PLANNING ON NOISE: THE IMPLEMENTATION OF NOISE COMPATIBILITY ZONING IN THE NORTHEAST UNITED STATES

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Abstract

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This study examines the reasons that airport noise compatibility land use regulations are infrequently implemented in the Northeast United States. Noise compatibility land use regulations are advocated by the Federal Aviation Administration as a solution to the negative externality of airport noise but are rarely enacted by local jurisdictions. To investigate the topic, a mixed-methods approach involving document review and interviews is used to assess the historical circumstances under which some municipalities have adopted this form of regulation while others have not. Five case studies of commercial hub airports in the Northeast serve as examples of implementation scenarios and highlight the challenges inherent in the coordination of airport and municipal development.

Background

The impetus for this project was a term paper completed for a course on environmental impact assessment at Columbia University. The project, which focused on the measurement of airport noise and its mitigation, concluded with the recommendation that the best strategy for addressing the issue of airport noise is environmental planning. By restricting the development of land uses sensitive to noise, such as residences, schools and public gathering places, from areas experiencing or expected to experience high levels of aviation noise, the noise impacts could be avoided. Further investigation revealed that it is still an uncommon noise management tactic even though there is federal support for this type of policy and examples of its successful implementation.

A case study that was brought to my attention during this research project was that of Belle Fair, an exurban development of 261 homes in the Village of Rye Brook, New York. In 1999, Westchester County and the Village of Rye Brook approved the development for construction, even though the subdivision is situated very close to the end of the Westchester County Airport's primary runway and would therefore experience high levels of aircraft noise. While the County required the homes to be very well insulated, the new construction resulted in noise-sensitive land uses being developed in areas most affected by aircraft operations, increasing the likelihood of future land use conflicts.

Throughout the United States, in cases similar to Belle Fair, residential developers build housing and other noise-sensitive uses in approach and departure paths, increasing the population exposed to aircraft noise. Consequently, in many cases, complaints about airport often noise increase, public opinion toward the airport declines, and communities organize in opposition. In the case of Westchester County Airport, communities have leveraged political power and taken legal action to demand mitigation of noise and restrict airport expansion.

Belle Fair Development near Westchester County Airport

To prevent this land use conflict, airport operators and municipalities are capable of collaborating to implement land use regulations that restrict noise-sensitive uses from undeveloped areas that experience high levels of aviation-related noise. The working hypothesis of this early research—the underlying assumption that led to the research question—is that these regulations can protect an airport from

encroachment by preventing the development of noise-sensitive uses while also preventing unknowing residents from living, working or sending their children to school in an area experiencing unbearable levels of noise. It was easy to conclude, given this assumption, that both airports and municipalities would be motivated to implement regulations to ensure land uses that are compatible with the airport. The airport would have an interest in preventing development that interferes with expansion or operation, while municipalities have an interest in protecting communities from the negative effects of noise.

Even with these consequences, however, few municipalities have restricted sensitive land uses in noise-affected areas. Some cities have even guided residential development into noise-affected areas in opposition to vocal airport officials. For example, in the 1970s, Alameda, California, planned extensive residential and recreational uses on land adjacent to Oakland International Airport (Blitch 1975). The housing built in this area was immediately exposed to high levels of aircraft noise.

The intent of this research is to explore the relationship between airports, surrounding municipalities and potential residents to identify the reasons that some airport operators have been able to coordinate development with local governments while others have not. Why, given that airport noise has negative consequences for both municipalities and airport operators, have more cities not restricted land uses sensitive to noise from noisy areas? Why have some cities implemented these regulations while others have not?

The explanation to these questions that was initially proposed by this investigator is based on two related ideas. First, decisions made at the federal and state level early in the history of jet aircraft represented critical junctures that resulted in a single set of standards for measuring and responding to aircraft noise in communities. These standards established a dose-response relationship for measurement and specified tolerable noise thresholds. The hypothesis predicted that this standardized system of noise measurement and the accompanying noise compatibility recommendations do not meet the needs of all communities, and therefore were not widely adopted. Since the experience of noise is highly subjective and the impacts vary at both the individual and community level the standardized noise thresholds would not be acceptable for every community. As a result, it was predicted that local governments would be unable or unwilling to adopt the standards regulations. Moreover, if this were to happen, the standardized system of measurement would provide local governments with few alternatives to the prescribed recommendations. They would receive no technical assistance from the FAA to negotiate noise compatibility standards with municipalities.

Second, the local governments that have collaborated with airports to implement noise compatibility regulations have worked to encourage, incentivize, or otherwise promote alternatives to residential

development around airports, such as industrial parks or retail centers, before encroachment could occur into noise-affected areas. The outcome—implementation or not—is the result of municipal planning and development decisions made much earlier, before encroachment was problematized by either residents or airport authorities.

Literature Review

The purpose of the literature review is to situate the investigation of airport noise regulation within a theoretical framework, elaborate on the research question, and provide justification for the hypothesis.

Airport Noise as an Externality

At its foundation, airport noise is a problem of negative externalities. A negative externality is defined as a cost that is not incorporated into the price of the good. The production of air travel results in both private and social costs. Airport noise, as an externality, results in a social cost; the cost is not paid for by the producers and consumers of air travel, but instead by those affected by the noise. The private costs of air travel include the costs associated with the inputs, such as aircraft, airports, fuel, and labor. These goods—required for the production of air travel—are priced in the market. In contrast to private costs are social costs. The social costs of air travel are the costs incurred that are not factored into the market price, such as noise, air pollution and congestion; they are borne by the communities surrounding airports. More specifically, these costs include annoyance, health impacts, and property devaluation. The measurement of social costs is complicated by the variability of individual response to noise. The costs associated with airport noise and community response are described in greater detail below.

Airport noise, when affecting surrounding communities, is an example of a market failure, because costs are borne by the community that are not incorporated into the market. In traditional microeconomic theory, a market failure occurs when a market is not Pareto Efficient—the market is not reaching equilibrium at an optimal point and can continue to improve outcomes for some individuals without making outcomes for other individuals worse.

Strategies to prevent land use conflicts or mitigate airport noise are policy interventions to correct a market failure. The market inefficiency can be corrected by incorporating the social cost into the price with a tax (Baumol 1972). Others argue that the problem of negative externalities, in the absence of transaction costs, can be solved through negotiation (Coase 1960). However, market mechanisms are not the only tools available to planners to correct market failures. The market may be regulated through command-and-control policies to prohibit or restrict the activity generating the externality. Restricting noise-sensitive development with land use regulation is an instance of this strategy.

Jurisdictional Responsibility

The implementation of noise compatibility land use regulations is complicated by jurisdictional arrangements in the United States. The majority of the costs of airport noise are borne by the residents of municipalities that surround airports, and the authority to adopt noise compatibility land use recommendations is held by local jurisdictions. Airports may recommend the adoption of land use measures, but the authority to adopt these recommendations is held by the local jurisdiction. Airport operators, rather than airlines, municipalities, or the Federal Aviation Administration, are legally liable for the noise impacts generated by the airport (Welich 1981). The actor that generated the cost—the airport—has little ability to address the issue without the cooperation of neighboring municipalities, but is still held accountable for its damages.

Commercial airports are typically publicly owned and operated by a government entity and have authority only over the property that is owned. In some instances, the owner of the airport is the municipality, permitting the airport to make recommendations to other departments within the same jurisdiction. In other cases, such as New York City, the operator of the airports is a state authority, distinct from the city government responsible for land use regulation.

