review federal policies that govern the assessment of airport noise impacts. FICON produced this report and made the following policy recommendations:

- Continue use of the DNL metric as the principal means for describing long-term noise exposure of civil and military aircraft operations.
- Continue agency [FAA] discretion in the use of supplemental noise analysis.
- Improve public understanding of the DNL supplemental methodologies and aircraft noise impacts.

- If screening analysis shows that noise-sensitive areas will be at or above DNL65 dB and will have an increase of DNL 1.5 dB or more, further analysis should be conducted of noise-sensitive areas between DNL 60-65 dB having an increase of DNL 3 dB or more due to the proposed airport noise exposure.
- If the DNL 65 dB screening test calls for further analysis between DNL 60-65 dB, agency mitigation options will include noise sensitive areas between 60-65 dB that are projected to have an increase of 3 dB or more as a result of the proposed airport noise exposure.
- If a FAA FAR Part 150 program is included by the FAA as a NEPA mitigation measure, the FAA and the airport operator are responsible for ensuring that the commitment is carried out and the Part 150 study scope conforms to the NEPA scope of analysis.
- Increase research (R&D) on methodology development and on the impact of aircraft noise. To foster this, a standing federal interagency committee should be established to assist agencies in providing adequate forums for discussion of public and private sector proposals identifying needed research and in encouraging R&D in these areas. The following initial R&D issues are recommended:
  - Evaluate potential modifications to the 1980 FICUN land use compatibility table to improve its usefulness for both routine land use planning and planning for noise-sensitive land uses.
  - Continue research into community reaction to aircraft noise, including sleep disturbance, speech interference, and non-auditory health effects of noise.
  - Investigate differences in perceptions of aircraft noise, ground transportation noise (highways and railroads), and general background noise.
  - Continue and expand research on the airport noise impacts of rotary-wing operations.

This report explicitly recommends continued the use of DNL, but recognizes that metric and use of only the value of 65 dB DNL may be insufficient to communicate the potential noise effects and the need for mitigation. It also recognizes the differences in perception to aircraft and other forms of transportation noise.

Feitelson, Eran I., Robert E. Hurd, and Richard R. Mudge. "The Impact of Airport Noise on Willingness to Pay for Residences." *Transportation Research* 1D, no. 1 (September 1996): 1–14. http://www.elsevier.com/wps/find/homepage.cws_home and http://www.sciencedirect.com/.

Author abstract: The effects of aircraft noise following airport expansion on the willingness to pay (WTP) for residences is examined, using a contingent valuation approach. WTP estimates are elicited for a standard residence whose noise settings are systematically changed. The results show that most current compensation programs are inadequate, as they do not fully compensate home owners or renters for the loss associated with higher noise exposure. This analysis also shows that such valuations should analyze noise as a multi-attribute externality, rather than by a single composite measure. Finally, the results indicate that household WTP structures are skewed, whereby, beyond a certain disturbance threshold, households are unwilling to pay anything for the residence; yet, different households have different thresholds. This skewed WTP structure helps explain the higher noise premiums obtained in studies relative to hedonic price estimates.

Fidell, S. "The Schultz curve 25 years later: A research perspective." *The Journal of the Acoustical Society of America* 114 (6), Pt. 1, December 2003.

This paper reviews and provides a critique of the reliance on the "Schultz" curve (and FICON's endorsement of it) for predicting community reaction / annoyance to aircraft noise and for determining policy related to analysis of aircraft noise. It identifies several issues that need further research and better understanding, which include: 1) effects on aircraft noise decision-making because policy relies on a relationship (the Schultz curve) that poorly reflects the realities of community reaction; 2) manner in which the community response data have been used to develop the Schultz curve; 3) unknown error-bounds and uncertainty inherent in developing a relationship such as the Schultz curve from community response data; 4) use of community response data,

rather than a derived curve / relationship for setting policy; 5) quantitative, theory-based consideration of non-acoustic factors that affect annoyance to aircraft noise; 6) recognition of geographic distributions of noise complaints as an alternate indication of actual community reaction to transportation noise.

Fidell, S., H. Richard, B.G. Tabachnick, K. Pearsons, and M.D. Sneddon, "Noise-Induced Sleep Disturbance near Two Civil Airports," NASA Report 198252, December 1995 (DIA).

This report presents the methods and results of four in-home sleep studies conducted in the vicinities of Denver Stapleton International Airport (DEN) and Denver International Airport (DIA). The studies were carried out before and after the closing of DEN and before and after the opening of DIA. "Both indoor and outdoor measurements of aircraft and other nighttime noises were made during four time periods. Measurements were made in 57 homes located as close as feasible to the runway ends of the two airports. Sleep disturbance was measured by several indices of behaviorally-confirmed awakening (button pushes upon awakening) and body movement (as measured with wrist-worn actimeters)." Sound Exposure Level, SEL was the metric of the noise event used. The percent of noise events producing either awakenings or increased movement varied widely, especially for movement depending upon how the increased movement is defined. Approximately 2 percent of events at 70 dB SEL resulted in behavioral awakenings, and from 21 to 75 percent of events at 70 dB SEL resulted in actimetric (movement) responses depending on the criteria used. All measures show an increasing awakening or arousal response with increasing SEL.

Fidell, S., and L. Salvati, "Parsimonious alternatives to regression analysis for characterizing prevalence rates of aircraft noise annoyance," *Noise Control Engineering Journal*., 52 (2) March-April 2004.

This article provides an alternative method for deriving the relationship between percent of the population that reports being "highly annoyed" and the day-night average sound level. The original relationship, the "Schultz" curve, included all transportation noises, while there are sufficient aircraft noise-only data to derive a relationship between prevalence of annoyance and aircraft noise. Using both logistic regression and linear regression, the authors derive two such relationships. For example, at 65 dB DNL, the Schultz curve, or its more recent revisions (FICON 1992), gives 12.3 percent highly annoyed, while the proposed logistic regression of aircraft noise only gives 27.3 percent highly annoyed and the linear regression gives 28.2 percent highly annoyed. Yet another alternative is suggested, using only the available data and assuming no relationship other than grouping the highly annoyed results in 5 dB bins, weighted by number of points, and determining for each bin the mean percent highly annoyed. This latter approach yields 28.0 percent highly annoyed at 65 dB DNL.

Fields, J.M., "Effect of Personal and Situational Variables on Noise Annoyance in Residential Areas." *Journal of the Acoustical Society of America* 93, no. 5 (1993): 2753–2763. http://scitation.aip.org/.

Author abstract: This study uses methods that control for noise level and data quality to objectively evaluate the evidence on 22 personal and situational explanations for annoyance with environmental noise in residential areas. The balance of the evidence from 464 findings drawn from 136 surveys suggests that annoyance is not affected to an important extent by ambient noise levels, the amount of time residents are at home, the type of interviewing method, or any of the nine demographic variables (age, sex, social status, income, education, home ownership, type of dwelling, length of residence, or receipt of benefits from the noise source). Annoyance is related to the amount of isolation from sound at home and to five attitudes (fear of danger from the noise source, noise prevention beliefs, general noise sensitivity, beliefs about the importance of the noise source, and annoyance with non-noise impacts of the noise source). The evidence is too evenly divided to indicate whether changes in noise environments cause residents to be annoyed more, less, or about the same as would be expected in long-established noise environments. The evidence shows that, even at low noise levels (below DNL 55 dB), a small percentage of residents are highly annoyed and the extent of annoyance is related to noise exposure.

Goto, K., and T. Kaneok Proceedings of the 8th International Congress on Noise as a Public Health Problem. 382-383. 2003.

The authors looked at three groups of subjects which include a control set, areas over 75 weighted equivalent continuous perceived noise level (WECPNL), and areas over 90 WECPNL. The results indicate that annoyance with aircraft noise was not associated with blood pressure levels.

Hubbard, H.H. "Noise Induced House Vibrations and Human Perception," *Noise Control Engineering Journal*, 19, (2), September-October 1982.

Document Abstract: This paper summarizes noise induced house responses including frequencies, mode shapes, acceleration levels, and outside-to-inside noise reductions. The role of house vibrations in reaction to environmental noise is defined and some human perception criteria are reviewed.

Summary: Vibration of residential houses can be induced by sound impinging on the structure. Generally, for a given peak sound level, windows vibrate most readily, followed by walls, and lastly floors. Acceleration levels (vibration levels) tend to increase linearly with the incident peak sound levels. Very little if any damage to structures is likely except at extreme noise levels, such as those created by blasting or sonic booms. Human perception of structural vibration is greatest at frequencies between 1 and 100 Hz, with decreasing sensitivity outside of this range. Thresholds of perceptible vibration in floors, walls, and windows are provided in graphic form as a function of frequency and sound pressure level.

International Civil Aviation Organization (ICAO). "Guidance on the Balanced Approach to Aircraft Noise Management." Doc 9829, AN/451, First Edition – 2004.

This document provides ICAO Member States with useful information to set up a balanced approach to noise management at international airports. It provides an internationally agreed method to address aircraft noise problems in an environmentally and economically responsible way. The document gives Member States a flexible way to identify a specific noise problem. It calls for an airport-by-airport approach and recognizes that airports can apply similar solutions if they have similar noise problems. The balanced approach stresses the need for considering various measures available according to the noise assessment at each airport while preserving potential benefits gained from aircraft-related measures. The four principal elements of the balanced approach are: reduction of noise at the source, land use planning and management, noise abatement operational procedures, and operating restrictions on aircraft. In preparing this document, ICAO recognized that Member States have laws, existing arrangements, and policies that may govern managing noise problems at their airports. Therefore, any existing U.S. laws, regulations, policies, and obligations incurred under Federal agreements for surplus property and airport development grants supersede the Guidance on the Balanced Approach to Aircraft Noise Management.

Lane, T. "The Impact of Airport Operations on Land Values: A Case Study of Seattle Tacoma International Airport." Ph.D. Dissertation, 1998. (Paper presented at the Thirty Second Annual pacific Northwest Regional Economic Conference, 1998).

Single family residential values are assessed for a number of neighborhoods in proximity with Seattle-Tacoma International Airport. Ordinary Least Squares Regression (OLS) regression is employed. The modeled structural and locational variables include:

- Lot size
- Structure size
- Number of bedrooms
- Number of bathrooms

- Distance from flight track
- Neighborhood dummies

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

The paper suggests that future research should include some variable that models the aircraft flight elevation.

Lercher, P., S.A. Stansfeld, and S.J. Thompson. Proceedings of the 7th International Congress on Noise as a Public Health Problem. Vol.1:213:220. 1998.

Lercher, Stansfeld and Thompson provide a review of the health effects literature from 1993 to 1998 which included 30 studies and 16 literature reviews. They report that although the quality of the research methodology has improved, there needs to continue to be improvement in exposure characterization and design, setting characterization and selection, confounding, mediating and moderating variables, and outcome characterization and design. An example of one of the confounding variables is emotional response. They feel that the annoyance/affectedness of interference has not been looked at enough.

Lipscomb, C. "Small Cities Matter, Too: The Impacts of an Airport and Local Infrastructure on Housing Prices." RURDS Vol. 15, No. 3, November 2003.

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

Three major assumptions are made in the analysis and include: households can be aggregated, households choose particular spaces because of combinations of available public goods, and households make their choices based upon valuation of quality of life.

Variables used in the analysis include: parcel size, house size, number of bedrooms, number of bathrooms, community type, most recent sales date, fireplaces, proximity to transit, local amenities, and others.

Noise is not found to be a significant factor in house price. Proximity to the airport, however, is a significant and positive predictor of housing prices. In this case "nearness" appears to be valued by consumers.

Lu, C., and P. Morrell. "Determination and Applications of Environmental Costs at Different Sized Airports–Aircraft Noise and Engine Emissions." *Transportation*, 2006.

Social costs of air travel are said to come in two forms: noise and air pollutants. The analysis is based upon hedonic price methods where property values vary in response to neighborhood factors, location, and environmental quality. The annual social cost of noise is then a function of a noise depreciation index (percentage decrease in house value per dB above ambient levels) and the number of houses within each dB region. This is modified by an annoyance function which recognizes that disturbance increases non-linearly with dB increases. The cost of pollutants is a function of emissions from various engine/aircraft types, the number of aircraft movements, the unit costs of pollutants, and flight mode (cruise, take-off, etc.). The two sets of costs are summed to derive an average environmental cost per landing and an annual environmental cost in total for

five case study airports, which include Heathrow, Schiphol, Gatwick, Stansted, and Maastricht. Emission cost is higher per landing and on an annual basis for each of the five airports. The societal utility of an airport only increases while the net benefit of additional aircraft movements outweighs their cost. Noise charges are suggested that reflect this relationship.

Maryland Department of Aviation, State Aviation Administration, "Selection of Airport Noise Analysis Method and Exposure Limits," January 1975.

This study, required by the Maryland Environmental Noise Act of 1974, identifies the Day-Night Average Sound Level (DNL) and a computation procedure for determining aircraft noise exposure around Maryland airports. In this report, the Maryland Aviation Administration (MAA) set DNL 65 dB as the official noise limit for residential land use.

"The choice of acceptable noise limits can never be based only upon the relationship between noise exposure and the corresponding effects upon people. Considerations of the economic and technical feasibility must also enter into the decision. Setting the balance between criteria for an acceptable noise environment and the cost (in time and money) of achieving it is the proper concern of government, not the scientist."

In discussing the apparent contradiction between the Environmental Protection Agency (EPA) conclusions regarding a long-term goal of DNL 55 dB and MAA's recommendation of DNL 65 dB, the report states:

"We emphasize immediately that EPA's Levels Document was published to present information as required by the Noise Control Act; the noise levels identified therein… do NOT constitute EPA regulations or standards since they deliberately do not take into account cost or technical feasibility, or whether or not, in any particular situation, it would be desirable to undertake noise abatement activities that will undoubtedly interfere with other activities of value. Throughout the Document the words 'identified level' are used to express the environmental noise levels whose attainment would "protect the public health and welfare with an adequate margin of safety". The words 'goals', 'standards' or 'recommended levels' are avoided as inappropriate, because neither Congress nor EPA has concluded that the identified levels should be adopted as limits or standards by states and localities. This is a decision that the Noise Control Act clearly leaves to the states and localities themselves."

Ultimately the report recommends the adoption of the following proposed limits for cumulative noise exposure for residential land use, in terms of Day-Night Average Sound Level in dB, recognizing not only the work of the U.S. EPA (U.S. EPA, July 1973) and the significance of the "adequate margin of safety", but the also effects of changing technology and feasibility:

65 dB, Effective 1 July 1975
60 dB, Effective when U.S. fleet noise level is reduced 5 dB below the 1 July 1975 level

Mestre, V., "Effects of Aircraft Noise: Research Update on Selected Topics," ACRP Synthesis 9, ACRP Project 11-03, Transportation Research Board, 2008

This project, ACRP Project 11-03, "Synthesis of Information Related to Airport Practices," searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute an ACRP report series, *Synthesis of Airport Practice.* This synthesis series reports on current knowledge and practice, in a compact format, without the detailed directions usually found in handbooks or design manuals. Each report in the series provides a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems.

Miedema, H.M.E., et al, "Elements for a position paper on night-time transportation noise and sleep disturbance," TNO (Netherlands) Inro report 2002-59.

The EU Directive [DIRECTIVE 2002/49/EC, relating to the assessment and management of environmental noise, 25 June 2002] specifies L_{night} as the indicator for sleep disturbance. This report presents relationships between L_{night} and sleep disturbance for transportation noise. The effects of sleep that are addressed are: onset of motility, increase in mean motility during sleep, and self-reported sleep disturbance. Motility is determined within the 15 second interval that contains the maximum noise level of the aircraft overflight. To address onset of motility, equations are derived from various sleep studies to provide computation of the maximum annual total number of noise induced motilities L_{night} for aircraft noise events. Similarly, to address increase in mean motility, an equation is provided for computing mean motility as a function of L_{night} for aircraft noise events. Predicting self-reported sleep disturbance from aircraft could not be derived.

Miller, N.P., et al. "Study of Low Frequency Takeoff Noise at Baltimore – Washington International Airport." HMMH Report No. 294730.03/293100.09, April 1998; also as paper 302-01, in Proceedings, Inter-Noise 98, Christchurch, NZ, November 1998.

Detailed simultaneous measurements made over a one month period in August 1997 near Baltimore-Washington International Airport yielded data that relate measured start of takeoff sound levels to wall vibration levels, to resident ratings of the objectionable nature of the events, and to sound level propagation rates into the community. The house where the vibration measurements were made was located approximately 3,200 feet to the side of the departure runway and was exposed primarily to the sound levels produced while the aircraft were starting the takeoff roll. Findings were that start of takeoff roll noise that exceeded a C-weighted maximum level of about 80 dBC was likely to produce tangible wall vibrations. Also, takeoff roll noise of this level or greater had a better than 50 percent chance of being rated in the upper half of a scale of being objectionable by the house occupant.

Moorhouse, A., et al. "Proposed criteria for the assessment of low frequency noise disturbance." Defra, (Department for Environment, Food and Rural Affairs), UK, February 2005.

The purpose of this study is to recommend a method for assessing low frequency noise (LFN) that is suitable for use by Environmental Health Officers (EHOs) in the United Kingdom. In laboratory tests, a set of 'thresholds of acceptability' were established by asking 18 subjects to set the level of various low frequency sounds to a just-acceptable level for imagined day and night situations.

Morrell, Peter, and Cherie H.-Y. Lu. "Aircraft Noise Social Cost and Charge Mechanisms—A Case Study of Amsterdam Airport Schiphol." Transportation Research, Part D, Transport and Environment 5, no. 4 (July 2000): 305–320. http://www.elsevier.com/wps/find/homepage.cws_home and http://www.sciencedirect.com/.

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

movements. Several noise charge mechanism scenarios are derived according to the modeling results, as well as the environmental objectives of the airport related authorities.

National Association of State Aviation Officials (NASAO) and the Federal Aviation Administration (FAA). "Cooperative Partnership between the FAA and the State Agencies for Reducing Community Concerns related to Aircraft Noise." February 2000. http://www.faa.gov/about/office_org/headquarters_offices/aep/planning_toolkit/media/V.F.pdf.

This survey of state agencies and FAA regions identifies some specific noise abatement and noise reduction activities, but primarily focuses on awareness and education programs and activities, including laws and regulations in effect. Responses were received from eight FAA regions and 42 states. Of these, 79 percent reported some type of noise program run by local or state officials, including many regulations and guidelines. Of the reported programs, few were directed at public education and awareness. The document summarizes the best examples of education programs gleaned from the survey.

Nelson, J.P. "Meta-Analysis of Airport Noise and Hedonic Property Values: Problems and Prospects." *Journal of Transport Economics and Policy*, 2004.

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

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

Nijland, H.A., E.E.M.M. Van Kempen, G.P. Van Wee, and J. Jabben. "Costs and benefits of noise abatement measures." Transport Policy 10 (2003) 131-140.

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

Ollerhead, J.B., et al. "Report of a Field Study of Aircraft Noise and Sleep Disturbance." Department of Transport, December 1992.

This is one of the first large scale in-home studies of awakening due to aircraft noise. Subjects were located in eight different neighborhoods and included 189 males and 211 females between the ages of 20 and 70 years. Subjects kept sleep diaries and wore actimeters (to measure motility) for 15 nights. Sound levels were measured outside only, collecting data on events that exceeded 60 dBA and that were associated with radar tracking data to identify aircraft events. The objectives were to determine the relationship between outdoor aircraft sound levels and the probability of sleep disturbance. "Sleep disturbance" was determined by motility, which in turn was related to EEG awakenings as measured on a sub-set of the subjects. Overall, aircraft noise events with a Sound Exposure Level less than 90 dB were unlikely to produce any measurable increase in rates of sleep disturbance. The study also found that sensitivity to sleep disturbance varied across by more than a factor of two – the most sensitive individuals were more than twice as likely to be disturbed by an event than were the least sensitive. An important conclusion was that all the sleep disturbance data collected in laboratory situations significantly over-estimated the probability of awakening in a home situation.

Passchier-Vermeer, W., et al. "Sleep disturbance and aircraft noise exposure, Exposure-effect relationships." TNO Report, number 2002.027, June 2002.

This study was conducted in people's homes in 15 locations in the vicinity of Schiphol Airport on 418 subjects, aged between 18 and 81 years, over a time frame of 11 days. Both actimeters and button pushes were used to identify motility and behavioral awakenings. Sound levels were measured both in the subject's room and outdoors. Results are reported as probability of motility and probability of increased motility relative to non-noise motility. One result suggested that the probability of increased motility increases when indoor maximum A-weighted sound levels from aircraft exceed 40 dB (or an SEL of about 50 dB). Indoor sound levels were found to affect subjects' response, with louder interior levels decreasing the probability of aircraft noise induced motility.

President's Airport Commission, "The Airport and Its Neighbors." May 1952.

This report made several recommendations related to land use planning and noise. The report recommended that airports and metropolitan areas be jointly planned so that they develop each to serve the other (constructing, for example, limited access highways to minimize airport access times), that zoning laws be used to limit development in fan shaped areas at least 6,000 feet wide and two miles long at runway ends, that ground noise reduction (run-up noise) programs should be accelerated, and that flight personnel should receive instruction in use of noise reducing departure and approach procedures.

Public Law 108-176, H.R.2115, Vision 100- Century of Aviation Reauthorization Act, December 2003.

The law enabled states or local governmental agencies to receive federal funding for land use compatibility projects around large or medium sized hub airports that would increase land use compatibility with aircraft operations and prevent future incompatible land uses. The state or local agency must have the authority to plan and adopt land use control measures, enter into a written cooperative agreement with the airport operator that the agreement will achieve, to the maximum extent possible, compatible land uses consistent with Federal land use compatibility criteria under section 47502(3), and that those compatible land uses will be maintained in perpetuity. Additionally, the law requires jurisdictions that accept federal funding for land use compatibility plans to comply in perpetuity with all FAA land use regulations including airspace and height constraints.

