sured method. Using the direct method is suggested for those locations where public involvement has been high and the possibility of controversy has surfaced. This method would give greater credence to the ability of the barrier owner to accurately anticipate barrier effectiveness.

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Airport Noise Monitoring Systems in North America

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ABSTRACT

Airport noise is a recognized by-product of a transportation-based economy. Because the number of airports, aircraft, and flight operations over adjacent airport communities are essential to the economic base, noise monitoring systems are being installed by airport proprietors. Currently, there are 25 systems in operation at airports in North America (two additional airports are in the process of bidding on and installation of noise monitoring systems). They have been installed for a variety of reasons and purposes, including compliance with enacted regulations or standards. These airport noise systems consist of four basic components: remote monitoring station, central processing station, software, and accessories. It is anticipated that the number of such systems will increase more rapidly in the future, partially due to available federal funding under Federal Aviation Regulations (FAR) Part 150: Airport Noise and Land Use Planning.

Air transportation is a major component of the national transportation system. The Federal Aviation Administration (FAA), U.S. Department of Transportation, estimates that there are nearly 15,000 airports (towered and nontowered) in the United States. These airports operate civil air fleets of approximately 195,000 aircraft throughout the United States, generating nearly 8 million flight operations annually.

Although aircraft operations are beneficial to the economic base of the United States, there are certain impacts associated with such operations. Due to the rapid growth of airports and the adjacent airport communities, along with increasing numbers of jet-engined aircraft that operate during a 24-hr period, potential noise impact conditions often exist in residential areas near airports.

Many techniques are being used to address this potential problem through source controls (i.e., engine noise suppression, new generation aircraft) as well as receiver controls (i.e., building codes, land using planning) at the federal level, primarily through the FAA. Such noise-related FAA activities include Federal Aviation Regulations (FAR) Part 36: Noise Certification, FAR Part 91: General Operations and Flight Rules, and FAR Part 150: Airport Noise and Land Use Planning (1). Some state and municipal governments are also taking certain steps to control airport-related noise by using the regulatory and planning process (2-4). An increasingly common approach as part of the overall management of airport noise is the establishment of a permanent airport noise monitoring system.

HISTORY

The acoustical monitoring of airport noise on a permanent and continuous basis is a relatively new phenomenon in the United States. Historically, the first such system was installed by the Port Authority of New York in 1967, and was used initially at John F. Kennedy International Airport (5). Similar systems

were subsequently installed at LaGuardia International Airport and Newark International Airport by the Port Authority of New York. The impetus for this instrumentation system was the establishment of a maximum peak noise-level requirement for aircraft operating in a takeoff mode. Such a noise standard was developed by the Port Authority of New York in part due to concerns about airport noise raised by neighboring municipalities. A peak noise-level threshold was established for aircraft takeoff purposes; it was equivalent to 104 dBA.

Inglewood, California, was the first municipality to have a permanent noise abatement program, beginning in 1969 (5). This city was specifically concerned about the problem of flyover noise associated with Los Angeles International Airport. In response to this problem, a series of three fixed monitoring stations was erected in Inglewood by using telephone poles with monitors connected by land lines to a central receiver system, located at City Hall. This noise abatement program also used a mobile van for observing aircraft flyover noise at locations throughout the community. The Noise Abatement Office developed both a fixed and mobile noise monitoring program.

Other than these efforts by New York Port Authority and Inglewood, California, there was little activity concerning noise abatement until the early 1970s when the California Department of Aeronautics established an Airport Noise Standard in their Administrative Code (6). These provisions, enacted in 1973, required a continuous monitoring system for noise when the composite noise exposure level (CNEL) exceeded a certain annual level along with a daily single event noise exposure level (SENEL). Beginning in 1975, several airports began to establish noise monitoring programs to determine compliance with this code.

CURRENT STATUS OF NOISE MONITORING SYSTEMS

Interest has grown steadily since the initial system for airport noise monitoring was installed in 1967. Currently, there are 25 airports in North America that operate permanent noise monitoring systems [two additional airports are in the process of bidding on and installation of noise monitoring systems (see Table 1)]. A large number of air carrier airports have been required by state law in California to install noise monitoring systems.

All existing airports that have monitoring systems are civilian based. These systems generally apply to air carriers, as opposed to general-aviation airports. The largest concentration of these airports (93 percent) are situated in the United States. Nearly one-half of these instrumented airports (42 percent) are located in California, while the remaining 58 percent are distributed throughout 10 states and the District of Columbia.