Technical Standards

The CEQR Technical Manual begins its chapter on noise assessment with a succinct description of the underlying problem of noise, "Noise, in its simplest definition, is unwanted sound" (CEQR). While the absolute level of sound can be measured with ease, assessing the impact of noise is more difficult since its perception is highly subjective. A regulation, however, standardizes the measurement of subjective impacts. Although the response to noise is subjective, noise compatibility planning has an objective, highly structured process. The adoption and promulgation of a single set of noise compatibility planning regulations (see CFR 14 Part 150) has led to a particular set of acceptable methodologies becoming institutionalized.

The institutionalization of a particular methodology is neither an inherently good nor bad outcome. The standardization of regulation is "generally advantageous" and can improve public health and wellbeing, encourage best practices, reduce costs, and increase confidence in the market (Srinivas 2005, 14). An off-the-shelf solution for noise compatibility land use regulation allows eases implementation for some municipalities. The regulatory standards may be "good," but their assessment must take into account their relationship to "development concerns" and "local needs" (Srinivas 2005, 48).

Technical Standards of Noise Measurement

Noise is assessed with a variety of different metrics including sound pressure level, A-weighted sound pressure level, continuous equivalent level, day-night equivalent level, sound exposure level, maximum a-weighted sound level, and time above. Each of these tools provides a different perspective on a given noise event; aircraft noise is usually described with a combination of these measurements.

The fundamental unit of sound measurement is the sound pressure level or SPL. The measurement represents the difference between the ambient pressure and the pressure generated by the sound wave. It is expressed in decibels on a logarithmic scale; the threshold of human hearing is set to zero decibels. Since the decibel scale is logarithmic, a sound with an SPL of 70 dB is experienced as ten times louder than a sound at 60 dB. A change in noise of 3 dB is not usually perceptible, while a change of 5 dB is generally perceptible.

While the sound pressure level, expressed in decibels, measures the difference between ambient pressure and the pressure generated by the noise wave, it is not an accurate representation of the human sensitivity to noise. The perception of the sound is influenced by the frequency, or pitch, of the sound. A high pitched noise at an SPL of 60 dB may be perceived as louder than a low pitched noise at the same sound pressure level. To compensate for this characteristic, sound pressure levels are computed as a-weighted levels (dB(A)).

The sound pressure level and weighted sound pressure level are instant measurements. They assess the level of sound at a given moment but are not representative of overall noise experienced at an assessment site. To represent the noise exposure at a given location, the continuous equivalent level measurement (L_{eq}) is used. This descriptor represents the average SPL over a given time period, included in parenthesis. The $L_{eq(12)}$ is the SPL that, if held constant over a 12 hour measurement period, would result in the same sound-energy output as the observed, disparate SPL measurements.

The continuous equivalent level descriptor is modified to create the day-night equivalent level (DNL). The DNL represents a measurement of SPL taken over a 24 hour long period. Measurements of SPL taken between the hours of 10 PM and 7 AM are adjusted upward by 10 dB to account for the extra sensitivity to noise experienced by communities at night and then averaged. This measurement is used in environmental impact assessments and to determine the boundaries of noise compatibility overlay zones.

The Regulatory Standards of Noise Measurement

These standardized metrics are employed in a standardized noise compatibility planning procedure. This system is encouraged and promulgated by the Federal Aviation Administration and State Departments of Transportation and is closely tied with the community noise level recommendations of other federal bodies such as US Department of Housing and Urban Development and the US Environmental Protection Agency.

To measure existing and potential noise impacts, the Federal Aviation Administration (FAA) has developed a system to analyze and address potential impacts. The basis of a civil airport noise assessment is the Integrated Noise Model (INM). The INM is a computer model within a geographic information system that describes noise based on airport operation parameters. The model requires an airport master plan, flight path data, aircraft models utilizing the airport, and terrain. The output is a noise metric that can be visualized as noise exposure maps. The noise exposure maps, also called noise contour maps, indicate the location and severity of airport noise impacts. This information is displayed in contours, or bands, based on five DNL increments. These maps provide a convenient, easily readable visualization of the predicted effects of airport traffic. The contours from these maps can be exported and used in common geographic information system software. These maps become the basis for noise compatibility overlay zones.

Community Reaction

A listener's experience of sound and attitudes towards it are important factors in determining the perceived annoyance of the sound impact. Numerous studies emphasize the subjectivity of community response to noise. In a seminal review of community noise surveys, Schultz concludes that, while the correlation between individual subjective response and noise is poor, the correlation between community response and noise level is relatively high (Schultz 1978). The study resulted in the development of the metric "percent highly annoyed" and the dose-response relationship illustrated by the Schultz Curve. The relationship between noise level and the percent of the community annoyed are positively correlated.

In a retrospective on Schultz's contribution, Fidell writes that "land use compatibility recommendations (notionally linked to dosage-effect analysis, which in turn relies on cumulative noise exposure as a sole predictor variable) have effectively displaced all other interpretations of transportation noise effects for federal purposes." The Schultz Curve and the dose-response relationship it predicts is not a perfect predictor of community annoyance. Fidell continues, "high levels of annoyance can exist at low levels of noise exposure, and low levels of annoyance can exist at high levels of noise exposure" (Fidell 2003).

The dose-response metrics that emerged out of Schultz's relationship are a poor metric for determining policy.

Substantial research has reported that a variety of factors influence noise annoyance, in addition to noise levels. A community's attitude toward the source of the noise and sensitivity to noise explain more variation than level of noise exposure (Job 1987). Fear and noise sensitivity strongly affect levels of noise annoyance (Miedema 1998). Annoyance is influenced by "isolation from sound" and other attitude-based variables, such as fear of danger, attitudes to noise prevention, sensitivity to noise, beliefs about the importance of the noise source, and annoyance with the noise source itself (Fields 1993).

Health Effects

Like a community's annoyance to noise, community health impacts are also methodologically challenging to measure. Although excessive environmental noise has been found to negatively affect health in numerous ways by contributing to noise-induced hearing impairment, cognitive issues, sleep disturbance, mental health problems, hypertension, and cardiovascular disease (Passchier-Vermeer 2000), the noise generated by aircraft traffic around airports rarely generates the levels of noise necessary to cause the most severe consequences.

There has been substantial research conducted on community health impacts of aircraft noise. For instance, the WHO reports that cardiovascular effects, such as hypertension, may result from $L_{eq(24)}$ values between 65 and 70 dB(A) (Berglund 1999). It also notes that lifetime environmental noise exposure of less than 70 dB(A) $L_{eq(24)}$ will not result in hearing impairment in most people. Airport noise has been shown to affect cognitive development in children. Noise from aircraft has been associated with poor reading comprehension and long-term memory in children. These results suggest that chronic noise exposure can significantly impair cognitive function (Haines 2001). Another study concludes that children exposed to aircraft noise have less developed reading abilities than children attending school in a quiet neighborhood (Evans 1997).

Other studies conclude that research involving aircraft noise and health is methodologically inadequate and inconclusive (Morrell 1997). The Federal Interagency Commission on Airport Noise notes that "there is significant debate over whether aircraft noise causes long-term physiological effects" but also states that "there have been no studies to date that have found significant results" (FICAN 2008).

Economic Effects

The impact of aircraft noise on property values is well documented in the literature. A meta-analysis on airport noise and residential property values concludes that "a given property located at 55 dB would sell for about 10 to 12 per cent less if it was located at 75 dB, all other things held constant." In dollars, "a $200,000 house would sell for $20,000 to $24,000 less, which yields a hedonic price of $1000 to $1200 per dB" (Nelson 2004). The negative property value effects of airport noise are one of the other commonly cited reasons for resistance to airport expansion.

An airport has also been shown to increase property values. Other research suggests that, with a different scale of analysis, the positive attributes of an airport could be valued more by local residents than the negative externalities generated by the airport (Tomkins 1998). A similar study, incorporating an additional spatial variable, concludes that noise decreases home prices, but values also increase with proximity to the airport (Cohen 2008).