The law requires airports to fund at least 35 percent of their approved noise compatibility planning project. The law also provided funding for an FAA study to provide prospective home buyers located within the vicinity of an airport access to the Noise Exposure Maps (NEM) and other information derived from the NEMs. The ability to have information about an airport's noise exposure was seen as an expansion of real estate disclosure and was viewed as an important step in compatible land use planning and in gaining community support of an airport.

The website link below provides public access to airport NEMs:
://www.faa.gov/airports_airtraffic/airports/environmental/airport_noise/noise_exposure_maps/

Salvi, M. - Zurich: Zürcher Kantonalbank. "Spatial Estimation of the Impact of Airport Noise on Residential Housing Prices." 2003.

The economic impact of airport noise is measured for the region surrounding Zurich International Airport. A spatial hedonic model is employed in the analysis. The paper adds to the existing literature on airport noise impacts by adding spatial statistics to the discussion. Because of spatial dependence, spatial modeling allows for a more robust estimation of effects. In this case, a spatial errors model is deemed appropriate.
Noise is measured utilizing the Leq method, which is the equivalent consistent sound level derived from the discontinuous noise levels that occurs in reality.

Model results indicate that the NDI (noise depreciation index) is 0.74 percent. Thus for every dB increase in noise, housing prices are reduced by an average of 0.74 percent. This figure is broadly in line with previous studies. The spatial effects are minimal, though the spatial model does reduce standard errors.

The key structural variables in the analysis included:

- Construction type
- Number of bathrooms
- Number of rooms
- Age
- Transaction date
- Kitchen characteristics
- Building materials (brick)
- Lot size
- Swimming pool
- Renovation
- Maintenance level

Schomer, P.D. "On Normalizing DNL to Provide Better Correlation with Response." *Sound and Vibration*, December 2002

Day-Night Average Sound Level (DNL) has been used since the early 1970's to assess the effects of aircraft noise on humans. Studies that determine percent of people reporting that they are "highly annoyed" by aircraft, relate this percent to the DNL experienced. However, all of the studies show considerable variability. An alternative approach has been to attempt to relate community reaction to DNL. Again, high variability of the results suggests that DNL alone is not sufficient to predict community reactions. This paper uses a method proposed in a March 1974 US EPA report to attempt to better predict community reactions to noise. The method includes making adjustments to the DNL of a new or changed source based on such factors as background noise and prior experience. This article demonstrates the complexity of using DNL alone to understand or predict community reactions or annoyance.

Schultz, T.J. "Synthesis of social surveys on noise annoyance," *The Journal of the Acoustical Society of America*, 64 (2)1978

This article is the original published paper relating percent of people reporting to be "highly annoyed" to Day-Night Average Sound Level (DNL). It provides a curve, typically referred to as "the Schultz Curve," that graphically presents the "dose-response" relationship. It is often cited as the basis for the use of DNL 65 dB as the threshold of noise impact. It should be noted that the Schultz Curve includes annoyance from all transportation sources, see Fidell, S. March-April 2004, for an interpretation of annoyance produced by aircraft only.

Schwarze, S., and S.J. Thompson, S.J. "Proceedings of the 6th International Congress on Noise as a Public Health Problem." Vol.3:252:259. 1993.

Schwarze and Thompson presented a review of the literature on non-auditory physiological effects of noise during the period 1988 to 1993. Despite citing 48 articles, the conclusion they came to was that the "findings cannot support a consistent relationship between noise exposure and harmful health effects". They felt the studies were of poor quality and could not be regarded as evidence one way or the other.

Sharp, B., T. Beeks, and H. Veerbeek, "Groundnoise Polderbaan Overview of Results," Schiphol Group, WR 06-02, February 2006.

In this summary report, groundnoise is defined as the low frequency noise generated by aircraft operations that is not accounted for by conventional noise models or noise monitoring systems, both of which provide data in the form of A-weighted noise levels that are more suited to describing the noise from aircraft overflights. This investigation showed that air-borne sound levels of low frequency (31.5 Hz) from aircraft takeoffs can cause annoyance at homes located about 8,000 feet from the start of takeoff. Levels at the homes are highly dependent on wind direction and type of ground cover. The levels were successfully modeled and verified with measurements. A relationship is given that compares human reaction, sound level, and frequency.

Stansfeld, S.A., P.Lercher, and W. Babisch. "Proceedings of the 8th International Congress on Noise as a Public Health Problem." 84-90. 2003.

Stansfeld and Lercher reviewed 40 articles during the period of 1998 to 2003. They included a meta-analysis of studies on various noise sources which determined that airport noise affects both hypertension and coronary heart disease although the authors still feel that the results are inconclusive. They concluded that, despite an increased sophistication in the studies during this period, there is still uncertainty regarding the "nature and the size of the effects of environmental noise." Further research is recommended by the authors.

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

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

Transportation and Regional Services. "Expanding Ways to Describe and Assess Aircraft Noise." Australia, 2000.

The purpose of this document is to advance the way in which aircraft noise exposure information is conveyed to the non-expert as a basis for informed dialogue between airports and surrounding communities. It responds to the difficulties in communicating the sound levels produced or expected to be produced by aircraft operations at an airport. The cumulative metrics do not provide an intuitive sense of the noise and this document presents several tested alternative descriptions. The methods combine graphics of maps and data that show information about what flight paths are flown by aircraft, the percent of time each flight path is used, and the number that fly along each path. Graphics also show what times flight paths are not used and the number that produce sound levels likely to result in speech interference indoors. The methods presented supplement the cumulative metrics of noise exposure.

US Code. Title 49, Transportation, Subtitle VII Aviation Programs, Part B, Chapter 471 Airport Development, Subchapter I Airport Improvements, Section 47107 (c) Capacity Expansion and Noise Abatement, January 3, 2006.

This code describes policy that regulates navigable airspace. It states that: "It is the policy of the United States…it is in the public interest to recognize the effects of airport capacity expansion

projects on aircraft noise. Efforts to increase capacity through any means can have an impact on surrounding communities. Noncompatible land uses around airports must be reduced and efforts to mitigate noise must be given a high priority."

US Code. Title 49, Transportation, Subtitle VII Aviation Programs, Part B, Chapter 475 Noise, Subchapter I Noise Abatement, January 3, 2006.

The Aviation Safety and Noise Abatement Act (ASNA) of 1979 require that a single system be developed for measuring noise and determining the level of noise exposure caused by airport operations. It also requires identification of land uses normally compatible with exposure to noise. Section 103 of the act authorizes the issuance of grants for airport noise compatibility planning to minimize noise impacts in communities around airports.

US Code. Title 49, Transportation, Subtitle VII Aviation Programs, Part B, Chapter 475 Noise, Subchapter II National Aviation Noise Policy Airport Noise and Capacity Act of 1990, January 3, 2006.

Increasing public outcry against aircraft noise required the establishment of a procedure to eliminate Stage 1 (the noisiest) and Stage 2 aircraft from operating in the United States. As of December 31, 1999, all turbojet aircraft must meet Stage 3 (the quietest) noise levels or cease operations. These requirements are predominantly focused on aircraft used by the airline industry.

United States Department of Transportation, Federal Aviation Administration. Advisory Circular 150/5020-1, "Noise Control and Compatibility Planning for Airports," August 5, 1983.

This document provides guidance for the implementation of FAR Part 150, which allows for the development of an airport plan that establishes a compatible relationship between land uses and noise-related issues. This is accomplished by the reduction of incompatible land uses around airports and noise sensitive areas, and the prevention of additional incompatible land uses.

United States Department of Transportation, Federal Aviation Administration. Advisory Circular 150/5020-2, "Guidance on the Balanced Approach to Noise Management," September 28, 2004.

This document accepts the International Civil Aviation Organization document, Guidance on the Balanced Approach to Aircraft Noise Management, as additional guidance material to consider when applying FAR parts 150 and 161 at United States international airports.

United States Department of Transportation, Federal Aviation Administration. Advisory Circular 150/5320-14, "Airport Landscaping for Noise Control," January 31, 1978

This AC establishes guidance for the implementation of landscaping for noise control purposes and recommends a variety of vegetative species to use for such purposes.

United States Department of Transportation, Federal Aviation Administration. AIP and PFC Funding Summary through 2006.
http://www.faa.gov/airports_airtraffic/airports/environmental/airport_noise/part_150/states/.
http://www.faa.gov/airports_airtraffic/airports/environmental/airport_noise/part_150/funding/.

- Total airports participating in the C (AIP) - 268
- Airports with AIP grants for Part 150 studies - 249
- Approved Noise Compatibility Programs (first-time) - 234
- Revised/Amended Noise Compatibility Programs – 81

Funding summary through fiscal year 2006 for preparing Part 150 studies:

- Airport Improvement Plan - $83,478,586
- Passenger Facility Charge - $11,575,617

Funding summary through fiscal year 2006 for Part 150 implementation:

- Airport Improvement Plan - $4,544,011,054
- Passenger Facility Charge - $2,999,605,924

United States Department of Transportation, Federal Aviation Administration. "Airport Noise Compatibility Planning (ANCP) Toolkit." Washington DC, May 1999. http://www.aee.faa.gov/noise/LUPItoolkit.htm.

The Airport Noise Compatibility Planning Toolkit was designed for FAA regional offices to help them assist local jurisdictions interested in compatible land use planning. The Toolkit provides information on federal legislation, FAA policy, regulations, programs and funding, and sample state legislation and programs for addressing airport land use compatibility. The roles and responsibilities of twelve stakeholder groups are discussed. The Toolkit encourages: "cooperative planning, zoning, subdivision regulations, disclosure and open communication;" working with all parties to develop a balanced airport noise compatibility plan; and mitigating existing incompatible uses through sound insulation, easements, and voluntary acquisitions.

United States Department of Transportation, Federal Aviation Administration. "Compatible Land Use Planning Initiative." Federal Register 63, no. 98:27876–27877, May 21,1998. http://www.faa.gov/arp/environmental/5054a/lupi.pdf.

This publication includes a request for comment on 14 CFR Parts 91 and 150 on concepts for maintaining land use compatibility around airports given that noise contours are shrinking. Background information includes a short history of the FAA's land use compatibility efforts.

United States Department of Transportation, Federal Aviation Administration. FAR Part 91, "General Operating and Flight Rules," CFR Title 14, January 1, 2003.

This federal regulation establishes general rules for the operation of aircraft with regard to diverse airport types. This includes various flight conditions, such as Instrument Flight Rules (IFR) or Visual Flight Rules (VFR), maintenance, special flight operations, foreign aircraft operations, and operating noise limits. FAR Part 91 is specifically concerned with planning regulations, further mandating a deadline of December 31, 1999 for the retirement of all Stage 2 aircraft. Between December 31, 1999 and December 31, 2003, waivers were granted (under special circumstances) authorizing Stage 2 aircraft operations, as indicated by FAR Part 91-873. However, effective January 1, 2004, under no circumstances were Stage 2 aircraft permitted to operate. The United States' commercial airline fleet is now completely comprised of Stage 3 aircraft. This transition to a quieter fleet mix results in smaller noise contours, thus reducing the noise impact areas surrounding many airports.

United States Department of Transportation, Federal Aviation Administration. *The Federal Aviation Authorization Act of 1994.*

This act authorizes the Airport Improvement Program (AIP), which provides federal assistance for airport development and noise compatibility programs. Title 49, CFR Part 24 implements the "Uniform Relocation Assistance and Real Property Acquisition for Federal and Federally Assisted Programs."

United States Department of Transportation, Federal Aviation Administration. "Next Generation Air Transportation System Integrated Plan." December 2004.

This report describes the plans for transforming the United States air transportation system over the next 25 years to meet the expected increased demand. The report is in response to Section 709 of the "Vision 100 - Century of Aviation Reauthorization Act" (P.L. 108-176). The plan defines goals in terms of retaining United States leadership in global aviation, expanding capacity, ensuring safety, protecting the environment, national defense, and security of the nation. In terms of environmental protection, the goal is to reduce, by 2025, "…the impact of aviation on community noise and local air quality…in absolute terms, even with anticipated growth in air traffic." Additionally, airports "…will be valued neighbors keeping the public well informed about environment issues." In order to allow sustained aviation growth, the plan would "…mitigate environmental impacts related to the growth of aviation to foster public acceptance of air transportation growth…" and to "[develop] and implement new models, metrics, policy and market-based approaches, operational improvements, and technology innovation."

United States Department of Transportation, Federal Aviation Administration. Order 5100.38C, "Airport Improvement Program Handbook," Chapter 7, Section 706, "Land Acquisition for Noise Compatibility," and Chapter 8, "Noise Compatibility Projects," June 28, 2005.

This Handbook describes the FAA's funding and project criteria that complies with the Aviation Safety and Noise Abatement (ASNA) Act of 1979, Title 49, U.S.C., Sections 47501 – 47510. Specifically, Chapter 7, section 706 (b) details FAA reimbursement funding that enables airport sponsors to acquire land for noise compatibility, including noise buffers in moderate noise exposure areas that are between DNL 65 dB and DNL 55 dB, but only if the acquisition is approved in a Part 150 program or as part of a mitigation measure in a FAA environmental document.

Chapter 8 describes Noise Exposure Maps (NEMs) as the reasonable representation of current and forecasted conditions at the airport. Noise Compatibility Programs (NCPs) are located in areas where aircraft noise exposure is DNL 65 dB or greater. Areas of moderate noise exposure (DNL 64 to 55 dB), referred to as noise buffers, may be eligible for FAA funding within an approved NCP. The noise buffer must be designated by the airport operator as an incompatible area that differs from Federal guidelines. Additionally the NEM and NCP identify the noise buffer areas as incompatible and the proposed mitigation measures are applied for during the Part 150 process, as well as meet Part 150 approval criteria. Finally, noise buffer areas should be developed with non-noise sensitive land uses regardless of whether they are approved for federal funding during the grant application year. Projects that "produce community wide-benefits", including developing noise attenuation standards for local building code, are also eligible for FAA funding.
Chapter 8 also describes a variety of options to convert incompatible land. These include land acquisition through assembly of large incompatible land parcels, particularly those within DNL 75 dB or greater exposure, for redevelopment into compatible land uses. Noise insulation of structures and physical noise barriers are recommended within or below DNL 65 dB. Noise insulation should achieve a minimum noise level reduction of 5 dB with a target noise level of an interior habitable area of DNL 45 dB. Noise barriers are devices designed to shield areas from airport noise and should result in a single event noise reduction of at least 5 dB. Finally, avigation easements tied to the land help notify citizens about aircraft noise and protect the continuation of airport's operations.

Van Praag, B.M.S. and B.E. Baarsma. "Using Happiness Surveys to Value Intangibles: The Case of Airport Noise," 2004.

This article estimates the social costs of noise using a method that measures happiness as a function of income, noise, and other variables. The assumption is that if markets are working properly, noise should not be related to happiness because market prices should have already compensated for increased annoyance. Because of high switching costs and market rationing in housing, however, there will be two effects: reductions in house values and residual shadow costs.

The article contends that the case of airport noise fits into a more general set of problems related to the discrimination between private and public costs (residual costs).

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

A set of models is developed that estimate "well-being" with measures of income, noise, age, family size, and other items. It is found that prices in Amsterdam do not relate significantly to noise levels. This finding, however, is explained by the fact that the housing market in the city is not in equilibrium. Residual costs are found to vary with income and based upon whether the housing stock is insulated.

Von Gierke, H.E., and K. Mck. Eldred. "Effects of Noise on People." *Noise News International*, Volume 1, Number 2, June 1993.

This article presents an extensive survey of the effects of noise on people, including a discussion of descriptors. The noise effects discussed include activity interference (speech, learning, mental activity, rest, and sleep), annoyance, and community reaction. It also addresses physiological/chronic health effects that include hearing loss and non-auditory effects on peripheral blood flow, heart rate, cardiac function, respiration, galvanic skin response, papillary dilatation, and renal and glandular function. In general, hearing loss and the activity interference effects have been the most quantified as has annoyance and to a lesser degree community reaction (and are discussed in other references listed in this bibliography). Non-auditory health effects have proven much more difficult to quantify. One paragraph is worth quoting in full:

"Many studies, primarily European, hypothesize and present evidence that chronic exposure to industrial and environmental noise levels can lead to an increased incidence of cardiovascular disease and hypertension, physician contacts, and drug purchases. Unfortunately, there are just as many studies which contradict these results, and in most cases they did not receive the same press coverage as the less rigorous studies which reported an alarming increase in disease caused by noise. A critical review of 83 studies on the detrimental effects of noise on cardiovascular health, based on the independent review by an epidemiologist, audiologist and cardiologist, found them all to be of relatively poor quality." [Reference - Thompson, "Epidemiology feasibility study: effects of noise on the cardiovascular system," EPA Report 550/9-81-103, September 1981].

Waldner, Leora. "Regional Plans, Local Fates? The Influence of the 1976 and 1985 Atlanta Regional Development Plans on Local Government Policy." Ph.D. dissertation, University of California at Berkeley, 2003.

This research investigates the effectiveness of regional development plans in the Atlanta region. Chapter Seven analyzes land use planning around airports. Rapid growth in both air travel and population in this region resulted in a situation with huge land use conflicts. Around two of the regions airports, over 3,000 homes were bought out and over 10,000 were soundproofed. 1976 and 1985 regional plans urged local governments to restrict residential uses in airport noise zones.

Waldner examines:

- The effect of voluntary regional airport/land use policies on local government comprehensive plans and ordinances.
- T he factors [that] inspire the adoption, and failure to adopt, land use measures near the airport.
- The implementation challenges encountered by local governments that chose to adopt implementation measures.

Waldner found that airport land use ordinances proved difficult to implement due to "property rights concerns, fear of lawsuits, developer power, homeowner opposition, and desire to increase the tax base." Industrial zones established to protect airport uses were often eroded through later rezoning decisions. The problem is "misaligned incentives", in other words, airports want to promote compatible land uses but they have no authority over land use, while local governments that have authority over land use have little incentive to promote compatible uses. This is complicated by the fact that airport impacts almost always affect more than one jurisdiction and collaborative planning efforts may be needed. Perhaps regional agencies could facilitate inter-jurisdictional communication and "help identify areas of mutual gain and joint incentives."
In Atlanta, regional airports are struggling both to provide enough capacity and to deal with incompatible land uses. The region has been attempting to site a new airport for over ten years. The biggest conflict for airports is caused by residential neighbors who are vocal about noise impacts and airport expansion plans. In the long run, airports have a negative impact on nearby residents, just as nearby residential uses have a negative impact on airports. One way to approach the impacts of airports is through land use regulations such as those required by the Federal Aviation Regulation Part 150. Communities that participate in this program must "develop noise exposure maps, use standard noise measurement techniques, and identify land uses that are compatible, possibly compatible with modifications, or incompatible with the airport." In turn the jurisdiction is eligible for "federal funds for noise compatibility planning, home purchase, soundproofing, and other noise measures." However, this program tends to be less beneficial for airports that are already surrounded by developed land.

Operational measures recommended by Part 150 "include changes in runways or flight track use, changes in flight track location, modifications to aircraft performance (e.g., altitude or airspeed), or changes to airport facilities (e.g., berms). Land use measures recommended "include zoning changes, noise overlay zoning, transfer of development rights, subdivision regulation changes, building code changes, noise or avigation easements, disclosure regulations, comprehensive planning, [and] capital improvement programming measures."

There are several reasons why local jurisdictions don't address land use issues near airports "including desire to increase the tax base, loss of development potential, fear of the costs of soundproofing, neighborhood advocacy from residents near the airport, [and] lack or awareness of the economic benefits of airports." Federal Aviation Administration studies of communities attempting to regulate land use near airports through zoning and building code regulations identify the following ten roadblocks to implementation:

1. Noise zones that encompass more than one jurisdiction.
2. Absence of cooperative relationships between the jurisdictions.
3. Lack of local government awareness about the ill effects of airport noise and the benefits of compatible land uses.
4. Frequent changes in local government administration.
5. Small amounts of vacant or developable land around an airport.
6. Low market demand for residential construction near an airport.
7. Low priority of airport noise problems compared to the economic advantages of residential development.
8. Need for additional housing stock.
9. Organized opposition from property owners - claiming that the zoning is a threat to private property rights and/or that monetary compensation is needed to avoid property devaluation.
10. Fear of takings lawsuits.

Appendix D, Practical Recommendations—Airports, includes specific recommendations for local planners and officials, regional and federal government, researchers, the Georgia Legislature, and regional and state agencies in Georgia. One recommendation for researchers is for further research "on smart practices for promoting compatible land uses, particularly for airports that are already surrounded by development."

HAZARDS AND THIRD-PARTY RISK

Airfields Environment Trust Aviation and the Environment Databank. Third Party Safety – Public Safety Zones and Safeguarding of Aerodrome. 2005.

This article talks about the United Kingdom (UK) Civil Aviation Authority and its administration of public safety zones in the UK. One noteworthy point is that the administration of the public safety zone policy was modified a number of times during the 1980s, but the size and shape of the zones remained the same.

Ale, Ben, Edward Smith, and Robin Pitblado. *Safety Around Airports – Developments in the 1990s and Future Directions*. IBC Conference Paper. *http://www.dnv.cz/Binaries/SafetyAroundAirports_tcm50-10759.pdf*.

This paper looked at the experiences of the Netherlands and the UK in third-party risk assessment around airports. The authors state: "In order to investigate third-party risk around airports, objective measures of risk are required." The paper talks about risk limits similar to those discussed in other documents from Europe. The aviation risk limits are offshoots of limits for industrial facilities. The paper also cites findings for proposed runway development at the Schipol Airport, the Netherlands, and Manchester Airport, UK. Planners struggled to keep risk from increasing with forecasted activity increases at each airport. This paper reinforces the European methodology and level of acceptable risk.

Department of Analysis and Research of NATS. "Third Party Risk Contours for 2000 and 2015 Movements for Possible Runway Configurations at Frankfurt Airport. Fraport AG." July 2003.