Within California, these monitoring systems are located primarily in the Los Angeles (7 systems) and the San Francisco (4 systems) metropolitan areas. New York, with four systems, and Washington, D.C., with two systems, are the only other metropolitan areas with multiple noise monitoring systems in place. The Port Authority of New York and New Jersey is in the process of replacing their original system installed during the 1960s. It should become totally operational before the end of 1986 (7).

Currently, there are three companies that manufacture equipment for measuring noise on a continuous basis at a fixed airport location: Tracor, Metrosonics, and Brael & Kjaer Instruments. Often the manufacturer will install a system after an independent acoustical study is prepared by a consultant for a specific airport proprietor.

TABLE 1 Airport Noise Monitoring Systems in North America

Geographic Location	Airport
California	
Burbank	Burbank Airport
Long Beach	Long Beach International Airport
Los Angeles	Los Angeles International Airport
Ontario	Ontario International Airport
Orange County	Orange County Airport
San Diego County	San Diego Airport
San Francisco	San Francisco International Airport
San Jose	San Jose International Airport
Santa Clara County	Reid-Hillview Airport
Santa Monica	Santa Monica Municipal Airport
Torrance	Torrance Municipal Airport
Florida	
West Palm Beach	Palm Beach International Airport[a]
Hawaii	
Honolulu	Honolulu International Airport
Massachusetts	
Boston	Boston Logan International Airport
Minnesota	
Minneapolis	Minneapolis-St. Paul International Airport
Missouri	
St. Louis	St. Louis Lambert International Airport
New Jersey	
Newark	Newark International Airport
New York	
New York	John F. Kennedy International Airport
New York	LaGuardia International Airport
White Plains	West Chester County Airport
Ohio	
Cleveland	Cleveland-Hopkins Airport
Virginia	
Hampton	NASA Langley Airport
Washington	
Seattle	Seattle-Tacoma International Airport
Washington, D.C.	Washington National Airport Dulles International Airport
Canada	
Edmunton, Alberta	Edmunton Airport[b]
Toronto, Ontario	Toronto International Airport

[a] As of December 1985, a specification document has been prepared for bidding on construction of an airport noise monitoring system in West Palm Beach.

[b] As of December 1985, bids have been received and a contract has been awarded for installation of a permanent airport noise monitoring system in Edmunton.

COMPONENTS OF A NOISE MONITORING SYSTEM

There are three basic equipment components of an airport noise monitoring system: the remote monitoring stations, central processing station, and associated software. Sometimes there is also a fourth component to a system, accessories. Each of these components will be discussed further.

Remote Monitoring Stations

Remote monitoring stations are fixed stations that physically measure airborne-generated noise. They consist of a microphone or hydrophone connected to a field equipment enclosure with microphone power, and single preprocessing and data transmission capability.

They are usually placed high above the ground, often roof-mounted. The total number of stations will vary according to three items: the specific airport, complexity of the airport layout, and associated impact on land use. The total number of noise monitoring stations per airport, based on the list of airports given in Table 1, ranges from 8 to 26. Currently, the maximum number of stations for a given airport is 26 because the printout area of the data printed is restricted. The average number of sites for all airport systems in place is 13.

Key factors to be considered in the performance characteristics of the field equipment include environmental protection from precipitation, wind

turbulence, extreme temperature variation, dynamic range of equipment, transmission of signal for processing central and remote calibration, and constant power supply.

Central Processing Station

The central processing station receives all of the input data from the remote monitoring stations. The principal equipment at this location is a computer for central processing that receives, analyzes, and stores data transmitted from the field. In addition to the computer, there is accessory equipment that includes a visual display unit (CRT) and a high-speed printer.

Storage capacity will be essential for maintaining a data file; however, its size (capacity) is somewhat dependent on the intended use of the system, including the data desired to be displayed.