Residents moving into housing developments constructed in highly noise-affected areas are receiving a discount on their properties as a result of the costs of the noise externality. Some portion of the social cost is capitalized into the price of homes. However, they may not be fully aware of the impacts of noise and, without perfect information, be unable to make rational decisions. Therefore, the costs of the noise are not fully capitalized into the price of housing.

Economists have investigated the role of information in determining the discount created by airport noise. In one such study, the role of imperfect information in pricing noise in the housing market is examined by assessing the effect of a noise impact disclosure law. Pope theorizes that homebuyers, when selecting a residence, may not fully understand the impacts of noise, and make purchasing decisions that do not incorporate the disamenity generated by noise. He writes that, "airports receive numerous complaints from new residents, indicating that they were unaware of the presence or extent of the airport noise before purchasing their homes." The study concludes that noise disclosure substantially increased the price discount of homes in her sample, suggesting that with greater information in the market about noise, a greater portion of the cost of noise is capitalized into housing prices (Pope 2007).

The literature also discusses the role of preferences in housing decisions. Research indicates that, in the case of road traffic noise, self-selection does not occur based on noise sensitivity. A study finds that noise has "only a minor role" in residential decision-making (Nijland 2007). Von Praag writes that "If the strict assumptions of a well-functioning housing market would apply then (ignoring heterogeneity) no relationship should exist between noise and happiness because house prices fully adjust to compensate.

However, due to the rationing on the market and the fact that residents face significant switching costs, in practice this equilibrium frequently does not hold and there are still positive *residual* shadow costs." He continues, "The noise problem around airports is a special case of the more general problem of how to deal with the difference between private and social costs" (Von Praag 2007).

Noise Mitigation Strategies

The airport may choose to reduce noise levels by modifying operations with the use of a preferential runway system, special flight tracks, noise abatement flight procedures, and airport use restrictions. For large airports with multiple runways, a noise-preferential runway system can be used to change noise exposure patterns. With this procedure, a runway is utilized based on the noise impact it generates, along with other environmental factors such as wind direction. Using the same principles, some airports will modify flight paths based on noise exposure. With these tools, aircraft can be routed around noise sensitive areas (Horonjeff 2010, Girvin 2009).

While all of these mitigation strategies help reduce the negative impacts of excessive airport noise, only the coordination of development between airports and surrounding communities addresses the underlying land use conflict. Some municipalities have acknowledged the limitations of existing noise mitigation strategies and moved to implementing land use regulation to manage the problem. Early capacity and expansion planning can inform environmental planning officials in advance of potential noise impacts. Municipal governments, working with airport authorities, can plan for land use that complements airport economic activity while restricting incompatible uses.

The airport may work with the local governments to ensure that land use planning excludes uses that are incompatible with expected airport noise. In the case of Dulles International Airport, the Metropolitan Washington Airports Authority writes that, "An airfield buffer is provided on airport property to ensure that close-in residential development does not occur. Loudoun and Fairfax Counties have worked closely with the Airports Authority to provide additional land-use protection through effective planning and zoning" (MWAA 2011). At the local level, the Fairfax County airport noise impact overlay district begins with a statement that its purpose is for, "controlling conflicts between land uses and noise generated by aircraft and to protect the public health, safety and welfare from the adverse impacts associated with excessive noise" (Fairfax 2011).

Design

Research Approach

An investigation into the adoption of airport land use regulations is an investigation into organizational and institutional interaction. While the definition of an institution varies, an institution is considered to encompass 'the formal rules, compliance procedures, and standard operating practices that structure the relationship between individuals in various units of the polity and economy'" (Hall qtd in Steinmo 1992).

This investigation will attempt to answer the research question with the approach described as historical institutionalism. This approach is concerned with the development and change of institutions through historical analysis. "At its broadest, historical institutionalism represents an attempt to illuminate how political struggles 'are mediated by the institutional setting in which [they] take place" (Ikenberry 1988 qtd in Steinmo 1992). The approach is loosely defined, and frequently described in the literature through juxtaposition with other subfields of new institutionalism, such as rational choice institutionalism and sociological institutionalism.

As for the framework of this approach, Capoccia writes that "The methods adopted should therefore reconstruct, in a systematic and rigorous fashion, each step of the decision-making process, identify which decisions were most influential and what options were available and viable to the actors that took them, and clarify both their impact and their connection to other important decisions" (Capoccia 2007). The primary "causal mechanism" for historical institutionalist research is path dependency (Capoccia 2007). A path dependent process is described by its "critical junctures," the critical decisions are made resulting in the formation, adoption, or substantial change of an institutional arrangement. A critical juncture represents a "relatively short period of time" when there is a "substantially heighted probability" that decisions will be made that affect the outcome under investigation (Capoccia 2007).

A critical juncture is followed by a period of equilibrium where the established path succeeding the critical juncture is followed in a "relatively deterministic manner." After the critical juncture has passed and the new institution has been created, it is highly resistant to change. A mechanism of "positive feedback" or "increasing returns" discourages change (Jordana 2004, 79-81). Scott Page describes this form of self-reinforcement as a decision which "puts in place a set of forces or complementary institutions that encourage that choice to be sustained."

Methodology

Case Studies Approach

In order to identify the historical circumstances affecting airport noise mitigation strategies, a multiple case studies approach will be used to investigate the research question. The case studies will be built on an analysis of contemporary and historic planning documentation and interviews with airport and municipal officials. The unit of analysis for these case studies is the organization (e.g., the airport operator, the municipality, the county). Other publicly available data will be used to supplement the analysis, such as aerial photography, land use maps, and federal policy documents. The purpose of this methodology is to identify the spatial and temporal values influencing the adoption of noise compatibility land use regulations.

Alternative methods were excluded after considering the nature of the research question. The investigation is directed toward identifying and analyzing different historical interactions and contemporary institutional relationships between airports and municipalities. Quantitative social science research methods, such as an experiment utilizing spatial data, could describe, as an example, the land use mix of noise-affected areas over time. While this explanation may provide an answer to a question about the evolution of land uses around airports over time, it does not answer the larger question about institutional interaction posed by this research.

Other qualitative methods such as surveys would be difficult to implement because of the varying conditions between potential research sites. It is difficult to standardize survey questions when circumstances vary. Moreover, answers to many of the questions originally considered for a potential survey were later discovered to be available in existing documentation. The alternative method selected for the study—interviewing—permits questions to be tailored to the subject being questioned.

Analysis of Planning Documentation

The primary method of investigation is an analysis of the planning documentation related to airport planning and the planning of adjacent municipalities. Planning documents under review include airport master plans, airport sustainability plans, environmental impact statements, municipal comprehensive plans, county comprehensive plans, airport noise compatibility plans, and noise exposure maps. These documents provide insight into the policies adopted by airports and adjacent municipalities.

Drawing from Brent Ryan's discussion of the interpretation of planning documents, the plans reviewed in this research were read not only for their "essential ideas" but also to "perceive additional levels of meaning" (Ryan 2011). The municipal plans were read not only as a policy document including policy

recommendations, but also interpreted as a reflection of each community's priorities and attitudes towards the airport and its environmental impacts. Airport plans were viewed similarly, as the product of institutional arrangements and organizational strategies.

Two of the documents to be studied are common deliverables of the Part 150 noise compatibility planning process. A noise exposure map indicates existing or anticipated noise exposure and the affected land uses. The maps are created in conformance with Part 150 guidelines and may be funded by the FAA. With this map, an airport has completed the technical analysis required to complete a noise compatibility plan. A noise compatibility plan is an airports plan of action to reduce the negative effects of aircraft noise. The actions recommended in the plan may be implemented by the airport alone or with the cooperation and assistance of the Federal Aviation Administration, and may involve airport patrons and local jurisdictions. The plans include a public participation process. These plans are frequently funded by the FAA through the Part 150 program.