This report was produced by the Department of Analysis and Research of NATS under contract to Fraport AG, who are the owners and operators of Frankfurt Airport. The work was part of the studies done to support the proposed new runway at Frankfurt Airport. The Department developed 1 in 10,000 and 1 in 100,000 individual risk contours. The contours show that the shape of the risk contour is a triangle pointing away from the runway end, almost an inverse shape to the Runway Protection Zones in FAA circulars. The length is almost directly proportional to the activity level used in the model. The contours are graphic illustrations of risk analysis being conducted in Europe.

Department for Transport. Public Safety Zones: Criteria and Policy, Risk Assessment and Expert Opinions. June 19, 2003.

This document is Annex B to Public Safety Zones: A Consultation Document. The background information includes views of experts in the Netherlands and the UK, as well as the zoning and associated permitted developments adopted by the Dutch and UK governments. There is also an objective method for looking at society's aversion to accidents that harm many people in a single incident. This may prove useful in a project if it is determined that protecting against catastrophic events is an element of the project.

ETSC, Brussels. "Safety In and Around Airports." 1999.

This document is a briefing presented by ETSC, Brussels to aviation decision-makers in Europe. Safety of people on the ground is a minor part of the document. The material contains subjective descriptions of recommended risk responses.

Gerson/Overstreet Architects. "Safety Analysis." In *San Francisco General Hospital Air Medical Access Needs and Feasibility Study*. 2003.

This document is a portion of a study conducted by Gerson/Overstreet Architects for the San Francisco General Hospital (SFGH). The study considered the issue of "safety" to be the most difficult to address with respect to airport and/or heliport/helipad land use compatibility. The study uses the California

Department of Transportation, Airport Land Use Planning Handbook as its guide for addressing issues. The study provides an analysis of the accident database for Hospital Emergency Service Providers and the accident potential for the San Francisco General Hospital. The study concludes that the fatal accident potential for the three service providers at SFGH is one per every 52.7 to 68.1 years. A relevant conclusion applicable to the study was: "There is little evidence to support any danger to surrounding neighborhoods, even though some of these neighborhoods could be subject to helicopter overflight." The study reaches this conclusion primarily by comparing the risk to other deaths and injuries in the community.

Gesellschaft fur Luftverkehrsforschung. Flight Safety and Risk Analysis. Internet Article. 2004

This article is a two-page notice of a new risk model to quantify the endangerment of residents from secondary events that can occur from aircraft accidents, such as aircraft impact with chemical plants, petroleum facilities, etc. The article gives little information about the program. The article states that government authorities are requesting the calculation methodology and it may be something to consider if regulatory agencies start to adopt the methodology.

HNTB Corporation. HNTB Memorandum to MSP Joint Airport Zoning Board. April 18, 2002.

This document is a memorandum from the HNTB Corporation to the MSP Joint Airport Zoning Board. It seeks to answer the question: "Are there empirical data that support the imposition of the Minnesota Department of Transportation (Mn/DOT) State Safety Zone A outside the Federal Runway Protection Zone (RPZ), or State Safety Zone B on the south end of new Runway 17-35 at Minneapolis-St. Paul International Airport (MSP)?" The document concludes there is no empirical data to support the State Safety Zones. HNTB's methodology was to use accident data to calculate the accident probabilities in the analysis areas and compare the accident probabilities to the risk standards. A United States standard for third-party risk in the vicinity of airports does not exist; therefore HNTB compared the accident probability to the FAA Flight Standards Division collision-risk analysis for proposed obstacles in approach clear zones. The memorandum also compared the results to the United Kingdom definition of individual risk. Both standards indicated no empirical data to support the current configuration of the State Safety Zones.

The HNTB analysis is one of the first efforts in the United States to objectively look at third-party risk analysis. Much of the work is logical and can be substantiated; however, several modifications may be necessary to make the methodology useable at a wide range of airports.

National Air Traffic Services (NATS), Ltd. "Public Safety Zones: a Consultation Document." December 4, 1997.

The document determines acceptable safety zones around airports and was developed by a consultant team that consisted of an in-house NATS team, Professor Andrew Evans of the Centre for Transport Studies, University and Imperial College, London, and Professor Michael Jones-Lee and Professor Graham Loomes of Newcastle University. The consultants determined that risk contour modeling was feasible and they proposed setting limits on the degree of risk that is tolerable for people on the ground near airports. The Europeans express risk in exposure per year if a person was in a location 24 hours per day for 365 days a year. They also discuss tolerable risk of death and discuss a range of limits that need to be reviewed by government executives in Great Britain. The tolerable risk of death is open for debate.

National Transportation Safety Board. "Accident Briefs for Aviation Accidents Involving Fatalities to Persons on the Ground." 1984 through 2003.

Briefs from the National Transportation Safety Board (NTSB) for aircraft accidents that occurred in the United States are available. Fatal ground accidents involving seaplane operations, balloon operations, en route operations, on-airport operations such as loading or taxiing, and helicopters dropping lifted objects in the vicinity of their work site are not considered relevant. Other documents, such as the California Airport Land Use Planning Handbook, contain similar data as the NTSB briefs, but cover different time

periods. The most recent twenty-year (20) year period includes reliable information on aircraft accident probability, which is typically included as a component of a third-party risk analysis.

Scottish Executive, Development Department, Planning Division. "Control of Development in Airport Public Safety Zone." October 15, 2002.

This document is a circular from the Scottish Executive, Development Department, Planning Division. It is the policy document used in Scotland for protecting airports and people and property on the ground in the vicinity of an airport. The policy for implementing public safety zones is based on modeling work that determines the size of public safety zones. The accepted level of risk is the one in 100,000 individual risk contour. This means that a person who stays in the same location for 24 hours per day, 365 days a year would be struck and killed by an aircraft once in 100,000 years.

Smith, Edward. "Third Party Risk." UK Sustainable Cities and Aviation Network. July 2000.

This article by Mr. Edward Smith is similar to the two papers referenced by Mr. Smith. The writing is subjective and does not include the objective standards included in his other papers on this subject.

Smith, Edward. "Trends for the New Millennium." *Airport*, 2000.

This paper gives a subjective review of the risk assessment approach and results for runway development proposals at the Schipol Airport, The Netherlands, and Manchester Airport, United Kingdom. The risk standards became so difficult at Schipol that a different policy was adopted for Schipol that attempted to reconcile the economic benefits of airport expansion and the safety concerns of people living in the vicinity of the airport. The individual risk accepted was twice as high as the standard level accepted by Dutch authorities. This paper shows that flexibility in acceptable risk may be required for decision-makers.

Thompson, Kimberly M., F. Frank Rabouw, and Roger M. Cooke. "The Risk of Groundling Fatalities from Unintentional Airplane Crashes." 2001.

This document is a study published after the crashes of four hijacked commercial planes on September 11, 2001. The media images heightened many citizens' awareness that they could be a fatality from an aircraft coming out of the sky. This study updated information in a 1992 study by B. L. Golstein. The results compared the expected number of groundling fatalities to the United States resident population; and developed a groundling risk model. While the formulas in the study are probably an objective tool, they are very complex and would be hard to communicate to residents and elected officials. It appears that considerable computer modeling would be necessary for an individual airport.

United Kingdom National Air Traffic Services. "Farnborough Airport: ERM 'Independent' Report on TAG Risk Contour." December 2002. http://home.clara.net/heureka/surrey-hants/tag1617i.htm.

This internet article is statements made by numerous people about "Risk Contours." The article shows the range of official comments, explanations, etc., that have been made about the subject of Risk Analysis.

United States Department of Transportation, Federal Aviation Administration. Advisory Circular 150/5200-33, "Hazardous Wildlife Attractants on or Near Airports," August 28. 2007.

This AC provides guidance regarding the types of land uses considered to be incompatible near airports due to their nature as wildlife attractants. These uses include, but are not limited to, wastewater treatment facilities, wetlands, dredge spoil containment areas, and solid waste landfills. Typically, these uses should be located at least 5,000 feet away from an airport runway end, if the airport serves piston-type aircraft, and at least 10,000 feet away from an airport runway end, if the airport serves turbojet aircraft.

United States Department of Transportation, Federal Aviation Administration. FAR Part 139.337, "Wildlife Hazard Management Plan," June 9, 2004.

A wildlife hazard assessment is conducted by a wildlife damage management biologist to provide the scientific basis for the development, implementation, and refinement of a Wildlife Hazard Management Plan, if needed. Part of the Wildlife Hazard Management Plan can be prepared by the biologist who conducts the wildlife hazard assessment. However, some parts can be prepared only by airport staff. For example, airport management assigns airport personnel responsibilities, commits airport funds, and purchases equipment and supplies. Airport management should request that the wildlife biologist review the finished plan prior to submitting it to the FAA for review and approval.

United States Department of Transportation, Federal Aviation Administration. Investment Analysis and Operations Research. "The Art of Aviation Safety Benefits Analysis." June 15, 2001.

This report was written to give the less experienced analyst knowledge of, and a feeling for, conducting a real-world safety benefit analysis. In addition to describing a step-by-step approach for conducting a safety benefit analysis, it identifies a number of cautions learned through experience. The report also includes a list of "Rules of Conduct" that should be observed in undertaking a predictive safety benefit analysis, as well as a descriptive "Benefits Universe" to assist the analyst in identifying the potential safety benefit categories of a proposed aviation project.

An extensive table of data sources and an example illustrating the potential danger in estimating benefits using aggregated data from dissimilar groups (Simpson's Paradox) is also included.

Wiklund, Eskil. "Flying with Unmanned Aircraft (UAVs) in Airspace Involving Civil Aviation Activity – Air Safety and the Approvals Procedure." Swedish Aviation Safety Authority. March 25, 2003.

What does unmanned aircraft flying in airspace involving civil aviation have to do with third-party risk analysis? It is a different aviation activity, but the paper used risk standards and probability analysis which may be useful in an effort to quantify third-party risk.

LAND USE REGULATIONS AND TAKINGS

Abolt v. City of Fort Madison, 108 N.W.2d 263, 252 Iowa 626, (Iowa 1961).

The court found that "power of eminent domain may be exercised only where public use is involved."

Ackerman v. Port of Seattle, 55 Wash. 2d 400 (1960).

The court found a taking based on continuing and frequent low overflights.

Aeronautics Comm'n v. State ex. rel. Emmis Broad. Corp., 440 N.E.2d 700, (Ind. App. 1982).

The court found that a state high structures act, which regulates structural height near airports for the purpose of protecting the safety and welfare of persons and property in the air and on the ground by ensuring the navigable air space overlying the state is maintained in an unobstructed condition, is valid "because Congress has evidenced a purpose to leave legal enforcement of regulations pertaining to high structures and air safety to state and local governments."

Air Host Cedar Rapids, Inc. v. Cedar Rapids Airport Commission, 464 N.W.2d 450, (Iowa 1990).

The court found that the lease agreement for the old airport location, which existed between the airport commission and concessionaire, did not give contractual right of first refusal for concession lease for the new airport.

Airport Commission for City of Cedar Rapids v. Schade, 257 N.W.2d 500, (Iowa 1977).

The court found that the "city airport commission was authorized under § 330.21, without violating § 364.1, to establish airport safety force whose members were not "policemen" or "firemen" under civil service statutes (§ 400.1 et seq.) or statutes relating to retirement systems for policemen and firemen (§ 411.1 et seq.)"

Austin v. Travis County Landfill Co., 73 S.W.3d 234 (Tex. 2002).

The Texas Supreme Court found evidence insufficient to support a compensable taking where flights over a landfill did not reduce the property's market value. The plaintiff did not provide evidence sufficient to support the claim that flights from the city airport over the landfill directly impacted the property's surface and caused the value to decline. Even though the landfill owner was exposed to an influx of risks and costs, the evidence was not sufficient to show that civilian overflight effects caused or contributed to the land's decline in market value.

Baker v. Burbank-Glendale-Pasadena Airport Authority, 220 Cal.App.3d 1602 (1990).

The court stated: "Avigation easements are required only when the noise, vibration, fumes, fuel particles and inconvenience caused by low-flying aircraft interfere with the use and enjoyment of the underlying property to the extent it amounts to a taking."

Bormann v. Board of Supervisors in and for Kossuth County, 584 N.W.2d 309, (Iowa 1998).

The court found that easements are subject to just compensation by both the state and federal constitutions.

Brackett v. City of Des Moines, 67 N.W.2d 542, 246 Iowa 249, (Iowa 1954).

The court held that a zoning ordinance be made in agreement with a comprehensive plan.

Brown v. U.S., 73 F.3d 1100, 1104 (Fed. Cir. 1996).

Proof of a physical taking requires evidence of low and frequent overflights causing a direct and immediate interference with the enjoyment and use of the land.

Burbank-Glendale-Pasadena Airport Authority v. City of Los Angeles, 979 F.2d 1338 (9th Cir. 1992).

Ordinance regulating taxiways and runways is preempted by FAA regulations because it interferes with movement and operation of aircraft.

California Department of Transportation. *The California Aviation System Plan Policy Element*. January 2001. http://www.dot.ca.gov/hq/planning/aeronaut/casp2006.html.

The Policy Element guides the development of the California Aviation System Plan (CASP) which helps direct improvement of the California aviation system. The Policy Element also directs the California Department of Transportation's (Department) Division of Aeronautics and serves as a resource guide for those outside of the Department. For example, the Policy Element discusses the Department's funding programs and the type of technical assistance the Department can provide to airports and Regional Transportation Planning Agencies (RTPAs). In sum, the Policy Element provides a written directive for planning, programming, and coordinating aviation activities.

Cheyenne Airport Board v. Rogers, 707 P.2d 717 (Wy. 1985), appeal dismissed, 476 U.S. 1110, 106 S. Ct. 1961, 90 L.Ed.2d 647 (1986).

The Wyoming Supreme Court applied federal and state law definitions of airspace property rights to reject a takings claim.

City of Burbank v. Burbank-Glendale-Pasadena Airport Authority, 72 Cal.App.4th 366, 85 Cal.Rptr.2d 28 (2d Dist.), review denied (1999).

A city's statutory authority to review an airport authority's development plans for a public airport is not preempted. FAA's sole authority to regulate the use of airspace to ensure its efficient use and the safety of aircraft includes all aspects of aviation navigation, such as air control towers, radio navigation systems, and other navigation aids, but does not extend to regulation of ground facilities not affecting inflight safety.

City of Burbank v. Lockheed Air Terminal, Inc., 411 U.S. 624, 36 L.Ed.2d 547, 93 S.Ct. 1854 (1973).

City's ordinance imposing curfew on takeoffs to control noise is preempted.

City of Cleveland v. City of Brook Park, 893 F.Supp. 742 (N.D. Ohio 1995).

City zoning ordinance requiring conditional use permit for construction of new runways is not preempted.

City of Iowa v. Hagen Electronics, Inc., 545 N.W.2d 530, (Iowa 1996).

The court found that the city "did not violate landowner's substantive due process rights by pursuing injunction for removal of owner's structures near airport, by denying building permit" based on public safety issues for "underlying airport zoning based on federal runway regulations."

City of New Hampton v. Blayne-Martin Corp., 594 N.W.2d 40, (Iowa 1999).

The court found that zoning is an exercise of police powers delegated to municipalities by the state, therefore, "ordinances are to be strictly construed in favor of the free use of property."

Comes v. City of Atlantic, 601 N.W.2d 93, (Iowa 1999).

The court found that the owner of farm land adjacent to the airport was not entitled to a permanent injunction barring the city from condemning his land for expansion of the adjacent airport until uncertainties about project were resolved.

Condor Corp. v. City of St. Paul, 912 F.2d 215 (8th Cir. 1990).

City requirement of a permit to use property for a heliport is not preempted.

County of Clark v. Hsu, Docket No. 38853 (Nev. 2004).

The Supreme Court of Nevada reversed an inverse condemnation claim against Clark County. The claim was based on a county ordinance that limited the height of buildings surrounding the airport.

Dolan v. City of Tigard, 512 U.S. 374 (1994).

The United States Supreme Court found that the government must demonstrate that the condition sought for granting a development permit meets the essential nexus test and also is roughly proportional to the problem created by the development.

Dolezal v. City of Cedar Rapids, 209 N.W. 2d 84, (Iowa 1973).

The court found that a navigation easement as one that permits free flights over land including those so low and so frequent as to amount to a taking of property.

Eck v. Bismarck, 302 NW2d 739 (N.D. 1981).

The court found no taking because it differentiated the facts from those in the McShane case discussed below. Unlike in McShane, the court said the challenged zoning ordinance did not place severe structural limitations or other safety regulations on the property in an attempt to accommodate direct physical intrusions by aircraft flights over the property. Rather, the ordinance was simply an attempt to prevent residential development in areas where it was considered to be undesirable due to airport-related noise.

Emerald Development Co. v. McNeill, 83 Ark. App. 193, 120 S.W.3d 605 (2003).

Federal law did not preempt issuance of an injunction to prevent the building of an airport that would allegedly create a safety hazard due to conflict with operations from an existing airport.

Euclid v. Ambler Co., 272 U.S. 365 (1926).

The United States Supreme Court found that zoning regulations were valid although they affected a 75 percent diminution in value of property.

Faux-Burhans v. County Commissioners, 674 F.Supp. 1172 (D. Md. 1987), aff'd, 859 F.2d 149 (4th Cir. 1988), cert. denied, 488 U.S. 1042 (1989).

A county zoning ordinance regulating the development and use of a private airport was not preempted.

Fitzgerald v. City of Iowa City, 492 N.W.2d 659 (Iowa 1992).

The court found no compensable physical invasion was present where the evidence presented by plaintiffs was devoid of any evidence showing either the frequency or approximate altitudes of planes flying over the plaintiffs' lands. Moreover, the height restriction at issue left the landowner with economically viable use of the property.

Garden State Farms, Inc. v. Bay, 77 N.J. 439, 390 A.2d 1177 (1978).

Local ordinance prohibiting a heliport within municipal boundaries was not preempted.

Gilbert v. City of Cambridge, 932 F.2d 51 (1st Cir. 1991).

Where a landowner must establish that the potential denial of a development permit is more than a mere possibility, rather the prospective of refusal must be certain.

Gorieb v. Fox, 274 U.S. 603 (1927).

The United States Supreme Court held that government imposition of setback requirements for aesthetic and other purposes is an appropriate, noncompensable exercise of the police power.

Greenawalt v. Zoning Board of Adjustment of City of Davenport, 345 N.W.2d 537, (Iowa 1984).

States that zoning ordinances are "enacted for purpose of promoting healthy, safety, morals, or general welfare of the community."

Griggs v. Allegheny County, 369 U.S. 84 (1962).

The United States Supreme Court examined whether a county-operated airport took an easement over a house through noise and air pollution from frequent and low overflights. Based on evidence that the homeowners abandoned their home because they became nervous and distraught from extreme noise and pollution, the court held that a compensable taking was present. This case affirmed the approach in Causby that flights within the navigable airspace defined by the federal government could still give rise to a taking if they eliminate uses to which the land could otherwise be put and further held that although airplanes may fly below 500 feet when necessary for takeoff and landing, this right does not divest the property owner of his protected property right to his usable airspace. Rather, a landowner may still make a claim for compensation for the government's use of that airspace.

Gustafson v. City of Lake Angelus, 76 F.3d 778 (6th Cir.), cert. denied, 519 U.S. 823 (1996).

City ordinances prohibiting the operation of seaplanes on the surface of a lake are not preempted.

Hadacheck v. Los Angeles, 239 U.S. 394 (1915).

The United States Supreme Court held that a local land use ordinance was valid even though it prohibited the highest and best use of the property.

Hageman v. Bd. of Trustees of Wayne Township, 251 N.E.2d 507 (1969).

Finding a taking where zoning established a corridor for use in the takeoff and landing of military aircraft.

Harrell's Candy Kitchen v. Sarasota-Manatee Air. A., 111 So.2d 439 (Fla. 1959).

The Florida Supreme Court upheld the validity of airport height restrictions without payment of just compensation. The court determined that the police power authority was necessary where the restrictions promoted the welfare of the state.

Harris v. City of Witchita, 862 F. Supp. 287 (D. Kan. 1994).

The court found that restrictions imposed on private land situated around a nearby Air Force base did not constitute a physical invasion of the land. The purpose of the airport overlay district was to restrict the use of the land so as to affect as few people as possible in the event of a crash.

Highline Sch. Dist. No. 401, King Cty. v. Port of Seattle, 548 P.2d 1085 (Wash. 1976).

Frequent and low overflights over property amounted to a taking.

Hoagland v. Town of Clear Lake, 415 F.3d 693 (7th Cir. 2005), cert. denied, 547 U.S. 1004 (2006).

Local zoning ordinance preventing heliport use was not preempted. "The siting of an airfield—so long as it does not interfere with existing [air] traffic patterns, etc.—remains an issue for local control."

Hoover v. Iowa State Highway Commission, 230 N.W. 561, 210 Iowa 1, (Iowa 1930).

Addressed the right of eminent domain and that all of the private party is subject to eminent domain unless specifically exempted by law.

In re Commercial Airfield, 170 Vt. 595; 752 A.2d 13 (2000).

State law requiring environmental review of operations by a small, rural airport was not preempted.

In re Letourneau, 168 Vt. 539 (1998).

The court found it acceptable that building setback requirements from a highway protect sight lines for automobiles and ensure emergency access to buildings for fire protection purposes without blocking the highway.

Incorporated City of Denison v. Clabaugh, 306 N.W.2d 748, (Iowa 1981).

Determined that setback provisions are a valid exercise of police power of zoning ordinances.

Indiana Toll Rd. Comm'n v. Jankovich, 244 Ind. 574 (1963).

A taking was present when a toll road had been built in a manner as to cross the inner area approach zone of a runway.

Iowa Coal Mining Co., Inc. v. Monroe County, 257 F.3d 846, C.A.8 (Iowa) 2001.

The court found that the enactment of a zoning ordinance precluded the mining company from operating a landfill on property it was strip mining. It was "not an unconstitutional taking, although it deprived company of the most beneficial use of the property."

Iowa Comprehensive Petroleum Underground Storage Tank Fund Board v. Shell Oil Co., 606 N.W.2d 370, (Iowa 2000).