Consideration should be given to several factors in locating the central processing station:

- Accessibility
- Ambient temperature
- Storage of data tapes, diskettes, and discs
- Ergonomics of user or users
- Convenience of location
- Security and safety
- Ease of service and installation of equipment
- Protection against electrical interference (e.g., power surge)

Software

Software refers to the programming package designed to process, analyze, and graphically portray the monitored noise and related information. Several factors are important in selecting the software, including:

- Software language
- Program or user friendly
- Expandability of software programming
- Flexibility in the software
- Software to expedite report preparation, including data summaries and special studies
- Simultaneous processing without interruption
- All key noise metrics and descriptors, both current and future
- Ease of modification
- Software documentation

Several of the recently installed systems provide a graphic color display in real time of the monitoring locations on the CRT. This is used to assist the airport personnel responsible for the noise program, rather than the public-at-large.

Accessories

Certain accessory elements that can improve the potential noise monitoring system are often found at airports.

Map Display

Many airports maintain an electronic map at the installation, which gives a graphic display of the monitored noise levels, often in real time. At certain airports, these monitored aircraft operations are shown with colored lights indicating the degree of compliance. For example, a flashing red light indicates exceedance of level of permissible take-off noise and a flashing green light indicates compliance. Such maps are situated in various locations ranging from public access areas to worker or airport employee areas.

The San Jose Airport was one of the first airports to use a map display. Measuring approximately 4 x 4 ft, this display is located in the main terminal area to give maximum public exposure. Various maps are incorporated into each airport display. Some displays also incorporate an aerial mosiac of the airport community, while others rely on a land-use base map. The average cost for such a map display is $10,000 to $12,000.

ARTS Data (Aircraft Radar Tracking System IIIa)

Several airports have integrated flight operation data, available through ARTS (Aircraft Radar Tracking System), with the airport noise system; the purposes are to assist in identifying specific time, flight-track characteristics, as well as aircraft and airline operator. ARTS is needed for air traffic control. ARTS-IIIA provides a continuous surveillance of aircraft activity in their assigned airspace every 4 sec. Only two airports now directly use the radar system as part of a noise monitoring program, Washington National Airport and Dulles International Airport; both of these airports are operated by the FAA. Cleveland, Ohio, and the Port Authority of New York and New Jersey are in the process of installing the necessary electronics to provide the ARTS-IIIA information for their respective noise programs. However, recording of each aircraft operation will not occur in real time, but will be delayed for 15 to 30 days because the FAA must keep all ARTS data for 2 weeks in case there is an aircraft accident. The amount of data generated by this system is significant (e.g., up to 15 reels of tape per day). Therefore, to avoid excessive storage and handling requirements, a select sample would be the most desirable approach. Automatic aircraft detection, counting, and aircraft identification have been considered important noise management tools at several air carrier airports.

PURPOSE OF ESTABLISHING NOISE MONITORING PROGRAMS

Airport noise monitoring programs have been established for a variety of reasons. It is important that airports analyze the advantages and disadvantages of establishing a program of this type before proceeding.

Based on the purpose of systems already installed at airports throughout the United States, collective purposes of establishing a noise monitoring program are to:

- Assess alternative flight procedures for noise control
- Assist in the investigation of specific public inquiries and complaints
- Instill public confidence that airport-related noise is being monitored to protect the public's interest
- Validate noise modeling efforts at the airport over an extended period of time (e.g., 1 year)
- Assist in addressing land-use planning and noise-impact issues
- Indicate official concern for airport noise by the jurisdiction and its governing body
- Detect unusual flight events
- Educate airplane pilots, airlines, the air-

port proprietor, and the public about airport noise and its characteristics

- Obtain valid statistical data using an objective and scientific resource
- Apply research tools to assist the airport in performing certain tasks, as required or mandated
- Assess compliance with some voluntary or mandatory noise level, established by a governmental entity

CONCLUSION

Interest in establishing a noise monitoring system at airports is increasing. Today, there are 25 systems in place, primarily installed at commercial air carrier airports. Three such systems are operated by the federal government, including two in Washington, D.C., and one in Langley, Virginia (NASA). Three systems have been installed this past year (West Chester, New York; St. Louis, Missouri; and Cleveland, Ohio) for a variety of reasons and purposes. Some of the earlier systems are now being upgraded to reflect the state of the art (e.g., Port Authority of New York and New Jersey). Because of the growth of aviation and the proximity of communities to airports, which resulted in potential land-use incompatibility, and because of the FAA Part 150 Program (8), the demand for such systems is predicted to increase. Several airport operators are in the process of receiving or have already received federal support on a matching basis (80 to 20 percent) through the FAA to obtain an airport noise monitoring system. Such systems generally range in cost from $250,000 to $1,000,000, depending on equipment specifications.

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