An airport master plan is an airport's strategy to meet future aviation demand. The plan includes forecasts of aviation demand, a plan for land use on airport property, a plan for the layout of the airport, airport approach documentation, terminal plans, ground transportation plans, and other elements. Physical, economic, financial, social and political perspectives are included in this documentation.

Municipal and county comprehensive plans define community values and aspirations. Land use regulations, in the form of zoning ordinances, are typically employed as the primary tool to implement the policies stated in the comprehensive plan. These plans will be reviewed to gain an understanding of the relationship between the community and the airport. The local planning documents will be used to address several questions. Are adjacent municipalities incorporated the airport's environmental and economic effects into the comprehensive plan? To what extent do existing zoning ordinances implement the policies stated in the plan? Is the municipality actively planning development within the airport's noise contours?

In addition to this documentation, aerial photography provided by Google Earth was used to review existing conditions around airports.

Interviewing of Public Officials

The investigation will also involve interviews with airport and municipal officials at the sites selected for case studies. Interviews intended to provide guidance to documentation and explanation of processes behind the airport and municipal plan-making process. The open ended interviews are intended to guide

interpretation of the planning documentation, provide insight into the politics between jurisdictions and airports, and direct investigation towards new material.

Selection of Study Area and Case Studies

The study area was selected based on state geography. An inventory of the 23 of small, medium and large hub airports located within Connecticut, Delaware, Massachusetts, New Jersey, New York, Maryland, Pennsylvania, Rhode Island and Virginia was assembled. These sites were selected to represent a particular region of the United States, under the assumption that different development patterns in other parts of the county, such as the Southeast or West, might lead to different outcomes based on different development patterns. While it was tempting to select sites based on their frequent use in the literature, such as Portland International or Denver International, the study area was defined to identify geographic variables influencing the research question while bringing new case studies into the investigation.

Airports Identified in Study Area

The geographic boundaries of the study area was selected to gather airports with sufficient variety, while limited the area to airports that could visited by the investigator should the opportunity present itself. Importantly, airports in the preliminary inventory are in different states and therefore under the jurisdiction of different state legislation and are managed by both municipalities, public authorities, or directly by state governments. The airports were constructed at different times and have expanded at different intervals. The airports are also surrounded by different environments, such as rural, suburban or urban communities.

Only airports categorized by the Federal Aviation Administration as small, medium or large were considered for the study. The FAA divides airports into two categories, *commercial service* and *general aviation*. The commercial service airports are further divided into *primary*, having more than 10,000 passenger boardings each year, and *nonprimary*, having fewer than 10,000 passenger boardings each year. The primary airports are further divided into *large* (facilities with 1% or more of annual passenger boardings), *medium* (at least 0.25% but less than 1% of passenger boardings), and *small* (at least 0.05%

but less than 0.25% of passenger boardings). Primary commercial service with more than 10,000 boardings but less than 0.05% of passenger share, as well as nonprimary commercial service airports, are considered *nonhub.*

While smaller non-primary commercial service and general aviation airports are also frequently the source of noise complaints, these airports are sufficiently different from larger hubs to justify a separate investigation. General aviation airports are frequently privately owned, have substantially fewer operations, do not operate commercial air carriers, and are normally used by private aircraft owners. Since these airports typically do not operate jet aircraft, the aircraft noise generated is not comparable to larger hub airports. Nonprimary commercial service airports also handle substantially less traffic, service much smaller aircraft, and serve a different economic role than larger airports.

Airports Included in Study

Airport Name	Size	Land Use Regulations
Albany International	S	No
Atlantic City International	S	No
Bradley International	M	Recommended
Buffalo Niagara International	M	Recommended
Baltimore/Washington International Thurgood Marshall	L	No
General Edward Lawrence Logan International	L	No
Greater Rochester International	S	Partial
Harrisburg International	S	No
John F Kennedy International	L	No
La Guardia	L	No
Lehigh Valley International	S	Partial
Long Island MacArthur	S	No
Newark Liberty International	L	No
Newport News/Williamsburg International	S	No
Norfolk International	S	No
Philadelphia International	L	Recommended
Pittsburgh International	M	Partial
Richmond International	S	No
Ronald Reagan Washington National	L	No
Stewart International	S	Recommended
Syracuse Hancock International	S	No
Theodore Francis Green State	M	No
Washington Dulles International	L	Yes
Westchester County	S	No

A preliminary investigation into the larger study area led to identification or specific sites with the potential to provide additional insight into the research question. From this list, a smaller group of case studies was selected for further investigation. These sites include Buffalo Niagara International and Stewart International Airports in New York, Bradley International Airport in Connecticut, Philadelphia International Airport in Pennsylvania, and Washington-Dulles International Airport in Virginia. The first three were selected because a cursory reading of noise compatibility and/or airport master plan documents revealed an interest in, or recommendation of, airport noise zoning to local municipalities. The latter two sites were selected because of indications that these airports had worked with local jurisdictions to implement noise compatibility zoning.

Case Studies Selected from Study Area

In these sites, further investigation into planning documentation was conducted, followed by interviews with related airport officials and municipal staff.

Case Studies

The findings are presented in this section for each case study. Each case is organized within the framework presented in the design and methodology sections; historical circumstances affecting noise management decisions are emphasized. The case studies are followed by a section that presents a summary and cross-cutting analysis of the studies.

Washington-Dulles International Airport

Background

Washington-Dulles International Airport (Dulles) is an exceptional case among the 23 airports reviewed in this research. Unlike all other airports reviewed, the jurisdictions surrounding Dulles have implemented land use regulations intended to prevent the noise impacts caused by encroachment. Both counties that are adjacent to the airport have enacted ordinances intended to manage development in areas affected by airport noise. The airport is operated by the Metro Washington Airports Authority, under the

jurisdiction of the Federal, rather than state or local government. Planning for the airport began in the 1950s and construction in 1958; the airport was operational in 1962.

Sources

Sources for this case study include the Loudoun County General Plan, the Loudoun Countywide Transportation Plan, the Fairfax County Comprehensive Plan, the relevant zoning ordinances from both Loudoun and Fairfax Counties, a 1959 engineering report on airport impacts, and interviews with airport and municipal officials.

Washington-Dulles International Airport

Findings

In comparison to other airports surveyed for this project, the development of Dulles has been less incremental and more centrally-planned. The airport was intended as a regional hub for commercial jet aircraft, rather than an expansion of an older military airstrip to accommodate commercial traffic. As a result, challenges now faced by older airports—such as a shortage of adjacent land for expansion—were accommodated for early in the development process. Documentation of early planning was found in a 1959 report entitled, "Preliminary Report on Impact of Dulles International Airport on Loudoun County as to Population, Water and Sewerage."

The site selected is nearly 30 miles outside Washington DC, in an area that had previously been developed at only very low densities. The selection of this site allowed MWAA to purchase sufficient land for a five runway configuration as well ensure an airport-authority owned buffer of land around the runways. This buffer is visible in aerial photographs today. In acknowledgement of both the future economic and environmental impacts of the airport, jurisdictions surrounding the airport site acted early to implement appropriate land use policies. Loudoun and Fairfax Counties reached out to the airport as early as the 1960s.

The airport now has thousands of employees and is central to the economies of Northern Virginia. There was and continues to be an interest in maintaining lands adjacent to the airport for industrial and commercial development, rather than residential. There has also been continued public investment in the

area surrounding the airport, including a recent project to extend the Washington Metro transit line to the airport.