The court held that the Comprehensive Petroleum Underground Storage Tank Fund Act applied retroactively to underground storage tanks in operation prior to the requirement that the owner or operator maintain responsibly.

Jackson Mun. Airport Auth. v. Evans, 191 So.2d 126 (Miss. 1966).

The court found a taking where the city airport authority demanded the topping or removal of trees that grew within an airport approach zone because they posed a serious obstruction to landing and departing aircraft.

Jersild v. Sarcone, 149 N.W.2d 179, 260 Iowa 288, (Iowa 1967).

The court found that a zoning ordinance establishing a building or setback line is presumed valid. Further, it is valid that the burden to prove the line is unreasonable is on the one asserting.

Kaiser Aetna v. United States, 444 U.S. 164 (1979).

The United States Supreme Court found that compensation was necessary if the government attempts to require public access to private property. The court concluded that requiring public access to an owner's pond resulted in an actual physical invasion of a privately owned marina. The court further concluded that "even if the Government physically invades only an easement in property, it must nonetheless pay just compensation." This case provided some of the reasoning that enabled the Nevada court in the McCarran Int'l Airport v. Sisolak case to hold that access for airlines to fly over property also gives rise to a physical invasion and the taking of an easement.

Kentucky Airport Zoning Comm'n v. Kentucky Power Co., 651 S.W.2d 121 (Ky. 1983).

> The court finds a taking where a power company had been ordered to mark and relocate electric power lines, which pre-existed the nearby airports, for purposes of aviation safety.

Keokuk Junction Ry. County v. IES Industries, Inc., 618 N.W.2d 352, (Iowa 2000).

> Found that if an easement is taken through eminent domain, just compensation is required.

Keystone Bituminous Coal Ass'n v. DeBenedictis, 480 U.S. 470 (1987).

> The United States Supreme Court rejected the notion that a public nuisance must be an inherently noxious or unreasonable land use and found that what would otherwise have been a lawful coal mine posed a threat to the common welfare akin to a public nuisance because of the subsidence risks it created. Therefore, the court upheld a Pennsylvania law that limited coal mining that caused surface subsidence.

Kimberlin v. City of Topeka, 710 P.2d 682 (1985).

> The court held that a zoning ordinance that establishes height and use restrictions to promote airport safety is a proper exercise of police power and does not result in an unconstitutional taking without just compensation.

Kinzli v. City of Santa Cruz, 818 F.2d 1449 (9th Cir. 1987).

> Even if a landowner has submitted development plans and been rejected, an applied regulatory takings case might still not be appropriate: a landowner must submit a meaningful application for development.

Kissinger v. City of Los Angeles, 161 Cal. App. 2d 454 (1958).

> The court invalidated spot zoning where evidence suggested that the legislative intent was to depress the property's value in order to facilitate its acquisition by the government at a lower price.

Kupster Realty Corp. v. State of New York, 404 N.Y.S.2d 225 (N.Y. Ct. Cl. 1978).

> The state is not preempted from imposing avigation easements on land adjacent to an airport. Property owner did not establish damages for taking due to imposition of avigation easement.

La Salle Nat'l Bank v. County of Cook, 34 Ill. App. 3d 264 (1975).

> The court determined that the enactment of an airport zoning ordinance that imposed height restrictions on buildings near certain airports, including a naval air station, for the purpose of preventing aviation hazards did not unconstitutionally deprive a landowner of property without just compensation. The need to protect the public from air hazards, the court reasoned, is a proper exercise of the police power.

Lied v. County of Clark, 94 Nev. 275, 279, 579 P.2d 171, 173-174 (1978).

> In order to prove a trespass, such as a taking, "a property right must be shown to have been invaded."

Lingle v. Chevron USA, Inc., 544 U.S. 528 (2005).

The United States Supreme Court held that in determining whether a taking has occurred, the test of whether an ordinance substantially advances a legitimate government interest is no longer relevant.

Loretto v. Teleprompter Manhattan CATV Corp., 458 U.S. 419 (1982).

The United States Supreme Court found that a taking was present where the government authorized a cable company to install cable boxes on an apartment building without the building owner's permission. This case is important because it establishes that even a relatively small or insignificant physical invasion of an owner's land can constitute a taking of property for which compensation must be paid. The court in the McCarran Int'' Airport v. Sisolak case used the reasoning in the Loretto case to find that zoning ordinances restricting building height allowed for airline overflights and thus effected a physical invasion.

Lucas v. South Carolina Coastal Council, 505 U.S. 1003 (1992).

The United States Supreme Court found that even if a regulation removes all economically viable uses from a property, a compensable taking may not occur if "…the nature of the owner's estate shows that the proscribed use of interests were not part of his title to begin with." For example, if the owner's proposed use would have been prohibited because it constituted a nuisance, then such owner could not claim that a local ordinance preventing such use effects a taking.

McCarran Int'l Airport v. Sisolak, 122 Nev. Adv. Op. No. 58 (2006).

Found that height restrictions enacted by the county within the approach zone, because they allowed airline overflights, constituted a physical invasion of airspace above private land amounting to a per se taking under the U.S. and Nevada Constitutions. The court awarded $16.5 million to Sisolak, who claimed the height restriction ordinances limited the development of his property and impeded his ability to sell the land. The following three summary points should be considered in summarizing the Nevada court's ruling:

1. Flights within the "navigable airspace" of 500 feet or above in non-congested areas, or 1,000 feet in congested areas, will not give rise to a physical invasion taking;
2. Flights landing and taking off at altitudes below the 500-foot level may give rise to a physical invasion taking; and
3. Requiring an avigation easement as a condition of development approval may not survive the requirement established in the Nollan v. California Coastal Comm'n case, that development conditions have a "rational nexus" to the effect of the development the condition is trying to mitigate.

McShane v. City of Faribault, 292 N.W.2d 253 (Minn. 1980).

The court found that an airport safety zoning ordinance that limited development and caused a substantial and measurable decline in market value was a taking. This case relied substantially on the fact that the ordinance benefited a government enterprise, a test similar to the third balancing factor outlined in the Penn Central Transportation Co. v. New York City case, to conclude that the landowner was being forced to bear a burden that benefited the airport. Moreover, the public was receiving the benefit of the airport while only a few owners were forced to shoulder the burden through restrictions on their land. Under more current case law, the type of entity benefited is less likely to be a decisive factor in determining whether a taking has occurred.

Milligan v. City of Red Oak, Iowa, 230 F.3d 355, C.A.8 (Iowa) 2000.

The court found that the promoting of airport safety was for public purpose. Further, the court supported the city's proposed condemnation of agricultural land between the airport's runways as the taking was "necessary to, and rationally related to," accomplishing the public purpose of promoting airport safety.

Montgomery v. Bremer County Board of Supervisors, 299 N.W.2d 687, (Iowa 1980).

> The court found that if the board of supervisors gave full consideration to public safety, welfare, changing conditions, and similarity of other land in same area, then zoning was in accordance with comprehensive plan.

Mook v. Sioux City, 60 N.W.2d 92, 244 Iowa 1124 (Iowa 1953).

> Addressed the condemnation of 1,600 acres of land by the municipality to enlarge the airport, which would be used jointly by the city and the United States Air Force. The court found that the municipality did not "violate any constitutional principle or statutory provision pertaining to exercise by cities of power of eminent domain."

Neuzil v. City of Iowa City, 451 N.W.2d 159, (Iowa 1990).

> The court determined that a "zoning ordinance is valid if it has any real, substantial relation to public health, comfort, safety, and welfare, including maintenance of property values." The general purpose of a zoning ordinance is the main consideration when applying this assessment, not the hardship of an individual case.

Nollan v. California Coastal Comm'n, 483 U.S. 825 (1987).

> The United States Supreme Court held that the commission had to pay landowners just compensation for the grant of a public access easement across beachfront property. According to the court, the required easement was not valid because it did not further public purposes related to the permit requirement.

Northwest Props. v. Outagamie County, 223 Wis. 2d 483 (Wis. App. 1998).

> The court determined that a municipality had authority to enact a zoning ordinance that protects the aerial approaches to an airport by regulating, restricting, and determining the use, location, height, number of stories, and size of buildings, structures, and objects of natural growth in the airport's vicinity.

Palazzolo v. Rhode Island, 121 S. Ct. 2448 (2001).

> The United States Supreme Court found that all economically beneficial use was not deprived because a portion of the plaintiff's property could still be developed.

Patzau v. New Jersey Dep't of Transp., 271 N.J. Super. 294 (App. Div. 1994).

> Addresses the constitutionality of an air safety and zoning act that, among other things, required the adoption of building height restrictions within airport safety zones. The court found that "the state may impose very substantial zoning and other restrictions on the use of property in order to advance legitimate public interests without being obligated to provide compensation."

Peacock v. County of Sacramento, 271 Cal. App. 2d 845 (1969).

> Finding a taking where the subject land "had no practical value or beneficial use" after its development had been frozen by government regulation.

Penn Central Transportation Co. v. New York City, 438 U.S. 104 (1978).

> The landowners argued that regulations prohibiting construction of a high-rise office building deprived them of "air rights." The United States Supreme Court concluded that the plaintiffs could

not establish a taking simply by showing they were denied the ability to use a property interest they previously believed was available for development. The test to determine whether a regulation goes too far and thus effects a taking is as follows: (1) the economic impact of the regulation on the owner; (2) the extent to which the regulation interferes with distinct legitimate, investment-backed expectations; and (3) the character of the government action—does it result in the equivalent of a physical invasion of the property or is it more a "public program adjusting the benefits and burdens of economic life to promote the common good." Where a landowner is restrained in his or her use of one spatial area of the property (e.g., airspace, side yards, or subsoil) as merely one species of regulation and no actual property has been appropriated by the government, a taking does not necessarily result.

Pennsylvania Coal v. Mahon, 260 U.S. 415 (1922).

The United States Supreme Court determined that state regulation of property may also require just compensation, recognizing regulations that go too far will be recognized as a taking.

People v. City of Chicago, 202 Ill.2d 36, 779 N.E.2d 875 (2002).

Approval of Illinois Department of Transportation was not required, as a matter of state law, for proposed airport terminal and ground transportation improvements.

Pruneyard Shopping Center v. Robins, 447 U.S. 74 (1980).

An ordinance requiring a shopping center to permit distribution of literature on its property during business hours was not a taking.

Richmond, Fredericksburg & Potomac R.R.Co. v. Metropolitan Washington Airports Auth., 251 Va. 201 (1996).

Twenty-three thousand (23,000) annual overflights were insufficient to establish a taking because there was no evidence of the types of airplanes using the runway, the height at which they passed over the property, or the frequency of landings.

Roark v. City of Caldwell, 87 Idaho 557 (1964).

A taking was present where zoning designed to protect the runway approach limited portions of the subject land to agricultural uses.

The Rocky Mountain Land Use Institute. "The Constitutional Protection of Individual Property Rights." 1996.

Satellite Broad. & Communications Ass'n v. F.C.C., 275 F.3d 337 (4th Cir. 2001).

A taking does not occur under a Loretto analysis unless the government has required acquiescence in the permanent physical occupation of property.

Schmidt v. City of Kenosha, 214 Wis. 2d 527 (Wis. App. 1997).

The court concluded that an airport zoning ordinance that prohibits construction along aerial approaches to an airport "is not arbitrary capricious, but is reasonably related to a legitimate public purpose."

Sneed v. County of Riverside, 218 Cal. App.2d 205 (4th Dist. 1963).

Holds, without resolving the issue of liability, that the complaint stated a claim for the taking of an avigation easement within the glide angle of approach zones and where frequent low overflights had been alleged. The court in this case distinguished between proper height limitation ordinances authorized under the police power and height limitations that take an avigation easement without compensation.

Tahoe-Sierra Preservation Council, Inc. v. Tahoe Regional Planning Agency, 535 U.S. 302 (2002).

The United States Supreme Court determined that the parcel as a whole test must be used in determining whether a taking is present. The case involved a nearly three-year development moratorium and a claim that the temporary regulations involved a taking of the entire value of the property for a temporary period. The court concluded that a temporary development moratorium cannot be a taking of property absent extraordinary delay.

United Power Ass'n v. Heley, 277 N.W.2d 262, 267 (N.D. 1979),

The court found that flights do not infringe any property rights as long as they proceed in the manner prescribed by law.

United States v. 48.10 Acres of Land, 144 F. Supp. 258 (S.D.N.Y. 1956).

Finds a direct condemnation of an avigation easement where the glide angle plane passed over the subject land.

United States v. Brondum, 272 F.2d 642 (5th Cir. 1959).

The court found that an avigation easement provides not just for flights in the air as a public highway, but it also provides for flights that may be so low and so frequent as to amount to a taking of property.

United States v. Causby, 328 U.S. 256 (1946).

The United States Supreme Court found that where a preexisting chicken farming business was destroyed by airplanes making frequent and low overflights of property, the taking of an easement is present.[1] This is so even where the flights were within the navigable airspace prescribed by federal statutes and regulations. The fact that enjoyment and use of the land are not completely destroyed does not eliminate the possibility of a taking. The court noted: "The path of glide for airplanes might reduce a valuable factory site to grazing land, an orchard to a vegetable patch, a residential section to a wheat field. Some value would remain. But the use of the airspace immediately above the land would limit the utility of the land and cause a diminution in its value." Compensation for the taking was warranted even though the airplanes were flying within the minimum safe altitudes of flight that had been prescribed by federal law.

United States v. Dico, Inc., 266 F.3d 864, C.A.8 (Iowa) 2001.

The court held that the retroactive application of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 to landowner's activities did not violate Fifth Amendment's due process or takings clauses.

United States v. Pewee Coal Co., 341 U.S. 114 (1951).

Just compensation was also found where the government seized and operated a coal mine.

US Code. Title 42, The Public Health and Welfare. Chapter 61, Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970.

This act is the most comprehensive and equitable legislation in United States history on land acquisition and the associated relocation of displaced persons. Under this act, persons will not suffer disproportionate injuries as a result of programs designed for the benefit of the public as a whole.
The Uniform Act provides minimum real property acquisition policies and requires uniform and equitable treatment of persons displaced as a result of a federally-assisted program or project. Property can be acquired through several methods, such as the purchase of property interests (fee) or through eminent domain (condemnation). It can also be acquired through easements or by donation or exchange.

United States Department of Transportation, Federal Aviation Administration. Advisory Circular 150/5100-17,"Land Acquisition and Relocation Assistance for Airport Improvement Program Assisted Projects," November 7, 2005.

This AC provides guidance to sponsors of an Airport Improvement Program (AIP) to develop land acquisition and relocation assistance procedures in conformance to the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (Pl 91-646, as amended).

Vacation Village, Inc. v. Clark County, Nevada, Adversary No.98-2313-RCJ, (2004).

In the 1960s and 1970s, the plaintiffs entered into various agreements with the county in order to construct and maintain a 501-room hotel and an 85,000 square foot casino. The county conditioned approval of the hotel on various regulations imposed by the airport because of the airport's close proximity to the Vacation Village property. In 1990, the county adopted an ordinance that further restricted a 1.25 acre portion of the Vacation Villages property. The restrictions limited the 1.25 acre parcel to uses as a parking lot, water area, or landscaping. Vacation Village claimed that the county's regulations resulted in the unconstitutional taking of its 1.25 acre parcel by severely limiting its uses. The court held no taking had occurred because not all reasonable use of the entire parcel was denied.

Village of Willoughby Hills v. Corrigan, 278 N.E.2d 658 (Ohio 1972).

The court found that unlike a surface invasion of land, an invasion of airspace above the land does not constitute a per se taking. Reasoning that zoning regulations always involve some restriction on the uses to which land may be put, the court balanced "the loss of use against the benefits to society thus obtained."

Webb v. Giltner App., 468 N.W.2d 838, (Iowa 1991).

Found that the county's zoning ordinance must promote the goals of the enacted county comprehensive plan.

Welch v. Swasey, 214 U.S. 91 (1909).

The United States Supreme Court has long recognized that police power enactments limiting vertical, lateral, and subjacent property development do not affect a compensable taking.

Williams Pipe Line Co. v. Bayer Corp., 964 F.Supp.1300, (S.D.Iowa 1997).

Where the court found that any pollutants that enter surface waters "either directly or through groundwater are subject to regulation by national pollutant discharge elimination system (NPDES) permit, as Clean Water Act's (CWA) goal is to protect quality of surface waters."

Yara Eng'g Corp. v. City of Newark, 40 A.2d 559 (N.J. 1945).

Finding a taking where zoning which the state legislature had not authorized, restricted development of salt marsh and meadow land and left it with only nominal value.

Yee v. Escondido, 503 U.S. 519 (1992).

The court found that a governmentally imposed restriction on the use of property, constitutes a non-compensable regulation of land use instead of a per se physical taking because it does not compel a property owner to submit to a physical occupation.

YMCA v. United States, 395 U.S. 85 (1969).

When a building is damaged during riots while under the protection of federal officers, a taking is not present.

ECONOMIC CONSIDERATIONS

Alberni, A., M. Scasny, and M.B. Kohlova. *The Value of a Statistical Life in the Czech Republic: Evidence from a Contingent Valuation Study*. Paper for the EAERE Annual Meeting, Bremen, June 2005.

The authors use a contingent valuation method to determine an estimate for the value of statistical life in the Czech Republic. The study uses the responses from approximately 950 surveys.

Results estimate the value of statistical life (VSL) at approximately €1,270,000 (77,224.70 USD). The results show that there are age and income effects with older individuals reporting lower VSL and higher incomes related to higher willingness to pay, and therefore higher VSL. The income elasticity for VSL is estimate to approximately 1.0.

Aldy, J.E., and K.E. Viscusi. *Age Differences in the Value of Statistical Life: Revealed Preference Evidence*. Resources for the Future Discussion Paper, RFF DP 07-05, April 2007.

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

Aldy, J.E., and W.K. Viscusi. *Adjusting the Value of a Statistical Life for Age and Cohort Effects*. Resources for the Future Discussion Paper, RFF DP 06-19, 2006.

Conventional wisdom suggests that VSL declines with age. This paper presents a series of analyses suggesting that while the relationship is age related, it does not decrease simply with age. In doing so, it calculates age specific VSLs and finds that the relationship is an "inverted U." The analysis presented in this paper discusses the relationship of age to work related risks using data from the Bureau of Labor Statistics. Using hedonic price models, the highest VSLs are found for individuals in the 35- to 44-year-old age group ($9.85 million), while the 18- to 24-year-old group has a VSL of $3.16 million and the 55- to 62-year-old group has a VSL of $3.77 million.

Other analyses show similar results, though the timing of the maximum VSL differs depending on the estimation methods that the authors use. The article suggests that VSL discounts might be applied for older-aged workers.

Aldy, J.E., and W.K. Viscusi. *Age Variations in Workers' Value of Statistical Life*. Harvard University, Department of Economics and Harvard Law School, 2004.

Using a number of different estimation techniques, the authors investigate the extent to which there are age relationships with the VSL. Specifically hedonic wage equations, minimum distance estimators, and regressions incorporating age-mortality interactions are calculated. The risk calculations used in this study are based upon employment related risks.

The study calculates a measure referred to as "age-specific values of statistical life years" which indicate the highest values for those in their middle to late 30s. The overall results of the study show that there are age effects related to VSL estimation, with VSLs being lower for the relatively young and the relatively old. The study reports that the VSL for those in their early 60s is between $2.5-3.0 million, roughly 35 percent of that for individuals in their mid 30s. The hedonic equations show positive relationships to wages (and therefore VSL) with education, marital status (being married), urban residency, mortality risk, and age among other variables.

American Society of Civil Engineers Committee on Urban Transportation Economics and Policy of the Urban Transportation Division, *Guide to Transportation Benefit-Cost Analysis*. August 26, 1998. http://ccenve.calpoly.edu/sullivan/cutep.

American Society of Civil Engineers (ASCE) developed this online Internet guide for the application of benefit-cost analysis in transportation planning. It was intended to be an evolving document to which practitioners can contribute materials on methodology and examples of exemplary practice in benefit-cost analysis (BCA) for transportation projects. ASCE envisioned the guide to cover the following information:

- General issues – motivation for BCA; types of benefit-cost evaluation; selecting appropriate level and basis for analysis; types of benefits and types of costs.
- Methods of assessing impacts on transport system efficiency (user impacts).
- Methods for assessing impacts on the economy.
- Methods for treatment of impacts on the environment and quality of life.
- Other factors and considerations in measuring benefits and costs.
- Application of benefit-cost analysis: calculations and presentations.
- Additional resources.

The last update of the on-line guide recorded on the Internet site was on January 10, 2000.

Ashenfelter, O. *Measuring the Statistical Value of Life: Problems and Prospects*. National Bureau of Economic Research Working Paper 11916, 2006.

Ashenfelter provides an overview of the concept of VSL and its uses in analyses. The idea of VSL relates to the willingness to pay for a decreased risk of fatality, or the requirement for higher wages of an increased risk of fatality. Rather than measuring the value of any specific life, the VSL measures the costs for changes in the probability of death. The use of VSL is common in many types of benefit-cost analysis (BCA) including those of traffic safety decisions, environmental regulations, and medical interventions and technology.

Since decisions relating to public policy are supposed to represent the population, it is useful to use the average or median preferences and VSL values for analyses. This is problematic, however, because it is unclear as to whether studies reporting VSL actually represent the appropriate values.

Bellavance, F., G. Dionne, and M. Leabeau. The Value of a Statistical Life: A Meta-Analysis with a Mixed Effects Regression Model. Canada Research Chair in Risk Management Working Paper 06-12, 2007.

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

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

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

Cambridge Systematics, Inc. *Guide to Quantifying the Economic Impacts of Federal Investments in Large-Scale Freight Transportation Projects*. Prepared for the U.S. Department of Transportation Office of the Secretary of Transportation, August 2006.

The purpose of this guide is to provide a thorough economic analysis framework to assess the benefits and costs of potential freight investments. While the focus is on freight investments, the procedures described for measuring benefits from reduced congestion (operating cost and travel time savings), and enhanced safety (accident reduction cost savings) provide general directions for measuring similar benefits (positive or negative) within the context of aviation and compatible land use.