Loudoun County

The Loudoun County Board of Supervisors approached MWAA in the 1970s to coordinate regulation to prevent development in areas impacted by airport operators. In the words of one official interviewed, the county wanted to "protect the lifestyle" of the region. At the time, Loudoun County was a predominantly rural community. Regulations to restrict development in areas surrounding the airport may have been seen both as a strategy to prevent future noise impacts, but also to maintain the rural character of the area.

To accomplish these goals, the County, working with MWAA, generated a noise model to assess the impacts of the airport at its fully planned five-runway configuration. The county's plan to restrict development in the noise-affected areas did generate resistance from homebuilders and real estate developers in the area; the County was threatened with a lawsuit, but this was later withdrawn. In 1990, ANKA placed restrictions on Stage II aircraft, changing the noise impacts of the airport. To maintain the existing regulations around the airport, the County revised the regulations to include the current 1-mile noise buffer around the airport.

The Loudoun County Comprehensive Plan is specifically addresses airport noise and makes policy recommendations to address the issue. In the section "Aural Environment," the document recommends the prohibition of development within the 65 DNL contour, the use of the integrated noise model (INM) for long-range planning, the use of the airport's noise exposure maps in noise compatibility planning, and the use of disclosure statements for residential properties within a 1-mile buffer of the 60 DNL contour. The airport noise contours are used throughout the document to guide development. No other comprehensive plan reviewed for this research emphasized the role of the airport and acknowledged its environmental impacts to this extent. (The document contains 102 instances of the word "noise.")

In recognition of the economic potential of the airport, the Plan also recommends continued industrial and commercial development near the airport in the form of the Route 28 Corridor Plan. This detailed local-area plan recommends office clusters, mixed-use developments, and industrial uses and provides guidelines for their development.

Fairfax County

The airport operator worked simultaneously with Fairfax County to protect affected lands from development. In the case of Fairfax, however, the County had greater levels of development around the

airport site. The airport noise overlay zone created by the County is similar to Loudoun County's, though the ordinance only prohibits residential development within the 75+ DNL contour. This regulation is significantly less stringent than Loudoun County's prohibition of residential development within the 65+ DNL contour. The Fairfax ordinance specifies compatibility by land use; different uses fall under different requirements. For instance, child care centers are not permitted within the 75 DNL contour, but are permitted within the 70 to 75 contour and 65 to 70 DNL contour with interior insulation.

Philadelphia International Airport

Background

Philadelphia International Airport (PHL) is sited along the Delaware River on the boundary between the City of Philadelphia and the Tinicum Township in Delaware County. The airport is operated by the City of Philadelphia. The airport was constructed to serve the aviation needs of the Pennsylvania National Guard in 1925.

Sources

Sources for this study include interviews with Tinicum Township, Delaware County, and Philadelphia International Airport officials. Documents reviewed include the Philadelphia Airport Noise Compatibility Plan, Philadelphia 2030 Vision Plan, and the Philadelphia International Airport Capacity Enhancement Program. The comprehensive plan and zoning ordinances for Tinicum Township are not available online and are not distributed for free. Delaware County does not have a comprehensive plan.

Philadelphia International Airport

Findings

The majority of noise impacts are borne by residents of Tinicum Township, as the paths to the commercial traffic runways on the Philadelphia side of the airport are protected by undeveloped airport property and the Delaware River. The relationship between Tinicum and the airport is strained. The airport is currently pushing an expansion program into land within Tinicum; unsatisfied with the expansion plans, the Township is suing the City based on legislation that prevents the City from acquiring

land outside its boundaries without the Township's approval. Noise was identified by all three interviewees as a very contentious issue in the community.

The PHL Part 150 Noise Compatibility Program recommends that Tinicum Township and the City of Philadelphia adopt land use controls for areas within or adjacent to the 65 DNL noise contour. The study, in land use management measure LU-3, recommends supporting local municipalities with comprehensive planning strategies to reduce noncompatible land use.

Further review of the maps provided in the Noise Compatibility Program reveal that the majority of the area currently within the 65 DNL contour is full built-out. This conclusion was confirmed by all three officials interviewed. The largest developed area within the 65 DNL contour is at the southwest side of the airport in Tinicum Township. The land use area in mostly industrial, but there are also single family homes within the contour. The County official that was interviewed reported that all areas within the contour in the Township had already been rezoned to compatible uses; this is difficult to confirm because the Township's comprehensive plan and zoning ordinances were not available for review. The majority of land within the 65 DNL contour is over airport property or the Delaware River.

The City of Philadelphia's comprehensive plan indicates that airport noise compatibility measures are in place. The City has identified airport-noise zones and has restricted residential uses in these areas.

Stewart International Airport

Background

Stewart International Airport (SWF) is located in a rural community west of Newburgh, New York in Orange County and is bordered by Stewart State Forest to the east. The facility was built in 1939 as a training facility for the U.S. Military Academy at West Point. The airport was acquired by the Port Authority of New York and New Jersey in 2003. The Port Authority is a state entity separate from the municipalities in the region.

Stewart International Airport

Sources

Sources for this case study included two interviews

with a Stewart International Airport official and review of the Stewart International Airport Master Plan and the Stewart International Airport Environmental Sustainability Plan. The airport no longer participates in a master planning process; the airport official reported that the PANYNJ considers this process to be too expensive and not worthwhile. The airport also has not completed a Part 150 study. The decision to include this site as a case study is based on the recommendation for land use regulations in the airport's sustainability plan.

Findings

The Master Plan reviewed for this report was completed in December 2006. The airport has no plans to update the existing Master Plan. The interviewee reported that the PANYNJ does not consider the master planning process to be an effective use of limited resources. The Master Plan addresses the issue of land use compatibility and includes a brief description of the existing land use regulations around the airport, noting that the areas to the west of the airport are public lands while to the east there are still undeveloped lands within the Town and City of Newburgh, though these areas are outside the projected noise contours. The report does not make recommendations that the Newburgh adopt ordinances, but the section concludes, "An EA/EIS would include a detailed overview of existing zoning and its potential to influence future incompatible development patterns with the Airport." The recommendations in the master plan are limited to easements and property acquisition.

In September 2010, the airport completed an Environmental Sustainability Plan. This document, unique among the cases studies assessed, outlines policies for air quality enhancement, energy conservation, noise abatement, water conservation, and other environmental concerns. A section of the chapter on noise abatement is titled "working with municipalities on compatible land use." The report notes that "given that the Port Authority does not have control over land outside the Airport boundary, cooperation with neighboring municipalities is necessary." The report recommends that the Port Authority "continue to work" with municipalities adjacent to the airport to discourage the development of incompatible land uses. However, the document does not specify specific mechanisms or establish a plan or schedule for this activity.

The boundary of the City of Newburgh, New York is approximately one mile from the edge of the airport property. It is the closest municipality to the airport property. The Newburgh Sustainable Master Plan, adopted December 2008, discusses the role of the airport strictly as a transportation facility and economic driver. The report notes that the Port Authority recently acquired the airport and has ambitious expansion plans. The airport and expansion program are viewed as a job creator and economic development engine.

The report does not discuss the existing or potential environmental impacts of the airport, and makes no mention of noise.

Review of planning documents and multiple interviews with an airport official indicate that concern over aircraft noise around Stewart International Airport is low. The Master Plan specifically notes that complaints about noise are rare, even though a noise complaint phone line is advertised. While the Environmental Sustainability Plan recommends land use compatibility measures, the airport official suggested that noise impacts were a relatively low priority and that devoting resources to programs to achieve land use compatibility with local jurisdictions is a low priority. The airport official reported that implementing the land use regulations in the sustainability plan is a low priority.

Bradley International Airport

Summary

Bradley International Airport (BIA) is located in rural central Connecticut, to the immediate west of the Town of Windsor Locks. The airport was constructed as a training facility for the US Army in 1940. It is now owned and operated by the Connecticut Department of Transportation and classified as a medium hub airport.