De Blaeij, A., R.J.G.M. Florax, P. Rietvald, and E. Verhoef. "The Value of Statistical Life in Road Safety: A Meta Analysis." Tinbergen Institute Discussion Paper TI 2000-089/3, 2000.

The value of statistical life is defined as the "valuation of a change of risk rather than the valuation of the life of a specific individual." The European Union (EU) commonly uses €1,000,000 as the cost of human life; this figure, however, underestimates the true cost because it only includes economic costs. Additionally, the research literature has estimated very large ranges in the appropriate figure to use for value of statistical life (VSL).

The meta-analysis performed by the authors indicates that revealed preference estimates for VSL tend to be lower than that found for stated preference studies. In addition, academic studies, on average, estimate lower VSL than more politically-based studies. VSL for private decisions made by individuals (e.g., buying safer products) is often higher than that for public decisions (building safer airports). Moreover, the VSL is also found to be related to existing risk level.

The study calls into question the ability to generalize VSL measures across situations due to the inherent variability in gross domestic product (GDP), risk and other parameters of potential reductions in risk.

Dionne, Georges, and P.C. Michud. "Statistical Analysis of Value-of-Life Estimates Using Hedonic Wage Method." Working Paper 02-01, May 2002.

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

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

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

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

The study concludes that a VSL of $5 million is appropriate for use in Quebec for road BCA (BCA is what?) relating to road safety.

VSL is calculated as follows:

$$VSL = \frac{dw}{dp}\Big/_{dp}$$

$$\frac{dw}{\Delta p} = \frac{U_l(w) - U_d(w)}{(1-p)U_l'(w) + pU_d'(w)}$$

U = utility of being live (l) or dead (d), U' = the marginal utility of wealth, w = wealth.

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

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

ECONorthwest and Parsons Brinckerhoff Quade & Douglas, Inc. "Estimating the Benefits and Costs of Public Transit Projects: A Guidebook for Practitioners." *Transit Cooperative Research Program Report 78*. Washington, DC, 2002.

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

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

While the guidebook focuses on transit application, the benefit-cost adjustment (BCA) concepts and measurement approaches discussed in the guidebook can provide general directions for measuring the costs of incompatible land uses in the context of aviation. For example, Section II of the guidebook addresses impacts such as reduced air, water, and noise pollution and provides guidance for estimating the cost of accidents.

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

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

Forkenbrock, David J., and Glen E. Weisbrod. "Guidebook for Assessing the Social and Economic Effects of Transportation Projects." NCRP Report 456. Washington, DC, 2001.

This guidebook is intended to improve the capacity of transportation professionals to take into account a wide array of social and economic effects when evaluating transportation projects. Emphasis is placed on methods, tools and techniques most likely to produce analyses that can be understood by community residents and decision-makers. The guidebook defines 11 general types of social and economic effects and provides insights into, and evaluations of, the methods, tools, and techniques available to assess them.
The 11 types of social and economic effects defined in the guidebook are as follows: changes in travel time, safety, changes in vehicle operating costs, transportation choice, accessibility, community cohesion, economic development, traffic noise, visual quality, property values, and distributive effects.

Gellman Research Associates, Inc. "A Report on the Value of Air Traveler's Time." March 31, 1988.

This report surveyed research literature and recommended values for air travel time. The three studies that formed the principal basis for the recommended values all applied logit analysis to data from the 1977 Census of Transportation National Travel Survey. A 1987 study by Pickrell estimated the value of time in business travel across all modes is at 164 percent of the after-tax

wage. Research published in 1985 by Steven A. Morrison and Clifford Winston yielded a value for business travel by all modes of 85 percent of the before-tax wage, while the value for personal air travel was stated at 149 percent. A later review by Morrison found that this figure was incorrectly derived and should have been 130 percent. Another study by Alan Grayson in 1981 found a value of 61 percent of the pre-tax wage rate for or 214 percent for personal travel.

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.

This report provides an update of economic values, often called "critical values," used by the FAA to make investment and regulatory decisions. These economic values are used to evaluate the benefit-cost of investments, including certain Airport Improvement Program (AIP) grants and regulations subject to FAA decision-making. Airport sponsors may also use the values to conduct benefit-cost analysis of proposed investments. The application of these economic values to corresponding physical quantities permits the valuation of physical quantities in dollars.

The report presents economic values that fall into four categories:

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

This report compiles the most recent updates of the above economic values from various APO (??) Bulletins, Department of Transportation Guidance, and other sources.

Grant, Michael D. *Analysis of Time Costs for Transportation*. August 10, 1994.

Time is one of the largest costs of transportation. Transportation investments are often justified based on resulting savings in travel time. The measurement of the value of time is therefore important in economic analyses of transportation infrastructure investments.

This paper reviews the literature on the following:
- Measurements for value of time – typically measured as a percentage of the average wage rate.
- Empirical basis for travel time studies – choice of mode, route, residential location, and speed.
- Factors that influence value of time – income levels, trip purpose, amount of time savings per trip, in-transport waiting/walking time, and level of service.

Gwilliam, Kenneth M. "The Value of Time in Economic Evaluation of Transport Projects: Lessons from Recent Research." *The World Bank Infrastructure Notes*, January 1997.

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

The conceptual model underlying the valuation of travel-time savings is one of consumer welfare maximization. Each individual maximizes the satisfaction or utility he/she gets by consuming and engaging in leisure activities subject to income and time constraints. The value of time can be estimated in two ways: revealed preference (RP) analysis and stated preference analysis (SP). RP

analysis estimates values of time that best explain actual observed choice behavior. SP analysis presents respondents with hypothetical alternatives to choose from and is designed to give numerous credible trade-off possibilities.

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

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

Hogarty, Thomas F. "Saving Time, Saving Money: The Economics of Unclogging America's Worst Bottlenecks." *American Highway Users Alliance*. 2000.

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

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

Litman, Todd. "Transportation Cost Analysis: Techniques, Estimates and Implications." Victoria Transport Policy Institute, June 2002.

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

Miller, Ted R. "The Value of Time and the Benefit of Time Saving." National Public Services Research Institute, May 1996.

This paper updates Miller's 1989 survey that provided time values for use in the Federal Highway Administration – Highway Economic Requirements System (FHWA HERS) model. In his 1989 paper, Miller recommended a value of 60 percent of the wage for auto drivers and 45 percent for auto and transit passengers on personal travel. After reviewing new research in this 1996 update, Miller recommends a downward adjustment to 55 percent for auto drivers and 40 percent for auto and transit passengers. Miller's findings and recommendations serve as the sources of values for local travel in U.S. Department of Transportation Guidance for the Valuation of Travel Time in Economic Analysis (1997).

Minnesota Department of Transportation**,** Office of Investment Management. "Benefit Cost Analysis Guidance." 2005.

The MN DOT provides an extremely basic overview of the benefit-cost analysis (BCA) procedure. With a focus on highway studies, the paper provides a description of the key components of BCA, the types of costs and benefits that might be evaluated, and discounting. Important considerations

include a thorough assessment of the geographic and temporal scale and scope of the project and accurate estimations of the benefits and costs.

Usually the BCA process will involve engineering estimates first – i.e., traffic volumes, assessments of road networks, etc. Base and alternative scenarios will be developed. Economic valuation of these alternatives is the next step and proper care must be taken to account for the time value of both the costs and the benefits so that the overall benefit-cost evaluation is accurate.

National Center for Statistics and Analysis Office of Regulatory Analysis and Evaluation. "Tire Pressure Monitoring System FMVSS No. 138." Final Regulatory Impact Analysis, March 2005.

Under section 13 of the Transportation Recall Enhancement, Accountability, and Documentation (TREAD) Act, the Secretary of Transportation was required to complete a rulemaking for a regulation mandating a warning system in each new motor vehicle to indicate to the operator when a tire is significantly under-inflated. Accordingly, the accompanying final rule requires a tire pressure monitoring system (TPMS) to be installed in all new passenger cars, multipurpose passenger vehicles, trucks, and buses that have a gross vehicle weight rating (GVWR) of 4,536 kg (10,000 lbs.) or less, except those vehicles with dual wheels on an axle. For this Final Regulatory Impact Analysis, the agency estimated the impacts of three TPMS systems that the manufacturers could use to meet the final rule. The study evaluated the benefits of the TPMS systems in terms of enhanced safety (reduced fatalities, injuries and property damage), travel delay savings, and vehicle maintenance and operating cost savings.

National Safety Council. "Estimating the Costs of Unintentional Injuries." 2005. http://www.nsc.org/resources/issues/estcost.aspx.

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

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

For non-motor vehicle injuries, the NSC recommends that costs be estimated based upon the number of fatalities at the rate of $3.5 million per fatal/non-fatal injury.

Navrud, Stale. "The State-of-the-Art on Economic Valuation of Noise." Final Report to European Commission DG Environment. April 14, 2002.

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

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

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

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

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

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

This article explains the benefits of meta-analysis as a method to synthesize results of many previous studies in a comprehensive and systematic way. Meta-analysis is a useful technique to generalize many disparate research findings and combine the results into a more concise form. This technique may be preferable to a more standard literature review. Specific research areas where meta-analysis may be particularly useful are regional economics, transportation, and environmental economics.

Several issues must be recognized prior to performing a reasonable meta-analysis. Each study reviewed must evaluate the same issue, outcome measure, population characteristics, and analytical objective. Meta-analysis possibilities are described for nominal, categorical, ordinal, interval, and fuzzy cases.

Office of Management and Budget. "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs." Circular No. A-94, October 29, 1992.

This circular is intended to promote efficient resource allocation through well-informed decision-making by the federal government. It provides general guidance for conducting benefit-cost and cost-effectiveness analyses. It also provides specific guidance on the discount rates to be used in evaluating Federal programs whose benefits and costs are distributed over time. The circular applies specifically to:

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

Benefit-cost analysis is recommended as the technique to use in a formal economic analysis of government programs or projects. Cost-effectiveness analysis is a less comprehensive technique that can be appropriate when the benefits from competing alternatives are the same or where a policy decision has been made that benefits must be provided.

In identifying and measuring benefits and costs, analyses should include comprehensive estimates of the expected benefits and costs to society based on established definitions and practices for program and policy evaluation. Social net benefits, not benefits and costs to the federal government, should be the basis for evaluating government program and policies that have effects on private citizens or other levels of government.

Portney, Paul R. "Benefit-Cost Analysis." The Concise Encyclopedia of Economics: Library of Economics and Liberty. 2007. http://www.econlib.org/LIBRARY/Enc/Beneftit-Cost Analysis.html.

Portney presents a critical discussion of benefit-cost analysis (BCA), which is an attempt to identify and express in dollar terms all of the effects of proposed government policies or projects. BCA initially gained widespread use in the evaluation of water projects in the United States in the late 1930s. Since then, it has also been used to analyze policies affecting transportation, public health, criminal justice, defense, education, and the environment. Key issues in BCA are discussed, using examples from the environmental arena, which include:

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

In spite of issues, BCAs seems to be playing a more important role in government decision making.

Small, Kenneth A. "Urban Transportation Economics." Reading: Harwood Academic Publishers, 1992.

Among the most important quantities inferred from travel demand studies are the monetary values people place on saving various forms of travel time. This concept of the value of time encompasses many specific measures defined for average or marginal time savings, for time spent on different modes or in different circumstances, for time spent on travel for different purposes, and for travel by people of different means. The value of time is a key parameter in cost-benefit analyses that measure the benefits brought about by transportation policies or projects.

Small describes some theories of time allocation that explain how the value of travel time depends on factors such as wage rate, enjoyment of work, and enjoyment of travel itself. Using these theories, he formulates empirical specifications of travel demand models, in which the value of time in a specific travel activity varies systematically with wage or income. He then reviews and interprets the results of some empirical studies that measure value of time.

Transport Canada. "Guide to Benefit-Cost Analysis in Transport Canada." Transport Canada Report TP 11875E, September 1994.

Benefit-cost analysis (BCA) is a method of measuring and evaluating the relative merits of public investment projects in support of sound economic decisions. It takes into consideration all of the effects of a project on members of society, irrespective of who is affected or whether the effect is captured in financial accounts.

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

The guide is divided into parts:

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

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

Treasury Board of Canada Secretariat. "Benefit Cost Analysis Guide." Draft July 1998. http://www.classwebs.psea.indiana.edu/krutilla/v541/Benfit-Cost%20Guide.pdf

This guide provides a more general treatment of benefit cost analysis (BCA) and is meant to serve as an authoritative statement of how a BCA should be undertaken for the Government of Canada.

United States Department of Transportation, Federal Aviation Administration. Investment Analysis and Operations Research. "Investment Analysis Benefit Guidelines: Quantifying Flight Efficiency Benefits." Version 3.0, June 15, 2001.

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

United States Department of Transportation, Federal Aviation Administration. Investment Analysis and Operations Research. "Investment Analysis Report: Airport Surface Movement Enhancement and Runway Incursion Prevention Phase 1 – ASDE-X," August 15, 2000.

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

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

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

United States Department of Transportation, Federal Aviation Administration. Investment Analysis and Operations Research. "Investment Analysis Report: Next Generation Air/ground Communications System.", September 1, 1998.

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

United States Department of Transportation, Federal Aviation Administration. Investment Cost Analysis Branch (ASD-410). "Economic Information for Investment Analysis, Data Package." Washington, DC, April 4, 2003.

This document provides Investment Analysis teams with current economic information to be used for analyses. It identifies sources of data and compiles the economic values from these sources for the following:

- Values for lost life
- Values for injuries
- Passenger value of time
- Aircraft direct operating expenses
- Aircraft utilization and capacity
- Aircraft replacement and restoration values
- Salary information
- Inflation Rates
- Office of Management and Budget (OMB) discount rates for cost-benefit analysis and cost effectiveness analysis

United States Department of Transportation, Federal Aviation Administration. Investment Cost Analysis Branch (ASD-410). "FAA Life Cycle Cost Estimating Handbook, Parametric, Analogy, Engineering Estimation, Risk Analysis, Modeling and Simulation." Washington, DC, Draft Version 0.2 as of June 3, 2002..

This handbook provides a complete reference for the cost estimator to support the FAA cost estimating requirements as outlined in the Acquisition Management System (AMS) within the FAA. The AMS sets forth certain guiding principles that imply the following: (1) cost estimates generally will be in life cycle terms; (2) cost estimates will occur at major points in the life cycle of a program; and (3) the cost estimate is a major consideration for investment decision.

The handbook covers the following topics:

- The management system discipline and general perspective on cost estimating and its role in the FAA AMS.
- The cost estimating process.
- Three methods of estimating (parametric, analogy and engineering), cost and risk uncertainty, source selection, cost models, and operations and support cost estimates.

United States Department of Transportation, Federal Aviation Administration. Investment Cost Analysis Branch (ASD-410). "Guidelines for Evaluating FAA Cost Estimates." Version 1.0. Washington, DC, 2001.

This document presents guidelines for review of cost estimates and cost analyses to ensure consistent, high-quality cost estimates throughout the FAA. The guidelines are to be used by both prepares and reviewers of the following types of Investment Analysis (IA) documents:

- Independent Evaluation Reports
- Investment Analysis Reports (IARs)
- Cost-benefit analysis reports
- Cost-effectiveness analysis reports
- Other related reports

The document identifies the following two general references: AMS Investment Analysis Process Guidelines and Economic Analysis of Investment and Regulatory Decisions. It also presents a detailed checklist for ensuring and judging the quality of a cost estimate or analysis. If the cost estimate is to be incorporated in a cost-benefit analysis, evidence must be provided that social costs beyond the scope of the cost estimate have been considered, and the correct economic values have been assigned to time, life, injury, and other benefits.

United States Department of Transportation, Federal Aviation Administration Office of Aviation Policy and Plans. "Airport Benefit-Cost Analysis Guidance." Washington, DC, December. 15, 1999.

This document provides guidance to airport sponsors on the conduct of project-level benefit-cost analysis (BCA) for capacity-related airport projects. It describes the purpose of a BCA and the steps involved in the BCA process.

BCA seeks to determine whether or not a certain output shall be produced and how best to produce it. BCA requires the examination of all costs and benefits related to the production and consumption of an output, whether costs and benefits are borne by the producer, the consumer or a third party.

The BCA process involves the following steps:

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

The FAA requires BCA on airport capacity projects for which airport sponsors are seeking Airport Improvement Program (AIP) discretionary grants of $5 million or more and Letters of Intent (LOI) funding in any amount over the life of the project. While the document is intended to guide BCA for capacity-related airport projects, it addresses the measurement of certain categories of benefits (or costs) relevant to compatible (or incompatible) airport land use; for example: decrease (increase) in airside delay; improved (diminished) schedule predictability; more (or less) efficient traffic flows; use of faster, larger and/or more efficient aircraft (limits thereon); and compliance with FAA safety, security and design standards.

United States Department of Transportation, Federal Aviation Administration, Office of Aviation Policy and Plans. "Best Practices Guide: Incorporation of Benefit Cost Analysis (BCA) Procedures into the Airport Planning Process." Washington, DC, Draft, October 15, 2003.

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

United States Department of Transportation, Federal Aviation Administration, Office of Aviation Policy and Plans. "Economic Analysis of Investment and Regulatory Decisions – Revised Guide." Washington, DC, January 1998. (FAA-APO-98-4)

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

- Chapter 1 discusses the purpose of economic analysis and the types of economic questions it addresses.
- Chapter 2 provides an overview of economic analysis and the procedures required to evaluate investments and regulations.
- Chapters 3 and 4 provide the conceptual framework for measuring and valuing benefits and costs, and provide practical guidance for estimating benefits and costs in situations which are typical of FAA investments, regulations and grant programs.
- Chapter 5 discusses the multi-period economic decision criteria and the discounting process.
- Chapter 6 deals with variability in benefit-cost estimates due to risk and uncertainty.
- Chapter 7 describes techniques for measuring price level changes and treatment of inflation in benefit-cost analysis.
- Chapter 8 addresses analysis of distributional issues.

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

- Safety – defined in terms of the risk of death, personal injury, and property damage resulting from air transportation accidents.
- Capacity increases which reduce congestion related delay – defined in terms of reduction in aircraft delays, which translates into passenger travel time savings and airline operating costs savings.
- Avoided flight disruptions – also defined in terms of reduction in aircraft delays.

- Cost savings – defined in terms of reduction in actual dollar outlays or dollar savings from efficiency gains.
- Other – noise reduction, missed approach benefit, avoided accident investigation costs, regulatory changes in capacity at access capped airports, and construction of a new airport where none currently exists.

United States Department of Transportation, Federal Aviation Administration, Office of Aviation Policy and Plans. "Economic Values for Evaluation of Federal Aviation Administration Investment and Regulatory Programs." Washington, DC, June 1998. (FAA-APO-98-8)

The report presents economic values, also called critical values, for use in the conduct of benefit-cost and other evaluations of investments, including certain Airport Improvement Program (AIP) grants, and regulations subject to FAA decision making. The values presented fall into two general groups: passenger-related values that include the value of passenger time, the value of an avoided fatality, and the value of avoided injuries; and aircraft-related values that include aircraft capacity and utilization factors, aircraft operating and ownership costs, and aircraft replacement and restoration costs. The economic values presented in this report have been updated in GRA, Incorporated (2004).

United States Department of Transportation. "Revised Departmental Guidance – Valuation of Travel Time in Economic Analysis." Memorandum, February 11, 2003.

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

United States Department of Transportation, "Treatment of the Value of Life and Injuries in Preparing Economic Evaluations." Memorandum, January 8, 1993.
http://ostpxweb.dot.gov/policy/Data/VSL93guid.pdf

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

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

- The Office of Management and Budget (OMB) requires the discounting of future costs and benefits to their present value to account for the fact that they are worth less in the future than they are today. Such analysis must use the discount rate specified by the OMB Circular A-94.

Viscusi, W. Kip. "The Value of Life: Estimates by Occupation and Industry." Harvard John M. Olin Center for Law, Economics, and Business Discussion Paper No. 422, May 2003.

This paper estimates a value of life of $4.7 million for the full sample, $7 million for blue-collar males, and $8.5 million for blue-collar females, based on data from the Bureau of Labor Statistics on total worker deaths by both occupation and industry over the 1992 to1997 period.

Viscusi, W. Kip, "The Value of Life in Legal Contexts: Survey and Critique" (2000). *American Law and Economics Review*, Vol. 2, pp. 195-210, 2000. http://ssrn.com/abstract=713112.

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

Viscusi, W. Kip, and Joseph E. Aldy. "The Value of a Statistical Life: A Critical Review of Market Estimates Throughout the World." *The Journal of Risk and Uncertainty*, 27: 1: 5-76, 2003.

Individuals make choices that reflect how they value health and mortality risks. Many of these choices involve market decisions, such as the purchase of a hazardous product or taking on a risky job. A substantial literature over the past 30 years has evaluated tradeoffs between money and fatality risks to arrive at estimates of the value of a statistical life (VSL). These VSL estimates in turn provide governments with a reference point for assessing the benefits of risk reduction efforts.

This article reviews more than 60 studies of mortality risk premiums from 10 countries and approximately 40 studies that present estimates of injury risk premiums. This critical review examines a variety of econometric issues, the role of unionization in risk premiums, and the effects of age on the value of statistical life.

While the tradeoff estimates may vary significantly across studies, the VSL for prime-aged workers has a median value of about $7 million in the United States. Other developed countries appear to have comparable VSLs, although some studies of the United Kingdom have found much larger risk premiums. Developing countries' labor markets also have significant, but smaller, VSLs. Meta-analysis indicates an income elasticity of the VSL ranging from 0.5 to 0.6. Union members in United States labor markets appear to enjoy greater risk premiums than non-members, while the evidence in other developed countries is rather mixed. The theoretical and empirical literature indicates that VSL decreases with age.

The estimates of the VSL can continue to serve as a critical input in benefit-cost analysis (BCA) of proposed regulations and polices. Refining VSLs for the specific characteristics of the affected population at risk remains an important priority for future research.

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

This report sets forth economic factors for quantifying the cost of loss of human life and injuries, business losses (including those to critical infrastructure that supports social and economic activity), and property value losses (usually included in business losses). Although they are developed for estimating effects of attacks on electric power, these economic factors are broadly applicable to other kinds of events involving deaths, injury or business loss. The report presents a variety of alternative measures and values to provide users flexibility in how they are applied.

STATE AND LOCAL COMPATIBILITY GUIDANCE

Airport Overlay Use Compatibility Table. Clark County, Nevada. 2004.

The Clark County development code includes a detailed airport land use compatibility table that lists uses permitted, uses permitted subject to noise attenuated construction, uses permitted subject to special use permit, and uses prohibited.

Aries Consultants Ltd. *Regional Airport System Plan General Aviation Element: Final Report*. Prepared for the Regional Airport Planning Committee, June 2003.

This report updates the General Aviation Element of the Regional Airport System Plan for the San Francisco Bay Area and addresses the nineteen publicly owned and operated general aviation airports in the region, as well as general aviation activity at the four commercial service airports and two military/federal airfields. The report reviews general aviation trends and issues, including land use compatibility and the role and operation of the airport land use commissions (ALUC's) in the region, environmental issues at each of the airports, and community perceptions about general aviation. The report provides an inventory of based aircraft and operations at each airport and a table (Table 4-1) that summarizes a variety of information for each airport, including plans for future improvements, environmental, land use compatibility and noise issues, runway approach protection considerations, and the status of updates to airport master plans or land use plans. A second table (Table 4-2) provides more detailed information on the most recent airport land use plan covering each airport, as well as selected environmental documentation and any FAR Part 150 Airport Noise Compatibility Plans. The report includes a number of recommendations, including seven that address land use compatibility issues and identify ways to increase the effectiveness of the ALUCs in the region. A separate Appendix report contains more detailed information assembled in the course of the study on a variety of aspects, including land use compatibility.

Aviation in California, Fact Sheet, Sacramento, CA. (2005).

This document contains numerous aviation facts such as the number of certified pilots and general aviation hours flown nationally. It also contains figures such as the annual total spent on fuel for general aviation flights. It lists grants received for airport acquisition and developments, along with airport improvements. Finally it lists the permitted aviation facilities and the number of passengers that travel through numerous airports in California.

Boyken, Grant. *Growing Pains: Airport Expansion and Land Use Compatibility Planning in California*. Sacramento, CA: California Research Bureau. September 2006. http://www.library.ca.gov/crb/06/10/06-010.pdf.

Senator Christine Kehoe requested this review of airport land use planning and airport governance in California, which examines issues relating to land development near airports and airport expansion. The report evaluates the state of airport land use regulation, airport land use commissions (ALUCs), and airport expansion in California. The six key findings are: 1) the benefits of airports are regional while the impacts are localized; 2) for the most part, airport land use compatibility planning and review is under local control; 3) despite the efforts of ALUCs, conflicts over airport noise and other impacts have affected the operation and development of airports in California; 4) ALUCs effectiveness is limited because only new development is subject to review, compatibility plans are out of date, and local conflicts or litigation can override compatibility plans; 5) regional airport planning bodies are more effective for airports that play an important regional or national role; and 6) regional strategies to distribute air traffic have not been implemented in California, but the interest in idea has increased.

A survey examined ALUC characteristics, planning activities, and approaches to compatibility planning (the survey is contained in Appendix D). The survey was sent to all ALUC contacts on a list maintained by the Division of Aeronautics. 52 potential respondents generated 23 responses. The survey found that although twelve plans were updated between 2002 and 2005, three had not been updated since 1993 and another three since 1989. The most frequent reason given for not updating a plan was lack of funding and staffing. This is not surprising given that ten of the 23 ALUCs had less than one full-time staff to support their efforts and five ALUCs did their last update with no outside funding. On the other hand, seven ALUCs did acquire state, federal, and/or local funding. In addition, the survey found that noise criteria vary widely. The highest noise contours in which residential uses are considered compatible ranged from 55 dB CNEL or less to 70 dB CNEL or less, while compatibility for retail and commercial uses ranged from 60 dB CNEL or less to 75 dB CNEL and even above 75 dB in one case. Additional issues discussed include local general/specific plan consistency, California Environmental Quality Act (CEQA) compliance, defining Airport Influence Areas, and litigation.
The report also describes different airport governance structures and current conflicts related to airport operations and development including community opposition to airport development projects, curfews and other operating restrictions, and existing development and natural features of the terrain.

California Department of Transportation. *The California Aviation System Plan Policy Element*. January 2001. http://www.dot.ca.gov/hq/planning/aeronaut/casp2006.html.

Four policies are specifically directed at issues relevant to airport land use planning: Policy 5 – Regulatory and Safety; Policy 6 – Noise; Policy 8 – Environmental; and Policy 9 – Land Use Compatibility. These four policies identify seventeen implementing actions related to airport land use planning. In addition, Policy 12 – Funding includes an implementing action to provide a long-term funding mechanism for ALUC/CLUP activities through state and federal funding, and Policy 14 – Local Assistance includes an implementing action to provide services, including land use planning expertise, to ALUCs.

California Department of Transportation, Division of Aeronautics. *California Airport Land Use Planning Handbook*. Santa Rosa: Shutt Moen Associates, January 2002. http://www.dot.ca.gov/hq/planning/aeronaut/documents/ALUPHComplete-7-02rev.pdf.

The Handbook is divided into two parts. Part I, consisting of chapters 1 to 5, describes Airport Land Use Commission (ALUC) procedures and plans. These five chapters discuss the establishment of ALUCs, the preparation and adoption of airport land use compatibility plans, formulation of airport land use compatibility polices, ALUC review of local actions, and responsibilities of local agencies. Part II, consisting of chapters 6 to 9, discusses in more detail the

two principal airport land use compatibility issues of aircraft noise and safety. The four chapters address measurement of airport noise, establishment of airport noise compatibility policies, aircraft accident characteristics and data, and the establishment of airport safety compatibility policies. The Handbook also contains a 14-page summary and ten appendices that include a summary of California laws related to airport land use planning, Federal regulation governing obstructions in the vicinity of airports, sample implementation documents and guidance on performing supporting analysis, general aviation accident data, and a list of reference documents.

California Department of Transportation, Division of Aeronautics. *Ground Access to Airport Study: Executive Summary*. December 2001. Available from http://www.dot.ca.gov/hq/planning/aeronaut/documents/GroundAccessStudyExecutiveSum.pdf.

This report summarizes the findings and recommendations of a study of airport ground access needs, issues, and problems at 47 airports throughout California and one in Mexico close to the California border. The policy recommendations focus on institutional roles and funding issues in addressing airport ground access needs. The report presents recommended criteria for selecting ground access projects. There is no discussion in the report of the relationship between airport land use planning and ground access considerations.

In addition to the Executive Summary, there are working papers prepared as part of the study. Working Paper One: Roles and Responsibilities, contains a brief description of Airport Land Use Commissions in California. However, there is no discussion of the role of airport land use planning in airport ground access issues beyond noting that although the relevant legislation did not intend the commissions to address airport land use compatibility issues related to ground access traffic, there is no law excluding consideration of such matters.

California Department of Transportation, Division of Aeronautics, *Subchapter 6: Noise Standards*. Title 21, Register 90, No. 10. March 10, 1990. http://www.dot.ca.gov/hq/planning/aeronaut/documents/statenoisestnds.pdf.

Article 3, Chapter 4, Part 1, Division 9, Public Utilities Code (Regulation of Airports) provides the noise standards governing the operations for all DOT approved airports. “These standards are based upon two separate legal grounds: 1) the power of airport proprietors to impose noise ceilings and other limitations on the use of the airport, and 2) the power of the state to act to an extent not prohibited by federal law.” Noise measurements will be based on the Daily Community Noise Equivalent Level (CNEL) in decibels (dB) which “represents the average daytime noise level during a 24-hour day, adjusted to an equivalent level to account for the lower tolerance of people to noise during evening and night time periods relative to the daytime period.” The Noise Impact Boundary (NIB) is the locus of points around an airport where the annual CNEL equals 65dB. The NIB contains the noise impact area and the CNEL 65 dB criterion was chosen because it is “the level of noise acceptable to a reasonable person residing in the vicinity of an airport” and within a typical California constructed residential home with a window partially open. Generally, all land uses are incompatible above CNEL 75 dB. For those land uses below CNEL 75 dB, sound insulation is recommended and projects should create an interior area that is habitable at a noise level of CNEL 45 dB or less.

If a county, city, or community declares an airport as having a noise problem (incompatible uses within the Noise Impact Boundary), then the county can require the airport to monitor the noise and validate the NIB. If the county audit of the NIB study shows the airport has a noise problem, then the airport must submit quarterly reports with a map depicting the NIB, noise measurement levels and number of people estimated living within the NIB, as well as aircraft operations and number of aircraft type having the highest noise levels. California’s Title 21 recognizes that the airport is mainly responsible for controlling the county declared airport noise problem. The airport is directed to alter air traffic flight patterns, runway usage, and aircraft types. The airport should also use natural terrain to shield noise impacts and develop compatible land uses within the NIB.

According to Title 21, the least desirable action is airport acquisition and conversion of residential dwellings into more compatible uses.

Title 21 stands in sharp contrast to Maryland's COMAR, which is explained below. California allows each community to decide if an airport is creating a noise problem. If a problem exists, the airport has the burden to reduce the noise problem and is required to study, monitor, report, and mitigate the areas within the NIB. Unlike the federal government, California has decided that the least desirable land use action within an NIB is acquiring and converting residential land uses.

California Department of Transportation. Office of Transportation Economics, *Benefit-Cost Analysis*. 2007. http://www.dot.ca.gov/hq/tpp/offices/ote/Benefit_Cost.

This is an on-line benefit-cost analysis (BCA) guide for application in transportation planning in California. Benefit-cost analysis, sometimes referred to as cost-benefit analysis, is a systematic process for calculating and comparing benefits and costs of a project. The website leads users, step by step, through the BCA process, explaining concepts and describing methodologies.

The guide identifies useful applications of BCA. BCA is particularly useful for large projects with significant opportunities for improvements in transportation enhancement and efficiency, and where the necessary variables can be appropriately measured. BCA is less useful for projects that are based upon the need to fulfill legal obligations, social equity, and some types of maintenance and renovation where the goal is to sustain pre-existing benefits.

In organizing the BCA, the following key issues need to be addressed:

- Defining the purpose for the study
- Preparing a thorough description of the project
- Determining how the BCA will be utilized in the decision-making process
- Determining the effort needed to conduct the BCA
- The audience for the BCA
- The base case and the alternative(s)
- The schedule for the project and realized benefits/costs
- BCA methodology
- The spatial scale and scope of the analysis
- The temporal scale of the analysis

The guide provides guidance and suggestions on how to calculate the various benefits and costs attributable to transportation projects. In particular, it identifies and describes procedures for measuring the following benefits:

- Travel time or delay reductions
- Accident reduction
- Emissions reductions
- Vehicle operating cost reduction

It also recommends approaches for evaluating effects that are difficult to quantify but may still be considered in BCA:

- Induced travel
- Noise effects
- Construction impacts

- Habitat and water quality impacts
- Economic effects
- Community impacts

An important component of a BCA – especially in valuing the benefit of avoiding fatality, injury, or adverse health effects (or the cost of exposure to risk of fatality, injury, or adverse health effects) – is the valuation of human life, or "value of statistical life (VSL)." The document indicates "researchers have estimated the VSL by evaluating both the willingness to pay for safety improvements and the willingness to accept compensation for increased risk." The California Department of Transportation uses the following VSLs: $3.1 million for death, $81,572 for injuries, and $6,580 for property damage only – these rates, however, vary by mode.

The online BCA guide discusses hedonic pricing and contingent valuation or willingness-to-pay approaches for valuing benefits without established monetary value. It also presents case studies of benefit-cost analyses of transportation projects and applications of hedonic pricing and contingent valuation approaches.

While the online BCA guide presents applications primarily to ground transportation projects, the methodologies can be adapted to aviation applications, given appropriate data.

Cidell, Julie L. *Scales of Airport Expansion: Globalization, Regionalization, and Local Land Use*. Center for Transportation Studies, University of Minnesota, 2004. http://www.cts.umn.edu/pdf/CTS-04-01.pdf.

Author abstract: This study examines two main issues surrounding the increasing demand for airport capacity: the effects of globalization and transportation on each other as expressed through local land use, and the politics of scale in struggles over airport expansion. The study centers around three case studies to illustrate how globalization, air transportation, and local land use are connected at the municipal, metropolitan, and regional levels. Each case study investigates a specific issue. The Minneapolis-St. Paul (MSP) case investigates the geographical distribution of economic impacts of the airport. The Chicago (ORD) case documents the changing land uses over time around O'Hare, as well as a detailed investigation of the current land use controversy in the vicinity of an expanding airport. The Boston (BOS) case study examines the regionally-based solution to airport demand, specifically the attempts to encourage passengers to use smaller regional airports in the area instead of the crowded Logan Airport in Boston.

Cidell, Julie L., and John S. Adams. *The Groundside Effects of Air Transportation*. Minneapolis: University of Minnesota Center for Transportation Studies, August 2001. http://www.cts.umn.edu/pdf/CTS-01-02.pdf.

This report documents the findings of a comprehensive study of the effects of airports on land uses in surrounding communities. The report includes a fairly extensive review of relevant literature addressing airport land use planning, aircraft noise and property values, strategies for controlling aircraft noise, and economic development issues in areas around airports. The report discusses methodologies for studying the effect of airports on nearby land use and includes twelve case studies of major airports in the United States, with more detailed attention given to Minneapolis-St. Paul International Airport and Denver International Airport.

Clark County, Nevada. Unified Development Code, Title 30, Zoning Overlay Districts, Section 30.48.

Clark County, NV uses an Airport Environs (AE) Overlay District to determine the range of compatible land uses, to prohibit incompatible development and prohibit uses that are detrimental to the health, safety, and welfare of its citizens.. The AE Overlay District supersedes the nine other types of overlay districts, which include a residential neighborhood preservation overlay, a gaming enterprise overlay, and a red rock design overlay. Specifically the AE Overlay District

requires all development to follow FAA regulations concerning airspace and safety and requires noise attenuated construction standards in compliance with Clark County Code, chapter 22.22. The code designates 12 sub-districts or areas with specific land use requirements that include runway protection zones, accident potential zones, and a variety of noise contour zones. These 12 sub- districts use a table to determine the appropriate type of land use, permitting standards, and mitigation requirements.

Specifically the land use table has four noise categories: DNL 80+dB, DNL 75-80 dB, DNL 70-75 dB, DNL 65-70 dB. The first two categories DNL 80+dB and DNL 75–80 dB require a special noise attenuation permit for manufacturing development. The third category, DNL 70-75 dB, allows manufacturing without noise attenuation but requires a special use permit for hotel or motel construction. Finally, the DNL 65 to70 dB range allows all development, but requires a minimum exterior to interior noise attenuation standard for residential construction. Further, the code requires all county airports to submit Airport Airspace Zoning Maps and specifically requires McCarran Airport, the largest airport in the county, to provide a noise exposure map to the County every five years.

Denver Regional Council of Governments (DRCOG). Airport Compatible Land Use Design Handbook, 1998. http://www.drcog.org/documents/Airport_Compatible_Land_Use_Design_Handbook_5-15-98.pdf

This reference document provides tools for local policymakers, planners, and airport managers to improve compatibility between airports and surrounding communities

Duluth Sky Harbor Municipal Airport. Zoning Ordinance. Duluth, Minnesota. Adopted 1994.

This ordinance generally follows the Model Zoning Ordinance for Minnesota Airports. The use restrictions in the safety zones follow the state model ordinance, except that they allow for assembly of 100 people for no more than two hours (p. 12).

Florida Department of Transportation. Airport Compatible Land Use Guidance for Florida Communities. 1994.

This document summarizes federal and state regulations pertaining to airport planning in Florida. Section III addresses three elements of aviation compatible land use, which include airspace protection, noise compatibility, and public safety. For each of these three topics, the authors explain the purpose, methods, and considerations for addressing the element, summary recommendations, and mapping techniques. A discussion of considerations for adopting and administering land use controls and a model ordinance are included in the document.

Maryland, Department of Transportation, Annotated Code of Maryland Regulations, Transportation Articles, 5-204(d)(4), 5-208(a) & (b), 5-801 et.seq., Title 11, Department of Transportation, Subtitle 03, Maryland Aviation Administration, Chapter 03, Airport Noise Control, 2003.

Maryland Aviation Administration is required by the Code of Maryland Regulations (COMAR) to update the Airport Noise Zone (ANZ) every five years. The ANZ, per COMAR, is an area defined by a composite of three noise level contours in terms of annual Day-Night Average Sound Levels, DNL or Ldn. For example, the three sets of contours for years 2005, 2012, and 2017 are overlaid on each other to determine the composite area. The largest area of each annual contour determines the Airport Noise Zone, thereby offering protection within the largest area of the existing or future noise exposure contours. This process is performed for each five-decibel increment of noise level, from 65 Ldn to 75 Ldn. The land use categories are based on noise sensitivity as determined by the Secretary of the Environment and to benefit the health and welfare of Maryland's citizens. The land use map shall depict the ANZ, land within the impacted area, and will develop a noise abatement plan to reduce or eliminate impacted land use areas. New construction including repairs and additions to residential dwellings within the ANZ are required to obtain a State permit and

mitigate or reduce the noise impact to the structure. Airport zoning districts currently include Baltimore-Washington International Airport and Martin State Airport.

Maryland requires airports to define aircraft noise impacted areas, but then places the burden of developing compatible land uses on the communities within the ANZ, with the state providing oversight through the permitting process.

Metropolitan Transportation Commission, Association of Bay Area Governments, Regional Airport Planning Committee, San Francisco Bay Conservation and Development Commission. "Protecting the Bay Area's Aviation Resources: The Land use Connection." Oakland, CA: Metropolitan Transportation Commission, April 2005. www.mtc.ca.gov/planning/air_plan/Aviation_Resource_Guide.pdf**.**

The resource guide aims to help local officials and the public address airport land use compatibility issues. It includes policy information, recommends engaging all stakeholders in discussions, and provides several lists of questions to ask when reviewing land use proposals around an airport.
The guide encourages the following actions:

- Review General Plans, Specific Plans and zoning regulations for consistency with ALUC plans, and revise as necessary;
- Consider the checklist of key land use compatibility questions;
- Use available information resources to evaluate the compatibility issues;
- Engage stakeholders in a forthright and open dialogue about the future impacts of the potential new land use on the airport;
- Search for reasonable compromises when they are available; and
- Make a careful and informed decision that ensures that the interests of both the aviation community and the local community will be well served in the future.

Minnesota Department of Transportation. Office of Aeronautics and Aviation. "Minnesota Airport Zoning Ordinance." Rochester, MN. Adopted 1982.

This ordinance generally follows the Model Zoning Ordinance for Minnesota Airports. It includes a short list of permitted and restricted uses, as well as discussion (on pp. 10-11) about how to address existing residential neighborhoods established prior to 1978.

Minnesota Department of Transportation. Office of Aeronautics and Aviation. "Model Zoning Ordinance for Minnesota Airports." 1990.

The state model ordinance was last amended in 1990. The model ordinance provides a recommended structure for implementing height and land use regulations intended to minimize airport safety hazards and protect airport operations. These minimum regulations are outlined in Chapter 360 and further discussed in Minnesota Rules, Section § 8800.2400, et seq.

Minnesota International Airport Zoning Ordinance. Duluth, Minnesota. Adopted 1988.

This ordinance generally follows the Model Zoning Ordinance for Minnesota Airports. The A, B, and C safety zone restrictions generally follow the state model (p. 8). It also includes a table of use factors (p. 11) and a short list of restricted uses (p. 12).

Minnesota State Legislation. "Regulation of Structure Height." Minnesota Rules, Rule 8800.1100, 2005.

This section of the Minnesota Rules authorizes the transportation commissioner to make any investigation necessary to assist in determining whether to grant a permit that is required by Minnesota Statutes 2004 §§ 360.81 to 360.91. It authorizes interested persons to intervene in any

permit determination by written notification to the commissioner. It further authorizes the commissioner to request an informal appearance by the permit applicant or any intervener.

Minnesota State Legislation. "Airport Zoning Standards." Minnesota Rules, Rule 8800.2400, 2005.

This section contains minimum standards for airport zoning air space, land use safety, and noise sensitivity. Any governmental body that has been granted airport zoning powers under Minnesota Statutes §§ 360.061 to 360.074 may adopt more restrictive standards. Subpart 3 establishes six airspace zones, which include primary, horizontal, conical, approach, precision instrument approach, and transitional airspace. Subpart 4 imposes height restrictions consistent with these zones. Subpart 5 establishes three land use safety zones for an airport and each runway associated with it. Subpart 6 details the use restrictions applicable to each land use safety zone. A separate section (6E) of this subpart specifies use restrictions for "established residential neighborhoods in built up areas." It includes a list describing hazards so severe that local airport zoning ordinances must prohibit them, but it authorizes local ordinances to prohibit other uses deemed to be equally hazardous. Examples of such extreme hazards include existing residences either located entirely within safety Zone A and within 1,000 feet of the end of a runway's primary zone, or entirely within either Zones A or B and which penetrate an approach airspace zone. Subpart 7 authorizes the creation of noise sensitivity zones.

Oregon Department of Aviation. "Airport Compatibility Planning, Recommended Guidelines and Procedures for Airport Land Use Planning and Zoning." Salem, Oregon, 1978.

Objectives of this document include:

- Describe the nature and extent of airport-related noise and potential safety problems.
- Identify compatible land uses in terms of noise and safety.
- Recognize conflicting land uses and methods to prevent or resolve conflicts.
- Provide a method to monitor land use changes.
- Reference model documents to accomplish required zoning.
- Discuss strategies to incorporate the airport land use plan into the local comprehensive plan.
- Illustrate mechanisms to assure early recognition of potential land use conflicts.

Oregon Department of Aviation. "Airport Land Use Compatibility Guidebook for Oregon." January 2003.