Sources

Sources for this case study include an interview with an airport official, review of the Bradley International Airport Master Plan and Noise Compatibility Plan (Part 150). The Town of Windsor Plan of Conservation and Development was also reviewed.

Findings

The Bradley International Airport Master Plan addresses the issue of noise, but does not make recommendations for land use regulations or other mitigation efforts. Areas exposed to high levels of noise to the north are mostly open space, while the areas to the south, east and west are mostly commercial and industrial. At the time of the report the Airport did not have capital projects planned that would increase noise around the facility and create new land incompatibilities in the area. Compared to other airport

Bradley International Airport

master plans read for this project, the discussion of noise is brief.

The town identified by the Airport Master Plan and Noise Compatibility Program as most affected by airport noise is Windsor Locks, to the east of the airport site. The general plan for the Town of Windsor Locks, adopted in 2008, is referred to as the Plan of Conservation and Development. Bradley International Airport is mentioned as an important transportation facility and driver of economic development, but noise and the other environmental impacts of the airport are not considered.

An airport official reported that plans had not yet been made to implement the land use regulation recommendations made in the Noise Compatibility Program. The priority for the airport was to complete the requirements in order to receive federal funding for insulation programs in order to address existing noise concerns, as insulation programs provide the "most bang for the buck." As of March 2012, the airport was hiring a new staff member to improve the airport's capacity to handle noise mitigation issues. The official noted that without additional staff, the noise mitigation office currently lacks the capacity to implement the land use recommendations in the Part 150 study, especially since implementation would require negotiations with four different jurisdictions surrounding the airport.

The interviewed official had several insights into the problems associated with implementing noise compatibility land use zoning. He voiced concern that communities would be resistant to the introduction of restrictive zoning ordinances because of municipal interests in developing their tax bases. A request by the airport to restrict residential development in a primarily residential community would meet resistance, as alternative development opportunities are less likely to be available. He felt that in the communities around the airport were generally interested in increasing property tax revenues and would not want to implement development controls that might restrict development or encourage development to relocate to a neighboring jurisdiction. Even with these concerns, however, he strongly felt that coordinating with local jurisdictions was worthwhile and believed that the airport would pursue negotiations in the future.

Buffalo Niagara International Airport

Summary

Buffalo Niagara International Airport (BNIA) is located in the suburban communities outside of Buffalo, New York. Per the FAA classifications, it is a medium-sized commercial hub airport. The current airport site was selected in 1925 and the original facilities were completed in 1926. It is operated by the Niagara Frontier Port Authority, a political entity that is under the jurisdiction of the New York State government.

Sources

Sources for this case study included an interview with an airport official, as well as review of three local comprehensive plans and BNIA's Part 150 Noise Compatibility Program. BNIA's Airport Master Plan was unavailable for review as it was in the process of being update. The previous version was completed in 2002 and in now out-of-date.

Buffalo Niagara International Airport

Findings

Buffalo Niagara's Part 150 noise compatibility program was completed in November 2006. The document makes very specific recommendations to three adjacent jurisdictions, the Town of Amherst, Town of Cheektowaga and Town of Clarence. The recommendation to the Town of Cheektowaga is to create three separate noise zones for each of the noise contours indicates in the noise exposure map. Amherst and Clarence are recommended to develop zones for only the outer contour, from DNL 65 to 70 dBA. A map of these zones is provided in the report; the zones follow the noise contours and do not accommodate property lines or block patterns.

Three comprehensive plans for Amherst, Cheektowaga and Clarence were reviewed in order to understand the role of airport in the local planning process. The Amherst Master Plan makes no mention of airport noise and has no specific discussion of the role of the airport in the municipality. The Cheektowaga Comprehensive Plan makes no mention of airport noise, but discusses in detail the existing zoning ordinances in effect in the area adjacent to the airport. This area is mostly zoned for commercial and manufacturing, but there are pockets of land designated for residential uses. The effect of airport noise is not discussed in relation to this zoning. The Clarence Master Plan makes no mention of either the airport or noise.

An interview with an airport official revealed similarities between BNIA and Bradley International Airport. At BNIA, insulation programs are the primary mitigation method, and noise impacts (and encroachment) are considered low priorities for the airport. The larger concern is the political issues involved with allocated resources for noise insulation installation. Community members are frequently

upset over the seemingly arbitrary nature of the noise exposure maps, which are used to determine residences that are eligible for funding.

An interview with a municipal planner confirmed speculation about the importance of noise in the communities surrounding BNIA. He reported that there is generally not a lot of community opposition to the airport in Amherst, though there are occasional complaints about noise. When asked about the Town's role in the noise compatibility planning process, he responded that it was represented in the Part 150 process and that he felt it was productive, but emphasized that the process is airport, and not a municipal planning process. He felt that the Town's role was limited and that the input was limited; the consultant managed the process.

The recommendations to come out of the last Part 150 Study were issued too late to be incorporated into the Amherst's previous general plan update, the 2006 Comprehensive Revision to Ordinances. He was optimistic but uncertain whether noise compatibility recommendations may be incorporated into the comprehensive plan in the future. However, he believed the airport had "no sense of urgency" with regard to implemented Part 150 recommendations. The more important priority is insulation programs.

Analysis

The research has identified two generalizable findings. First, airport noise zoning, while potentially effective, is less effective and feasible in practice and as a result not prioritized as a noise mitigation strategy by airport operators and municipalities. Second, while interviews with airport staff have identified noise compatibility zoning as a low priority, guidelines within the airport noise compatibility planning process continue to encourage the recommendation for noise compatibility zoning within noise compatibility plans. The recommendations for noise compatibility zoning do not necessarily correspond with an airport's actual intent to pursue their implementation.

Existing Conditions decrease Effectiveness of Noise Compatibility Zoning

Noise compatibility land use regulations are only effective when noise-sensitive uses have not yet been developed or when there is still potential to restrain encroaching noise-sensitive development. For example, John F. Kennedy International and La Guardia Airport in New York have made no recommendations to implement zoning regulations since development has occurred up to the property lines of these facilities. In these cases, the Port Authority's ability to persuade the City of New York to implement land use regulations is limited by development interests while the usefulness of the regulations is reduced or eliminated because the noise-affected areas are already developed.

The existing development adjacent to the airport may not be noise-sensitive. In these cases, neither the airport nor the municipality has an incentive to pursue a noise-specific zoning ordinance since the land is already used for a non-noise sensitive use, such as manufacturing or warehousing. In these cases, either advanced planning by local municipalities or chance has created conditions that reduce the need for noise compatibility zoning ordinances. The land surrounding the airport may not be developable. Geographic features, such as lakes, rivers, or the ocean or areas under preservation, such as state parks, reduce the need for airport zoning. This can be seen on the west side of Stewart International Airport, where a State Park prevents encroachment.

Preventing Residential Encroachment is a Low Priority

Concern about the noise-related consequences of encroachment is a low priority for the case study airports. The larger concern is encroachment that results in safety hazards, most notably obstructions such as tall buildings or trees. While the recommendation to enact land regulation is made in noise control plans, funding programs to implement land use regulations are not a priority. The preferred noise mitigation strategies include residential insulation programs and land acquisition. If land is acquired, it is usually developed as a noise-tolerant use, such as a farm, distribution facility, or preserve.

The Role of the Community Varies

Community support for noise compatibility zoning regulations is mixed. In the case of Loudoun County, adjacent to Washington Dulles, the County Board of Supervisors reached out to the airport operator to establish land use regulations to address aircraft noise related to Washington-Dulles International Airport. The County engaged with the airport to ensure that noise exposure would be projected and this exposure was accommodated for in development plans. In contrast, other municipalities, such as Tinicum Township, adjacent to Philadelphia International Airport, have a much more strained relationship with the airport. The poor communication between county, township and airport officials has, according to all those interviewed, hampered the implementation of noise mitigation measures.