Since 1974, Oregon has required all communities to develop and adopt comprehensive land use plans and perform periodic reviews. The plans must ensure compliance with Oregon's provisions for housing, employment, transportation, public facility, and service needs. Oregon has 19 statewide planning goals, of which airport planning is directly applicable to Goal 12 – to provide safe, convenient, and economic statewide transportation networks, including passenger and air-freight transportation.

Oregon's Department of Environmental Quality (DEQ) recognizes airport noise as a threat to the public health and welfare of residents living near an airport. Oregon accepts the FAA's DNL Noise Contour method as the primary measurement defining noise around an airport. DEQ has adopted Oregon Administrative Rule Chapter 340, Division 35 - "Noise Control Regulations" and an "Airport Noise Control Procedure Manual." The manual and OAR 340-35-045 - Noise Control Regulation for Airports establish procedures for an airport sponsor to use when a noise contour map or airport land use plan is needed. Oregon follows the FAA recommendations for specific noise mitigation within and above the DNL 65 dB noise contours. Although Oregon considers the DNL 55 dB contour as the study boundary for significantly noise impacted areas that in some instances need local zoning and regulations, they consider all land uses compatible with anything below DNL 65 dB.

The guidebook offers overlay zoning ordinances and planning templates for airports in order to identify current incompatible land uses, prevent future incompatible development, and protect the

airport as a viable part of the transportation system. Three templates are provided for private use airports, public use airports with visual approaches, and public use airports with instrument approaches and non-commercial service. Due to complex fleet mixes, these templates should not be used at larger commercial airports, such as Portland, Eugene, and Medford. The private use airport template focuses on runway and airspace safety zones and a continued vitality of operations. The public use airports templates include the safety zones and Airport Noise Impact Boundaries. Both visual and instrument approach airports templates have a noise impact boundary (NIB) that extends 1,500 feet from the runways or within the established noise contour that exceeds DNL 55 dB. Usually the NIB is contained within the FAR Part 77 surface restrictions and FAA Safety Zones for instrument approach airports. Land uses within the Airport Noise Impact Boundary should meet the FAA's guidelines for noise compatible land uses. Noise mitigation recommendations for each type of land use, from outdoor recreation through residential development, include soundproofing methods, easement acquisitions, airport overlay zoning, and real estate disclosure statements.

For more information about Oregon's Department of Aviation see: http://www.aviation.state.or.us/ or http://www.oregon.gov/Aviation/landuseguidebook.shtml

Oregon Study Team, Marjorie Hanley and Associates. "Oregon Aviation System Plan VI, Airport Compatibility Guidelines," 1981.

The purpose of this report is to provide information necessary for designing and implementing height restriction zoning and land use compatibility zoning for airports and vicinities. This report is designed to be a working document for planners, decision makers, and other interested groups. The ultimate responsibility for zoning, however, lies with the appropriate local jurisdiction city and/or county. To assist planners and decision makers, this report is divided into the two issue areas of height and land use.

Placer County Airport Land Use Commission. "Airport Land Use Compatibility Plan." Placer County. 2000.

This airport land use compatibility plan includes a summary of the State of California mandated interface between airport land use commissions' and local jurisdictions' planning and regulatory efforts. It contains guidance for coordinated airport master planning and land use planning and sets out criteria for review of proposed land uses within the airport area of influence.

Puget Sound Regional Council. "The Puget Sound Regional Council Strategic Plan for Aviation." 2002.

In 1998, the Regional Council began a two year effort to update the 1988 Regional Airport System Plan, which focused on addressing the 20-year improvement needs of the region's 25 general aviation airports. In May 2001 the Regional Council adopted its updated Metropolitan Transportation Plan (MTP), called Destination 2030, which included the Regional Airport System Plan as a model component.

These aviation-related planning efforts have produced valuable products and guided the region to critical decision. Looking ahead, the region will need to address a multitude of aviation issues, including system capacity, funding, maintenance and preservation, encroachment, system enhancements, environmental impacts and mitigation, and many others. Before embarking on specific planning programs to tackle these complex issues, the Regional Council has decided to pause, and undertake a strategic plan for its Aviation Program. The purpose of the strategic planning process is fourfold: (1) to set forth our vision and mission for the aviation program; (2) to identify and describe the critical issues facing the region; (3) in response to those issues, to document our roles, mandates, authority, and policy; and (4) to develop a multi-year action plan for the aviation program. The process is designed to establish a context and framework for future actions, programs, and projects to be undertaken by the Regional Council.

Puget Sound Regional Council. "Regional Airport System Plan (RASP)." 2001.

The 2001 RASP presents technical documentation regarding the general aviation airport system planning process. The plan includes a discussion of issues and trends affecting the general aviation market, an inventory of the current airport system, general aviation forecasting to the year 2020, analysis of system capacity and future requirements, recommended general aviation airport system improvement strategy, and a regional airport system capital improvement programs (CIP). In addition, the report contains supporting discussions of related planning issues, including airport compatible land use and airport ground access. The report also provides a summary of the technical advisory committee process which was highly instrumental in overseeing the development of the plan as it relates to the region's general aviation airports.

The 2001 RASP presents a 20-year general aviation airport system improvement program that focuses on maintaining and preserving the existing system combined with strategic investments in system enhancement. The program will enhance airport system safety by addressing the Federal Aviation Administration and State Department of Transportation airport design standards, provide system enhancements to meet forecast growth and changing user needs, support ground access improvements serving the region's major airports, and support airport compatible land use in communities adjoining the region's airports.

Shutt and Moen Associates, Brown-Buntin Associates, and Gatzke, Dillon & Balance. "State of California Department of Transportation Division of Aeronautics, California Airport Land Use Planning Handbook." 2002.

The State Aeronautics Act (Public Utilities Code, Section 21670 et seq.) requires preparation of an airport land use compatibility plan for nearly all public-use airports in the state (Section 21675). This requirement applies regardless of whether a county chooses to establish and maintain an airport land use commission or to utilize the alternative process or county-specific exception provisions of law.

Compatibility plans are the fundamental tool used by airport land use commissions in to fulfill their purpose of promoting airport land use compatibility in order to "provide for the orderly growth of each public airport and the area surrounding the airport within the jurisdiction of the commission…" and "safeguard the general welfare of the inhabitants within the vicinity of the airport and the public in general."

Shutt and Moen Associates. "Airport Land Use Compatibility Plan." Contra Costa County, California, adopted 2000.

"The basic function of this Contra Costa County Airport Land Use Compatibility Plan is to promote compatibility between the airports in Contra Costa County and the land uses which surround them. As adopted by the Contra Costa County Airport Land Use Commission, the plan serves as a tool for use by the commission in fulfilling its duty to review airport and adjacent land use development proposals. Additionally, the plan sets compatibility criteria applicable to local agencies in their preparation or amendment of land use plans and ordinances and to land owners in their design of new development."

Taylor County, Wisconsin. County Code, Chapter 35: Airport Zoning Ordinance,1998.

"It is the purpose of this ordinance to regulate the use of property and to regulate and restrict the height of structures and objects of natural growth in the vicinity of the Taylor County Airport, to promote the public health, safety, convenience and general welfare to increase safety in the use of the airport and to protect persons and property within the airport affected area and zoning districts."

Washington State Department of Transportation, Aviation Division. "Airports and Compatible Land Use. Volume One: An Introduction and Overview for Decision-Makers." Seattle, February 1999.

The State of Washington is not the local land use authority nor empowered to make land use decisions. The Washington State Growth Management Act establishes land use planning requirements upon cities and counties and thought the Airport Land Use Compatibility program, the law empowers the state to offer technical assistance and policy advice to cities and counties. The state board interests in transportation are to promote economic vitality, to improve the quality of life, and to protect the environment. The Washington State Transportation Commission adopted Resolution 567 on March 24, 1998, thereby establishing The Washington State Aviation Policy. In 1990, the Washington State Legislature determined that uncoordinated and unplanned growth, together with a lack of common goals expressing the public's interest in the conservation and the wise use of our lands, pose a threat to the environment, sustainable economic development, and the health, safety, and high quality of life enjoyed by the residents of Washington State.

Wold-Chamberlain Field Joint Airport Zoning Board. Minneapolis-St. Paul International Airport (Wold-Chamberlain Field) Zoning Ordinance. Adopted 1984; Amended 2004.

The amendments to the zoning ordinance applicable at Minneapolis-St. Paul International Airport (MSP) deviate from the state's model ordinance. The dimensions of safety Zone A were changed through the 2004 amendment to match the boundaries of the federally-mandated runway protection zone (RPZ). According to the Commissioner of Transportation's written findings (Order No. 589, 4/26/04), this reduced the length of safety Zone A for all MSP runways by 2,100 feet, and kept Zone A primarily within airport boundaries. The total length of both safety Zone A and Zone B did not change for any of the MSP runways from what had been adopted in the previous 1984 ordinance. The cumulative effect of these changes is to shift 2,100 feet (by length) of land and land use from being regulated as Zone A into the newly constituted Zone B. The change was based on an analysis of third-party risk research conducted primarily in Europe, as well as accident location information compiled by the State of California and other sources. In approving the change to the safety zone boundaries, the Commissioner also justified the amendment based on the airport authority's demonstration that "the social and economic costs of restricting land uses in accordance with existing state zoning standards outweigh the benefits of a strict application of those standards," as allowed under Minnesota Statutes § 360.063, subd. 2 (2002).

Wisconsin Department of Transportation. "Airport Land Use Guidance." 2000.

This report about airport land use follows the FAA Part 150 guidelines and states that land use above the DNL 65 dB is incompatible with United States Department of Housing and Urban Development (HUD) standards; between DNL65 and 55 dB land use controls should be considered but for HUD standards is considered "normally acceptable." Below DNL 55 dB, housing is clearly compatible with no special considerations for land use. The report also recommends outdoor parks, open public areas, and agricultural areas as land uses compatible with airports. Out of the 100 airports within the State of Wisconsin, only five communities have land use zoning ordinances while all 100 have height restriction zoning ordinances.

Wisconsin Law 114.136 designates the three-mile radius around the boundary of an airport as the critical approach zones and state law permits airport owners to establish extraterritorial land use controls in this area. The state recommends airport noise zone overlays utilizing airport noise exposure maps as a means to assist local communities around airports and promote compatible land uses.

The 1985 Wisconsin Act 136 supplemented existing zoning procedures and land use criteria for areas adjacent to or in the immediate vicinity of a public airport. These additional requirements include: developing a map depicting the effects of the airport and voluntary development of lands

compatible with airport operations; requiring the zoning authority to inform the airport operator of zoning changes within the "airport affected area = 3 mile radius of the boundaries of any airport" and allow the airport operator time to the change or modify the operations or the land use plans; and permitting the airport operator to protest the zoning change.

The Wisconsin State Airport System Plan 2020 is cited as the plan to provide for "the orderly and timely development of a system of airports adequate to meet the future aviation needs of the state over a 20-year planning period." In 1999, Wisconsin Act 9 required a comprehensive update to all planning laws. They required nine elements as a foundation for the comprehensive plans these include: issues and opportunities; housing; transportation; utilities and community facilities; agricultural, natural, and cultural resources; economic development; intergovernmental cooperation; land use; and implementation. The 1999 Act encourages communities to take an "all-inclusive approach" to determining the future needs of its residents. The state provided both administrative assistance and a transportation planning resource guide to communities.

In 1996, the Brown County Board of Supervisors adopted the Austin Staubel Airport Zoning Ordinance. This regulates the land within three miles of the airport boundary by providing three districts with land use restrictions extending below DNL 65 dB. District A, Noise Cone/Crash Hazard Zone, extends from the runway ends and encompasses all areas within DNL 65 dB. District B, Overflight/Noise Zone, extends one mile beyond District A and encompasses all areas subject to aircraft takeoffs and landings, but is below DNL 65 dB. District C, Height/Noise Zone, is the remaining land within three miles of the airport's boundaries, and requires building permits and informing applicants that the area is subject to moderate noise and frequent aircraft overflights.

ENVIRONMENTAL CONSIDERATIONS

Chicago Climate Exchange. 2007. http://www.chicagoclimatex.com/.

This is a market website that provides market values for the trade and exchange of CO_2 emissions. It provides current estimates of the value of CO_2 from aircraft engines.

Commission of the European Communities. *Air Transport and the Environment: Towards Meeting the Challenges of Sustainable Development*. Communication from the Commission to the Council, the European Parliament, the Economic and Social Committee and the Committee of the Regions. Brussels, Belgium, December 1999.

This communication serves as the point of reference for the Commission's work program from 1999 to 2005 and beyond. The work program includes measures to be applied at the level of airports and stresses the integration of environmental goals into airport policy, dealing in particular with CO_2 emissions and aircraft noise. Proposals include development of a common noise measurement and classification system for the EU and implementing noise monitoring, noise zoning, and land use rules around airports. Compatible land use planning is essential to ensure that the gains achieved by the reduction of noise at source are not offset by further residential and other non-compatible developments around airports. However, since land use planning is under local control, the commission recommends a guidelines approach and the possibility of leveraging airport development funds to encourage proper land use.

Davis, Mark N. Valuation of the Global Warming Impacts of UK Aviation. Masteral Thesis, Imperial College of Science, Technology and Medicine, September 2003.

In 2003, the UK Government conducted a benefit-cost analysis (BCA) of airport capacity expansion. The BCA, however, covers a narrow range of economic impacts and does not provide monetary values for environmental impacts of airport capacity expansion. This thesis seeks to fill

some of the gaps in the BCA by valuing the global warming impacts of capacity expansion. This thesis served as the basis for POSTnote Number 207 published by the Parliamentary Office of Science and Technology in November 2003.

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

This paper presents an estimate of the costs of two major pollutants – SO_x and NO_x – which result from shipping traffic in the United States. The authors implicate the growing international trade regime in the process, since free trade has resulted in additional foreign vessel traffic to the United States. The estimates for the total costs per year are $51 million for SO_x and $144 million for NO_x. The authors' state: "these costs represent abatement costs by private firms equal to the amount of externalities required to be abated under current air regulations." The additional costs of externalities such as health, ecosystems, acid rain, and the like, must be added to the estimate for the total costs for SO_x and NO_x.
To accomplish this, the authors add social costs, which are derived from previous studies conducted by the EPA and other authors, to their estimates. It should be noted that the estimates for such social costs vary widely: SOx costs range from approximately $1,000/ton to $3,000/ton and NO_x costs range from about $1,000/ton to $12,000 ton.

Intergovernmental Panel on Climate Change. "Aviation and the Global Atmosphere." 1999. http://www.grida.no/climate/ipcc/aviation/index.htm.

This article focuses mainly on the global warming impacts of aviation activity and does not discuss local air quality impacts. Approximately two percent of all anthropogenic CO_2 is produced by aviation activity and 13 percent of all transportation-related CO_2 is a result of air transport. Other major pollutants produced by aviation activity include methane (CH_4), nitrogen oxides (NO_x), sulfur oxides (SO_x), water vapor (H_2O), and others. Each of these gases have different atmospheric residence times, and therefore, differing geographic impacts. The article does not put economic valuations on these impacts, but rather suggests that aircraft are responsible for about three and one-half percent of all radiative forcing. Possibilities for reducing impacts are likely to come from future improvements in aircraft engine technology and more efficient air traffic management.

Lidskog, Rolf, and Linda Soneryd. "Transport Infrastructure Investment and Environmental Impact Assessment in Sweden: Public Involvement or Exclusion?" *Environment & Planning 32*, no. 8, 1465–1479, August 2000.

This paper analyzes the Swedish EIA process to see if it results in effective sustainable development in the context of an airport expansion proposal. The impacts of the project were identified as increased air pollution, increased noise, and increased environmental risk (to birds). The process is confused by the fact that the municipality has a dual role as both promoter of economic growth and protector of the environment. The authors note the following problems:

- The local population does not attend public meetings.
- In cases where the public does attend, they have very little impact on the decision.
- The EIA is done too late in the planning process
- The descriptions of impacts are often technical and difficult for non-experts to understand.
- The EIA is not objective and neutral as it often includes arguments that the project will not lead to environmental risks.
- The EIA considers the environmental impact only of a single project.
- In short, airport planning would be more effective if surrounding communities were included.

Parliamentary Office of Science and Technology. "The Environmental Costs of Aviation." POSTnote Number 207, November 2003. www.parliament.uk/documents/upload/postpn207.pdf

This document reviews the key categories of costs that must be considered when conducting an environmental/economic assessment of the overall costs of air-transport activity. Three types of effects are considered: global warming, local air quality and noise. For aviation in the United Kingdom (UK), the costs for 2000 are valued at £1.4b ($2.61 USD), £119-236($221.54-$439.36 USD), and £25m ($46.51 USD), respectively.
Several valuation methods are reviewed, including the use of market prices, stated preferences, revealed preferences, and the use of similar estimates from other contexts.
Estimates of global warming were derived from a government estimate that each additional ton of CO_2 will result in £70 of damage. Because CO_2 is only one of the many greenhouse gases emitted by aircraft engines, a multiplying factor of 2.7 was used.
The UK government review of noise studies concludes that house values fall between 0.5 and 1.0 percent for each noise unit (dBA Leq) rise. While techniques to derive these estimates are well-known, there are problems in that some studies actually show that the added value of proximity to an airport outweighs the negative effects of noise, as well as other confounding relationships. The UK government uses an estimate of 0.6 percent per decibel reduction in real estate values for each dB greater than 57 dB.
Regarding local air quality, the report focuses on the effects of particulate matter (PM10) and nitrogen oxides (NO_x). The costs related to these items are derived from damage to crops and structures, and impacts on health and to biodiversity. The specific techniques for valuation are not provided. Other potential impacts discussed include "landtake, heritage, wildlife habitat, and water and waste." The claim is also made that aviation is partially responsible for impacts relating to the production of fuel, aircraft, housing, and tourism that occur as a result of air transport. Again, no attempt is made to specifically value these items.
The report warns that several issues must be considered in making valuations, including the recognition of uncertainty, and the fact that policy decisions based upon those valuations will result in those that benefit and those that do not.

Pearce, B., and D. Pearce. "Setting Environmental Taxes For Aircraft: A Case Study Of The UK." CSERGE Working Paper GEC, 2000.

Air transport consumes large amounts of energy per distance traveled per customer. Therefore, the possibility of taxing greenhouse emissions has become a greater possibility. This article discusses the issue in the context of the United Kingdom, where other environmental taxes for land fill deposits, extractive industries, etc. have been considered. The authors argue that market-based approaches are preferable, but that care must be taken to insure that the taxation scheme is efficient and effective in meeting its ultimate goals. In Europe, both Zurich and multiple airports in Sweden have enacted emissions and noise taxes.
One suggestion for calculating air emission taxes is: $Tj = \sum_i e_{ij} p_i$ where j is the aircraft type, i represents various pollutants, and p is the price of pollutants. For places that have enacted such taxes, effects have been minimal since they are low in comparison with overall costs of airline operations.

Noise costs are calculated by first calculating Leq and then determining the marginal cost per aircraft event (by aircraft type). The cost of noise for one aircraft event is then given as $tn_{i,m} = DHPD\ x\ \delta Leqi/\delta N$, where DHPD is the daily price depreciation in housing values, Leq is sound level, and N is total aircraft movements.

At Heathrow, noise costs are calculated and range significantly depending on the aircraft type (e.g., £168 ($312.75 USD) for a 744; £44 ($81.91 USD) for a 752).

Air emission taxes are calculated for a variety of chemicals including CO_2, O_3, and CH_4. Adjustments are made for long-haul, short-haul, and aircraft type as well as altitude. The overall environmental tax is then the air emission taxes plus the noise costs.

Stenzel, Jennifer, Jonathan Trutt, Carolyn Cunningham, and Richard Kassel. "Flying Off Course: Environmental Impacts of America's Airports." New York: Natural Resources Defense Council, October 1996.

This report discusses the results of a study about the environmental impacts of airports. A questionnaire, addressing land use, water quality, air pollution, expansion plans, and basic geographical information, was sent to the nation's 125 busiest airports (46 responded). In depth research was conducted on the 50 busiest airports. The issues "found to be most significant [were] noise and land use, ground-level air emissions, water pollution, and, on a more global scale, climate change and energy efficiency." Findings indicate that noise will increase, average sound level measurements do not accurately reflect noise problems, the Environmental Protection Agency (EPA) could play a greater role in addressing airport noise impacts, and efforts focus on noise reduction and outreach rather than land use planning. The report recommends that the FAA use 55 dB CNEL instead of 65 dB DNL contours for measuring noise impact and that single-event noise be taken into account. Further recommendations include: site specific noise mitigation plans, disclosure of noise impacts, and more EPA research on the health effects of noise.

United Kingdom Civil Aviation Authority. *ICAO Aircraft Engine Emissions Databank*. http://www.caa.co.uk/default.aspx?categoryid=702&pagetype=90.

This databank provides technical emissions data for aircraft engines that are or have been in production. Data are provided by aircraft engine manufacturers.

US Code. Title 42, The Public Health and Welfare. Chapter 55, National Environmental Policy, Sec. 4321. National Environmental Policy Act (NEPA) of 1969.

The NEPA resulted from the development of guidelines for the application of a federal government national policy to consider impacts of proposed action on the environment. The act specifically states that "governments, and other public and private organizations, use all practical means and measures to create and maintain conditions under which man and nature can exist in harmony." When an airport sponsor proposes a project or action requiring federal approval, then all actions are reviewed to determine their impacts on the environment.

United States Department of Transportation, Federal Aviation Administration Advisory Circular 150/5200-34, "Construction or Establishment of Landfills near Public Airports," August 26, 2000.

This AC provides guidance regarding compliance with new federal statutory requirements for the construction or establishment of a municipal solid waste landfill facility (MSWLF) units near public airports. Section 503 of the Wendell H. Ford Aviation Investment and Reform Act for the 21st Century (AIR-21), Pub. L. No. 106-181 (April 5, 2000) replaced Section 1220 of the 1996 Reauthorization Act, 49, USC Statute 44718(d), with new language that further limits the construction or establishment of a MSWLF unit near certain smaller public airports.