In the communities around Bradley and Buffalo Niagara, apathy towards airport noise reduces the pressure on both airports and municipalities to mitigate and plan for it. At and around Stewart International Airport, Bradley International Airport and Buffalo Niagara International, noise is a relatively low priority. Communities surrounding these airports were found to be apathetic towards airport noise, whether evidenced through low complaint volume, a lack of incorporation of the issue into municipal plans, or a lack of concern from airport or municipal officials. Municipal officials reported that if

community members do not voice concern over aircraft noise, there is little motivation to address the issue with local ordinances.

Outside the study area, in Klamath Falls, Oregon, the negotiations between the airport and municipality were very open and productive. The community strongly supports for the Air National Guard base that operates there and is therefore supportive of the airport. Communication between the airport, the municipality, and the National Guard is productive; it has resulted in a well-coordinated planning process. In this situation, the airport and the National Guard base that operates there are viewed as an important community asset, and the municipality actively plans to protect its operations and reduce environmental impacts.

The Role of Federal Guidelines

Airport Development Occurred before Guidelines Development

The site for Philadelphia International Airport, Stewart International Airport, Bradley International Airport, and Buffalo Niagara International Airport were all selected and developed decades before the large-scale adoption of jet engines for commercial aircraft and the rise of civil aviation. Only until after this technological change did the FAA begin to adopt regulations that would encourage advanced planning for new environmental impacts. These changes began to occur with the passing of Federal enabling legislation, beginning with the National Environmental Policy Act in 1969 and the Aviation Noise Abatement Policy in 1976. It was not until 1979, with the passage of the Airport Safety and Noise Abatement Act, that Congress directed the FAA to create procedures for noise and land use compatibility. The FAA responded with the Federal Aviation Regulation Part 150 in 1985. The predecessor to FAR Part 150 was the FAA's Airport Noise Control and Land Use Compatibility (ANCLUC), a less comprehensive regulation that had been initiated in 1977. By 1985, practically every major American airport had already been built.

Washington-Dulles International Airport is an outlier in this regard, since it the site was selected in the late 1950s and construction was completed in 1962. At this time, the role of civil aviation was recognized, jet engines were in use, and the environmental impacts of airports were beginning to be acknowledged. As a result, the site selected for the airport was miles outside of Washington DC and suburban Virginia. In addition, studies were conducted to determine noise impacts by supposing a fully built out runway configuration with modern aircraft operations. The facility was planned not only for the initial post-construction noise levels, but also all potential future levels.

For the other case studies, the guidelines for assessing and establishing compatible land uses occurred too late after site selection and airport development to be effective. These facilities had already experienced significant development around the airports prior to both the identification of aviation noise as a concern and availability of procedures and Federal support to plan for encroachment.

The Effect of the FAA's Regulatory Guidelines

The guidelines provided by Part 150 create the impression that airports desire airport noise compatibility zoning, when further investigation reveals that this recommendation is not pursued in earnest. The recommendations for noise compatibility zoning found in noise compatibility plans contain boilerplate language that is not context sensitive. The noise compatibility plan is, in the words of those officials interviewed, a process of "box checking" or "smoke and mirrors" to satisfy a requirement for federal funding. One interviewee told me that "you have to play the game" with regard to FAA requirements.

While the Federal Aviation Administration will fund the Part 150 noise compatibility planning process and may provide funding for noise insulation or land acquisition, it will not provide funding to assist with the implementation of land use regulations. Since airport budgets are constrained by federal regulations and pressures from airlines to keep fees low, the lack of federal funding for a program to implement noise compatibility zoning lowers its priority among other noise compatibility or management strategies.

In the cases that had completed Part 150 studies, including Philadelphia, Bradley and Buffalo Niagara, the purpose of the study and the accompanying Noise Compatibility Program was primarily to gain access to Federal funding for noise insulation. The other recommendations contained in the study were not a priority. In the case of Philadelphia and Buffalo Niagara, airport officials suggested, for the reasons described previously, that these recommendations would never be implemented. At Bradley, the recommendation for land use measures was deprioritized in favor of its insulation program, which was viewed as having more immediate gains. In addition, the noise exposure maps create a bright line to limit liability for continued encroachment. In practice this means that development that occurs within the 65 DNL contour after the FAA accepts an NEM cannot receive funding for noise mitigation.

Conclusions

Summary

By conducting a series of case study emphasizing historical analysis, this research has investigated the reasons and circumstances underlying the failure of land use regulations to address the negative externalities generated by airports. The study has found that the history of airport development and noise

compatibility legislation have resulted in municipalities implementing airport noise compatibility land use regulations in only a few instances in the United States. In the Northeast, the existence of airport noise compatibility zoning in jurisdictions adjacent to commercial hub airports is the exception rather than the norm.

The implementation of land use regulations to address the problem of airport noise has been shown as largely ineffective at addressing existing noise problems due to the historical circumstances affecting airports. The guidelines for noise compatibility planning do provide other benefits to airport operators, by acting as a conduit for mitigation funding, continuing their usage even when elements related to land use are not feasible. The ineffectiveness of the regulatory approach to managing airport noise in most cases indicates that alternative approaches to the problem should be investigated. These approaches should be sensitive to the different circumstances affecting airports and surrounding municipalities.

History of Airport Development

As discussed in the analysis, the implementation of airport noise compatibility land use regulations in the municipalities surrounding case study airports would be ineffective in most cases since the use of land use regulation does not affect development that has already been completed. In all but one case study, noise-sensitive development has already occurred within the 65+ DNL noise contours. Since the built environment is durable, the implementation of a noise compatibility zoning overlay in an established community would be ineffective at preventing continued encroachment.

The durability of airports—their permanence—is an important part of the noise problem. The four airports used as case studies that have been unable to implement noise compatibility zoning were built in response to military needs on farmland near existing populations. The sites for these facilities were selected based on the original users' requirements and the availability of land within a practical distance of the facility's users. Over time, however, the usage, environmental impacts, and communities surrounding these facilities changed. Following the construction of these airports, World War II ended and military activity near urban centers tapered. The economy improved and civil aviation became an important transportation mode. Later, the invention and large-scale adoption of jet aircraft dramatically increased the noise generated by aircraft operations. Concurrently, the suburban expansion of American cities continued throughout the post-war period, bringing residential uses closer to these increasingly noisy airports. Even with these events increasing the severity of the noise problem around airports, few American airports relocated operations to new sites in order to decrease environmental impacts.

In the language of the literature on path dependency, the airports siting decisions of the 1930s and 1940s could be considered a critical juncture in the development of airports. The very high switching costs associated with relocating airports encourage their continued development in their original war-era locations. The relocation of a commercial hub airport of the size reviewed in this research could easily amount to a multibillion dollar project. There have only been a few cases where this type of relocation has been justified in the United States, such as construction of the Denver International Airport to replace Stapleton International Airport. In addition, the relocation of airports is discouraged by the self-reinforcement provided by the airlines and other businesses that use or locate near the original airport. The development of business parks, hospitality industries and other complementary uses reinforce the original siting decisions by increasing the indirect costs associated with relocating the facility. Although the facility is a source of noise impacts, it still functions as an important economic center in the surrounding communities by providing jobs and stimulating local economic activity.

Asynchronous Development of Guidelines

The barriers to the implementation of noise compatibility land use regulations are also partially the result of the asynchronous development of airports and regulatory guidelines. The construction of most of the country's airports did not correspond with the institutional capacity to develop and implement airport environmental plans. The foundation for noise compatibility planning legislation was not enacted until after the vast majority of American airports were already built; the Airport Safety and Noise Abatement Act (ANSA) was not signed into law until 1979. Federal Aviation Regulation Part 150, the guidelines for airport noise compatibility planning enabled by ANSA, was not adopted until January 1985. This legislation provided a mechanism for airport environmental planning, but not until decades after the founding of many of the region's airports and over 20 years after the wide scale adoption of jet aircraft by commercial air carriers.

Referring back to the framework of historical institutionalism and path dependency, the encroachment affecting airports is a consequence of the siting of airports close to urban centers. The effectiveness of the Part 150 guidelines addresses land use compatibility is reduced by the airport encroachment that occurred years and sometimes decades prior to the adoption of federal legislation providing resources and instruction for noise compatibility planning. The capacity to plan for airport impacts developed too late to have a major impact on environmental outcomes. By the 1980s, most American airports had already been built, and the suburban expansion that began in the 1950s was in full force. Development pressures had already driven encroachment to airport property lines; at this time land use regulations would be ineffective at preventing future noise impacts.

Role of Guidelines

The guidelines established by Part 150 have become *de facto* technical standards; the recommendations contained in Part 150 are applied without variation, allowing little negotiation between the Federal Aviation Administration, airport operators, and affected communities. The result is a package of measurement standards, procedures, and recommendations which do not consistently represent the diverse interests, demands and priorities of airports and communities. As identified in the literature and reinforced by the case studies, community and individual response to noise varies widely and cannot be easily addressed with standardized measurements and policies. As a result, the prescribed procedures can be followed and recommendations can be made, but these recommendations are feasible, effective, and adopted by local jurisdictions only in limited circumstances.

Rather than because of their role as an effective tool for environmental planning, the guidelines dictated by the Part 150 are followed because of their use as a requirement in order to receive funding through the Airport Improvement Program for noise mitigation programs such as insulation installation. The insulation programs are recognized as an effective noise mitigation technique and are well-received by noise-affected communities. As a result, noise compatibility programs include recommendations that are to fulfill elements of the Part 150 guidelines, rather than ones that will be implemented.

Limitations

It became clear during the course of this project that several important elements of the overarching problem of airport noise were being excluded from the investigation. The research focused exclusively on the effectiveness of a regulatory approach to noise mitigation, without sufficient consideration of other mitigation strategies such as noise insulation programs. Early in the research, these methods were excluded from the study in order to focus on the regulatory approach using zoning, which were seen as a way to address the underlying land use conflict and prevent unwanted noise at the source. As the investigation progressed, it become evident that, as a result of the limitations of noise compatibility land use regulations described previously, the preferable noise mitigation strategies are those that mitigate the impacts of noise rather than prevent its occurrence. In many of the interviews conducted for this research, the airport or municipal official would report that the preferred method for addressing airport noise was through noise insulation programs.

In addition, as the research progressed, it was found that the answer to the research question would be best discussed through the lens of historical institutionalism and that historical circumstances could be used to explain the infrequent implementation of land use regulations. This early shift in direction led to

the role of guidelines themselves, at a local level, being downplayed in favor of a more historically driven and institution-focused design and methodology. While this paper discusses the Part 150 guidelines as a regulatory standard, it does not address the effects of these guidelines at the community level. While the research identified the guidelines as being inflexible, it did not provide an in-depth analysis of the elements of the guidelines that are responsible for this outcome.

Based on the conclusions resulting from this research and their limits, future research should be directed toward investigating negotiation-based approaches to managing the noise impacts of airports. It would be helpful to have a better understanding of the effectiveness of noise insulations programs. Do households within 65+ DNL contours that receive noise insulation have an improved attitude toward aircraft noise? Do households involved in land acquisition programs feel that the transaction was equitable? Additional research of these questions would assist in the development of more nuanced noise mitigation policies.

Recommendations

When addressing the issue of airport noise, the planner's role is first to identify the magnitude of the problem within a given community and then advocate for interventions that are sufficiently flexible to address the problem at a community or even individual level. The intervention begins with measuring the severity of the externality and measuring the social cost, and only then selecting the most appropriate policy instrument to address the underlying market failure. This description of the planner's role is in contrast to the responsibilities assigned to airport and municipal planners by the Federal Aviation Administration's guidelines. The guidelines define the externality on behalf of the planner, limiting the planner's responsibility to locating the externality and selecting a preset combination of predefined policy interventions to address it.

The planners' role may be described as "market planning" to ensure that the social costs of noise are minimized and shared (Banerjee 2007). While noise is an externality leading to a market failure, the magnitude of the cost generated by noise is highly dependent on variables that are difficult to measure, such as community and individual response to noise. The planner must not only identify whether an externality exists, but also assess the magnitude of its social cost at the level of each community and select a locally appropriate intervention. Once the social cost has been measured, noise mitigation interventions that are based on market mechanisms such as land acquisition or noise insulation programs can be implemented.

When the land use conflict has not yet occurred, the planner has a different role. In these cases, the solution to the airport noise problem may not always involve interventions within existing markets, but

instead may involve the formation of new markets entirely. The externality can be prevented by shifting the market for residential and other noise-sensitive land uses away from land exposed to airport noise. The market for land can be segmented, so that land surrounding airports is prioritized for industrial and distribution uses, while land outside of noise affected areas is zoned for residential development. Through the use of land use regulations, the planner is able to create new markets to achieve more socially optimal ends.

Given the limitations of the existing noise compatibility guidelines in addressing noise at airports that have already experienced encroachment, the investigator recommends that the existing guidelines be revised to be more sensitive to "development concerns" and "local needs" (Srinivas 2005, 48). The guidelines should take into account the historical and spatial circumstances leading to the encroachment of noise sensitive land uses. Airports that were developed earlier and have already experienced encroachment should be subject to flexible guidelines that emphasize the mitigation of existing noise impacts. Municipalities around more recent airport developments, where encroachment has not yet occurred, should be encouraged to follow more stringent and rigid guidelines, as these jurisdictions can more easily implement land use regulations.

The land use recommendations found in the Part 150 guidelines are very useful for addressing potential environmental impacts that would result from encroachment in new airport. For this reason, these guidelines should remain in place for the planning of new facilities. More recent airport developments, such as Washington Dulles International Airport, Sacramento International Airport, and Denver International Airport, which have been built a significant distance from major metropolitan centers and are surrounded by undeveloped land, have successfully implemented noise compatibility land use regulation in cooperation with adjacent municipalities.

The noise compatibility study process was identified in the case studies as being ineffective at creating realistic noise mitigation strategies for airports already experiencing encroachment. The Federal Aviation Administration should acknowledge the inability of the standard recommendations to address existing encroachment. Recommendations for these cases should be adjusted to accommodate this class of airport and the communities typically surrounding it. The FAA could begin this reform by separating the existing use of the noise exposure maps and noise compatibility programs as a conduit for airport improvement program funding for noise mitigation programs (e.g., noise insulation, land acquisition) from noise compatibility land use planning. As reported by airport officials interviewed, the land use recommendations included in the noise compatibility planning process is only a hurdle to gaining access funding for Federal funding. The strategies have already been selected by airports when the noise

compatibility programs are being developed. The receipt of funding for noise insulation or acquisition programs should be tied more immediately to the conclusions reached during the development of noise exposure maps.

At the municipal level, planners can take steps to improve household's decisions within the market. If the problem of airport noise is considered to be a market failure as a result of imperfect information, existing encroachment concerns could be addressed through greater adoption of noise disclosure laws that require notification of prospective residents before the purchase of residence in a noise affected region. While these laws do not prevent all problems associated with airport noise and encroachment, it is an effective method to reduce the information asymmetry in the market and reduce the problems associated with the principal-agent problem inherent in the real estate brokerage system.

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