These new limitations apply only to airports receiving federal grants, or to those that primarily serve general aviation aircraft and scheduled air carrier operations using aircraft with fewer than 60 passenger seats. The new restrictions require a minimum separation distance of six miles between a new MSWLF unit and a public-use airport.

United States Department of Transportation, Federal Aviation Administration. FAR Part 258, Subpart B, "Criteria for Municipal Solid Waste Landfills," CFR Title 40, March 24, 2004.

This subpart establishes criteria for the expansion and/or development of new landfills with regard to airports. In part, it states: "Owners or operators of new Municipal Solid Waste Landfills (MSWLF) units and lateral expansions located within 10,000 feet (3,048 meters) of any airport runway end used by turbojet aircraft, or within 5,000 feet (1,524 meters) of any airport runway end used by piston-type aircraft only, must demonstrate that the units are designed and operated in such a way that the MSWLF unit does not pose a bird hazard to aircraft."
Owners or operators proposing to site new MSWLF units and lateral expansions within a five-mile radius of any airport runway end used by turbojet or piston-type aircraft must notify the affected airport and the FAA.

United States Department of Transportation, Federal Aviation Administration. Investment Analysis and Operations Research. "Draft Guidelines for Quantifying the Environmental Benefits of An Investment Analysis," September 29, 2000.

This paper describes techniques to quantify changes in emissions due to technological improvements. The paper, however, states that environmental benefits cannot be monetized.

The emissions of primary concern included in this study are:

- Carbon Dioxide (CO_2)
- Nitrogen Oxides (NO_x)
- Carbon Monoxide (CO)
- Hydrocarbons (HC)
- Sulfur Dioxide (SO_2)

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

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

United States Department of Transportation, Federal Aviation Administration. Order 1050.1E, Change 1, "Environmental Impacts: Policies and Procedures," March 20, 2006.

This is the FAA's agency-wide environmental protocol for compliance with National Environmental Policy Act (NEPA), which implements the Council of Environmental Quality's (CEQ) regulations. Appendix A, Section 14, addresses noise. The FAA's primary metric for aviation noise analysis is the "cumulative noise energy exposure of individuals to noise resulting from aviation activities and must be established in terms of yearly day/night average sound level (DNL) or the alternative metric for California is CNEL (Community noise equivalent level)." An initial noise analysis is accomplished during the environmental assessment in order to determine if significant noise impacts are expected for forecasted conditions. A significant noise impact occurs if the proposed action "causes noise sensitive areas to experience an increase of DNL 1.5 dB or more at or above the DNL 65 dB noise exposure when compared to the no action alternative for the same time frame." If significant noise impacts are expected, then either mitigation that reduces noise impact below the significant noise impact threshold levels or a more detailed analysis as part of an environmental impact statement (EIS) is required. All detailed noise analysis must use the FAA's Integrated Noise Model (INM), Heliport Noise Model (HNM), or Noise Integrated Routing System (NIRS). The determination of significance is based on a detailed grid point map identifying local land uses overlaid with the appropriate FAA model's noise exposure contours of DNL 75 dB, DNL 70 dB, and DNL 65 dB. Additional contours and supplemental noise analyses are optional and determined by the FAA on a case-by-case basis.

The FAA recognizes that DNL 65 dB and FAR Part 150 land use guidelines may not be applicable in unique noise sensitive areas. Therefore, special consideration should be given for the evaluation of significant noise impacts within national parks, wildlife refuges, historic sites, tribal sacred sites, or cultural properties. Further, the FAA recommends that noise levels between the DNL 65 to 60 dB should be examined if the increase of 1.5 dB occurs at or above DNL 65 dB. Finally, if a noise impact is found in a noise sensitive area below the DNL 65 dB, then mitigation should be incorporated, but federal funding is not guaranteed for implementation of these measures.

United States Department of Transportation, Federal Aviation Administration. Order 5050.4B, "Airport Environmental Handbook," April 28, 2006.

This regulation establishes the instructions and guidance for preparing and processing an environmental assessment (EA), Finding-of-No-Significant-Impacts (FONSI), and an Environmental Impact Statement (EIS) for the federal action on airport development proposals requiring federal environmental approval. Categories of impacts to be evaluated are found in Chapter 5 of Order 5050.4A and include:

- Noise - outlines the parameters that an airport must meet before a noise analysis is required. It is predominately associated with the fleet mix of aircraft and an annual number of more than 700 jet operations.
- Compatible Land Use - defined as "the compatibility of existing and planned land uses in the vicinity of an airport … usually associated with the extent of the noise impacts related to that airport."
- Social Impacts - associated with relocating residences or businesses, altering surface transportation patterns, dividing or disrupting established communities, or disrupting orderly, planned development.
- Induced Socioeconomic Impacts - addresses such issues as population movement and growth, public service demands, and changes in the business and economic activity in the community created by the proposed airport development. These impacts are further affected by significant factors in the noise, land use, and direct social impact categories.
- Environmental Justice - identify, address, and avoid disproportionately high and adverse human or environmental effects on minority and low-income populations.
- Air Quality - the Clean Air Act (CAA), administered by US Environmental Protection Agency (EPA), establishes national air quality standards. An air quality analysis is required for airport development involving airport location, runway development, or physical airside and/or landside improvements that increase airport capacity. An air quality analysis is also required for any proposed development that does not conform to an approved state implementation plan for controlling area-wide air pollution impacts.
- Water Quality - the quality of ground and surface water must not be degraded by planned construction. The Federal Water Pollution Control Act, as amended by the Clean Water Act of 1977, provides the authority to establish water quality standards. Section 404(b)(1) of the Clean Water Act of 1977, provides for the protection of waters, including wetlands, and requires that alternatives, including mitigation, be considered. Section 401 of the Clean Water Act is administered at the state level through individual departments. Section 401 works to protect waters from being polluted by water runoff from such activities as aircraft refueling, aircraft deicing, and general storm water runoff.
- Department of Transportation, Section 4(f) - no program or project requiring the use of any publicly owned land from a public park, recreation area, wildlife refuge, or waterfowl refuge be permitted, unless there is no other alternative and that the planning of such program or project includes plans to minimize harm resulting from the use of the property. This legislation was superseded by Section 303C of the Title 49, USC; however, the criteria remain the same.
- Historical, Architectural, Archaeological, and Cultural Resources - based upon the requirements of the National Historic Preservation Act of 1969, the coordination of federal

historic preservation matters and recommended measures for coordinating federal historic preservation activities are required prior to obtaining environmental clearance. Comments on federal actions affecting properties included in or eligible for inclusion in the National Register of Historic Places are also referenced. The Secretary of the Interior is authorized to maintain a record, the National Register, of objects of significance to American history, architecture, archaeology, and culture.

- Biotic Communities - protect living communities, including native and introduced plants and animals in the project area.
- Endangered and Threatened Species of Flora and Fauna - the Endangered Species Act, Section 7, as amended, requires each federal agency to ensure that any action authorized, funded, or carried out by such an agency is not likely to jeopardize the continued existence of any endangered or threatened species. Administered by the United States Fish and Wildlife Service, this act ensures that proposed projects do not result in loss of habitat.
- Wetlands - protects wetland areas which can be defined by numerous methods. One wetland definition includes an area being inundated by surface or ground water with a frequency sufficient to support a prevalence of vegetative or aquatic life requiring saturated or seasonally saturated soil conditions for growth and reproduction.
- Floodplains - protect "the lowland and relatively flat areas adjoining inland and coastal waters, including flood-prone areas of offshore islands that are subject to a one percent or greater change of flooding in any given year."
- Coastal Zone Management - preserves and protects the nation's coastal zone and encourages wise use of a coastal zone's land and water resources. It also prepares a plan to provide protection for natural resources and coordinates public, federal, state, local, interstate, and regional agencies and governments affecting the coastal zone.
- Coastal Barriers – the Coastal Barriers Resources Act of 1982, PL 97-348, prohibits, with some exceptions, federal financial assistance for development within the Coastal Barrier Resources System, which consists of undeveloped coastal barriers along the Atlantic Ocean or Gulf Coasts.
- Wild and Scenic Rivers – the Wild and Scenic Rivers Act describes those river areas eligible for protection under the act as flowing and possessing "outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values."
- Farmland - the Farmland Protection Policy Act authorizes the Department of Agriculture to develop criteria for identifying the effects of federal programs on the conversion of farmland to non-agricultural uses.
- Energy Supply and Natural Resources - energy requirements generally fall into two categories: those that relate to changed demands or stationary facilities (e.g., airfield lighting and terminal building heating) and those that involve the movement of air and ground vehicles. Changes in energy or other natural resource consumption will not result in significant impacts for most airports.
- Light Emissions - consideration will be given to any lighting associated with an airport that will create an annoyance among people in the vicinity. An environmental assessment or environmental impact statement should consider site location, type of system, and measures to lessen the annoyance.
- Solid Waste Impacts - airfield development (runways, taxiways, and related items) usually will not have any direct relationship to solid waste collection. Terminal area development may require consideration of solid waste impacts. Consultation with local officials regarding solid waste disposal facilities must be documented in the environmental assessment or impact statement.
- Construction Impacts – any specific activities that may create adverse environmental conditions including noise, dust, air pollution from burning debris, and water pollution from erosion, must be discussed in the environmental assessment or impact statement. In general, a description of the type and nature of the construction and measures taken to minimize potential impacts should be detailed.
- Design, Art, and Architectural Application - normally, the EA or impact statement will include some discussion of design, art, and architecture, in mitigating adverse visual and other

environmental impacts, and will encourage enhancement of the environment. The FAA's Airport Improvement Program Handbook presents guidelines for treating and promoting design, art, and architectural objectives in airport aid projects.

United States Environmental Protection Agency. The Benefits and Costs of the Clean Air Act, 1970 to 1990. EPA Report to Congress, October 1997.

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

United States Environmental Protection Agency. "The Benefits and Costs of the Clean Air Act, 1990 to 2010." EPA Report to Congress, November 1999.

This report to Congress presents the results and conclusions of Environmental Protection Agency's (EPA) analysis of the benefits and costs of the Clean Air Act for the period from 1990 to 2010. This prospective analysis consists of six steps:

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

Estimates of reduction in pollutant emissions serve as the stating point for benefit and cost estimates. The emissions analysis focuses on six major pollutants: volatile organic compounds (VOCs), nitrogen oxides (NO_x), sulfur dioxide (SO_x), carbon monoxide (CO), coarse particulate matter (PM_{10}), and fine particulate matter ($PM_{2.5}$). The results of the emissions analysis feed into a linked series of models to estimate changes in air quality, human health effects, ecological effects, and, ultimately, the net economic benefits of the Clean Air Act Amendments.

United States Environmental Protection Agency. "Clean Air Markets." 2007. http://www.epa.gov/airmarkets/index.html.

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

United States Environmental Protection Agency. "Clearing the Air: The Facts about Capping and Trading Emissions." May 2002. http://www.epa.gov/airmarkets/presentations/docs/clearingtheair.pdf.

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

United States Environmental Protection Agency. "Community Noise." December 31, 1971.

This document is an early study of noise in communities that quantifies general outdoor noise versus intruding noise levels, attempts to relate community reaction to noise level, and explores increases in noise pollution. It recommends measuring to set a community noise baseline; defining speech privacy requirements; establishing source noise standards; researching effects of noise on health, sleep, and speech communication; determining the relationship between indoor and outdoor noise on individual reactions; determining noise criteria for people in parks; and quieting city street canyons. It also contains data from extensive noise measurements conducted in a range of communities in California.

United States Environmental Protection Agency, "Impact Characterization of Noise Including Implications of Identifying and Achieving Levels of Cumulative Noise Exposure." PB224408. July 1973.

The United States Environmental Protection Agency (the Administrator) was required by the Noise Control Act of 1972, Sec. 7(a), to conduct a study of the "…implications of identifying and achieving levels of cumulative noise exposure around airports…" A so called Task Group 3, chaired by Henning von Gierke, was formed specifically to conduct this study. This Task Group Report describes the rationale for each recommendation. The selection of a measure of cumulative noise exposure was to correlate with human responses regarding hearing loss, sleep and speech interference and annoyance, and the identification of maximum permissible levels was based on the protection of the public health and welfare.

The measure of cumulative noise was the "Day-Night Average Sound Level" or "Day-Night Level." Task Group 3 reached the conclusion that "…to achieve an environment in which no more than 20% of the population are expected to be highly annoyed and no more than 2% actually to complain of noise, the outdoor day-night average sound level should be less than 60 decibels. Higher noise levels must be considered to be annoying to an appreciable part of the population, and consequently to interfere directly with their health and welfare."

United States Environmental Protection Agency, "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety," March 1974.

The Noise Control Act of 1972 (Public Law 92-574) required the Administrator of the United States Environmental Protection Agency to publish "…information on the levels of environmental noise the attainment and maintenance of which in defined areas under various conditions are requisite to protect the public health and welfare with an adequate margin of safety." The requirement resulted in this report, which is now commonly referred to as "The Levels Document." This report recommended that to provide protection, the value of the outdoor Day-Night Level not exceed 55 dB. This report also contains background information on speech interference, annoyance, and community reaction to noise. Appendix D provides a method to account for non-noise factors in predicting community reactions. These factors include existing noise levels before a new source is introduced, seasonality (windows open or closed), presence of tones or impulse noise, and prior experience with the noise.

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

This document provides a comprehensive guide to the development and presentation of economic assessments for environmental regulations. Three levels of assessment are discussed (in ascending order of complexity and detail):

- Preliminary screening assessment

- Economic Impact Assessment
- Economic Analysis

The required report sections for each type of analysis are provided and discussed. For the most involved of these analyses, the components include:

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

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

Of particular relevance to land use study, is the framework for quantitative benefits analysis described in Chapter 7 of the document. Identifying the benefits of environmental regulation is analogous to identifying reductions in damages caused by pollutant emissions. These damages fall into three categories:

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

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

United States General Accounting Office. "Aviation and the Environment: Airport Operations and Future Growth, Present Environmental Challenges." Washington DC, August 2000.

This report provides "information on (1) the key concerns and challenges associated with airports' current operations and future growth—particularly concerns about noise, water pollution, and air pollutant emissions—and the actions being taken by the nation's busiest airports to balance environmental concerns with such operations and growth and (2) the actions taken by FAA and other federal agencies to address environmental concerns associated with airports' current operations and future growth." Through a literature review and survey, the study found that noise is the primary environmental concern and challenge for airports. The top concern was older aircraft, followed by incompatible local zoning, pressure for residential development, and increasing population. Appendix I cites the San Francisco Airport Roundtable as a model for community involvement in the airport development process and in the identification of environmental effects and concerns. Appendix II discusses Europe's approach which would link specific land use criterion in noise impact zones to funding for airport expansion and improvements.

United States Government Accountability Office (GAO). "Aviation and the Environment, FAA's Role in Major Noise Programs." GAO/RCED-00-98, Washington DC, April 2000.

This is GAO's report on the: 1) types of projects that are eligible for federally authorized funding to reduce airport-related noise or mitigate its effects' 2) differences in the major methods for measuring the impact of airport-related noise, 3) FAA's current noise standards for civil subsonic turbojets and the reasons some of those aircraft are not required to comply with these or earlier standards, and 4) the status of FAA's Land Use Planning Initiative and the major issues the initiative has raised about how best to address airport-related noise.

FAA determines AIP funding eligibility by a priority ranking of projects for areas that lie at or above DNL 65 dB and are part of a FAA approved Noise Compatibility Programs (NCPs). Although incompatible land use projects below DNL 65 dB, such as noise barriers, are eligible for funding, the FAA has approved projects only above DNL 65 dB. Passenger Facility Charge (PFC, see ://www.faa.gov/airports_airtraffic/airports/pfc/.) funding for noise reduction projects has been provided to airports only if the project is part of a FAA-approved NAS Change Proposal (NCP). "More than 75 percent of all Airport Improvement Program (AIP, see http://www.faa.gov/airports_airtraffic/airports/aip/.) funds and over 50 percent of all PFC funds spent on noise reduction or mitigation have been used to acquire land and to soundproof buildings."

The report notes that the cumulative single metric approved by the FAA (DNL) fails to provide sufficient information to effectively convey to people what they can expect to hear in any given area. The report recommends supplemental metrics such as: single event measures (Lmax and SEL) or estimates of population proportions that will be highly annoyed by transportation activities. Annoyance is defined as the noise that interferes with activities such as sleep, relaxation, speech, television, and school and business operations. Although some research has correlated health and welfare effects to single events noise levels, Federal Interagency Committee on Aviation Noise (FICAN) in 1992 asserted that there is no accepted methodology for aggregating the information on single event noise levels that would adequately explain the cumulative impact of those events on people in communities surrounding airports. The report cites the Department of Defense's (DoD) use of single event noise measures for supplemental metrics and recommends the revision of FAA Order 1050.1 in order to use supplemental information where warranted. Note: optional use of supplemental metrics is now permitted in Order 1050.1E change 1.

The report cited that as of December 31, 1999, about 31 percent of civil subsonic turbojet aircraft weighing 75,000 pounds or less are Stage 1 or 2 aircraft. Although the report recommends use of Part 161 to restrict, prohibit, and eliminate these aircraft, it also recognizes the need to apply a cost/benefit analysis before the FAA approves an airport's Part 161 restriction of these aircraft.

Finally, this report cites the five FAA strategies for land use compatibility planning. These include: 1) an information package on FAA noise policies, 2) local zoning and disclosure rules , 3) existing statutes for state aviation organizations,4) an information clearinghouse for federal, state, local, and public users about land use planning , and 5) FAA flight procedures that address impacts below DNL 65 dB. All of these were described on the FAA website. (The links provided within the report are no longer valid, but this information could be located in other areas of the FAA.gov website.) The report criticizes the FAA for maintaining the DNL 65 dB noise level as the threshold for funded projects especially in light of community complaints and annoyance levels at the FAA's threshold. Nevertheless, the report notes that the FAA's threshold focuses federal money on the most incompatible land issues and balances the cost/benefits of all stakeholders. The report also notes that land use planning is the responsibility of local jurisdictions and not the federal government.

Upham, Paul, Callum Thomas, David Gillingwater, and David Raper. "Environmental Capacity and Airport Operations: Current Issues and Future Prospects." *Journal of Air Transport Management 9*, no. 3 (May 2003): 145–151. http://www.sciencedirect.com/, and http://www.elsevier.com/wps/find/homepage.cws_home.

This paper defines the environmental capacity of an airport in terms of "aircraft noise, air quality, third party risk, biodiversity, climate change and community opposition to growth." Aircraft noise is the most important capacity issue. The positive effects of quieter aircraft have been offset by growth in air traffic. Impact can be mitigated in the short term through air traffic control procedures. Effective land use planning is mentioned as a long term measure. The recommendations for maximizing the environmental capacity of airport do not address land use

compatibility. Long term airport planning, including planning for ground transportation infrastructure, is recommended.

Waitz, IA et al. "Aviation and the Environment." Report to Congress: December 2004.

This is the study required by Vision 100 in order to seek ways to reduce aircraft noise and emissions and increase aircraft fuel efficiency. The 59 stakeholders from 38 organizations developed a National Vision for Aviation and the Environment: "In 2025, significant health and welfare impacts of aviation community noise and local air quality emissions will be reduced in absolute terms, notwithstanding the anticipated growth in aviation. Uncertainties regarding both the contribution of aviation to climate change, and the impacts of aviation particulate matter and hazardous air pollutants, will be reduced to levels that enable appropriate action. Through broad inclusion and sustained commitment among all stakeholders, the IS aerospace enterprise will be the global leader in researching, developing and implementing technological, operational and policy initiatives that jointly address mobility and environmental needs."

Three recommendations were made from this study. The first is to establish a federal interagency group to coordinate and communicate governmental actions to reduce the negative impacts of aviation on local air quality, noise, and climate change. This group, formed within the Joint Planning and Development Office (JPDO), will promote public-private joint partnerships, foster open exchange of ideas, and develop a strategic plan with achievable national goals. The second recommendation is to develop metrics and tools that communicate best scientific understandings of aviation's environmental impacts on human health and welfare. The tools should integrate environmental and economic cost/benefit analyses in order to evaluate research benefits of source reduction technologies and operational advancements, assess environmental constraints on airspace expansion, account for airline economics, assess policy and operational decision impacts on communities, and understand aviation's environmental damage and future mitigation costs. The third is to nationally pursue a balanced approach towards development of operational, technological, and policy options to reduce the unfavorable aviation environmental impacts. The report cites a variety of studies and reports that found as environmental public awareness increases, constraints on the aviation system increases such that environmental constraints may impose a fundamental limit on our air transportation system's growth within the 21st century. This report's recommendations are being implemented through The Next Generation Air Transportation System (NGATS).

In 2004, the Presidential commission on the future of the United States aerospace industry concluded that "aircraft noise is the single most local objection to airport expansion and construction." During the past 35 years, the number of people impacted by aircraft noise has been reduced by 95 percent. Unfortunately, noise reduction has slowed due to growth outpacing technological advancements, thereby leaving approximately half a million people living in areas with noise levels above DNL 65 dB. The report cites many examples of local jurisdictions ignoring federal land use guidance to the detriment of airports. For example, Dallas-Fort Worth International and Denver International airports were built in sparsely populated areas and local incompatible land use decisions have lead to problems appearing near these airfields. A disconnect remains between federal aviation policy and local land use decision-making.
Although airports see noise mitigation funding as an essential element in positive community relations, the National Research Council recommends shifting some of the $0.5 billion in federal funding for noise abatement projects (mostly for sound insulation and land acquisition projects) to noise reduction research and technology. NASA's noise reduction goal is to develop technology and achieve a 50 percent reduction in effective perceived noise levels by 2007, but they require increased funding to reach this technologically feasible goal. The FAA currently focuses its research funding on development of better tools and metrics to assess noise impacts and implement operational procedures to mitigate noise impacts. This report recommends a balanced approach that enables funding NASA's research opportunities, continues the FAA's efforts, as well as fostering relationships between airports and local jurisdictions that improve the application of appropriate land use measures near airports.