# Use of Acoustic Examples in Airport Noise Planning and Decision Making

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**A general understanding of noise measurement metrics is a critical element in applying land use/noise exposure criteria such as those contained in the Federal Aviation Administration's (FAA's) Airport Noise Compatibility Planning Program, FAR Part 150, or the military's AICUZ program. The author has developed a presentation system that blends computer-based training techniques with digital recording technology. An interactive presentation package has been created (for the FAA's Department of Environment and Energy) that treats the multiple elements of an airport land use/noise management program. Acoustic examples illustrate such concepts as differences between stage II and stage III aircraft, effects of flight track, and profile changes and alternate levels of building insulation. The presentation describes the system and its features. It then considers the political context of noise management decisions and how the introduction of specific noise examples might affect the decision process. Although experience with the system is not yet extensive, two effects have been observed. First, it appears that acoustic examples act to broaden the range of noise management strategies under public consideration. Second, because the system can produce site-specific noise data, it encourages personal questions about noise exposure from individual citizens. Although these features enrich the planning process and increase public understanding, they are not politically neutral. The paper notes that the broadening of strategies can also complicate decisions and that the personalization of noise impact can sharpen responses. Generally, the system has been successful in increasing community understanding of noise issues and the effectiveness of alternate noise management strategies.**

This paper looks at a new technique for presenting information about noise in the airport environment. It uses acoustical examples to explore noise management questions. After briefly considering the ways in which acoustic examples have previously been used in decision settings, focus is placed on the features of the new system. With the technology explained, consideration is given to how such a system can affect the decision environment.

Noise problems exist at many airports in the United States. More than a third have adopted policies that restrict operations in ways that are intended to reduce aircraft noise to adjacent communities. The Federal Aviation Administration (FAA) and Congress have developed a process of airport planning that assigns significant responsibilities to local decision makers. Although the FAA cannot approve local programs that create an "undue burden on interstate or foreign commerce," it has sanctioned plans that include restrictions on operations of noisy aircraft. Such local regulations affect the whole national system of airports and air travel, since restrictions on a type of aircraft at one airport affect all airports served from that location, as well as the way airlines assign available aircraft over their route system (*1*).

Planning at the local level can be an intensely political and controversial process. In the case of airport planning, the already difficult process of rational plan making is complicated by the complex mix of elements involved in airport noise management and by the unwieldy metrics of noise measurement that most people do not really understand. These two issues, coupled with the national reliance on a multiplicity of local planning efforts, make the uniform and effective presentation of noise planning data a topic of great importance.

## ACOUSTIC EXAMPLES

One obvious path to presenting easily understood information about aircraft noise is to use acoustic examples. There is an extensive but mostly unreported history of the use of such examples in public hearing settings. Engineers and planners with the responsibility for presenting information about noise usually include examples of some sort so that laymen can gain some perspective on what is being discussed. Practically every acoustic report on noise intended for nontechnical readers includes a table listing the decibels associated with a collection of familiar sounds. The reader uses memory and imagination to relate the tables to whatever noise management issues are under discussion. However, good acoustic memory is rare. Only 2 percent of the population have "perfect pitch," and such tables probably have little authentic ability to convey noise information.

More ambitious presenters have taken to the field, placing observers near an airport at what is estimated to be a noise exposure contour line, awaiting overflying planes, verifying the noise exposure level with sound level meters. This approach is not only unpredictable and awkward, it is also not portable and nonrepeatable, and is limited in

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its ability to describe noise remedies, such as noise abatement flight procedures, quieter aircraft, or soundproofing.

Other presenters have opted for the use of recorded sounds. This has the advantages of controllability and convenience. Modern recordings can be quite realistic, particularly wide-tape format, high-fidelity, or PCM digital recordings. The problem is that recordings sound "different" out of context, and the duration of a presentation requires an unusually patient and receptive audience.

Videos and movies have been produced for the specific purpose of informing the public about noise control methods. The New Jersey Highway Department has produced an excellent video explaining the capabilities of roadway noise barriers. The production of a movie or video is technically demanding, time-consuming, and expensive. Because such programs tend to be generalized and not problem-specific, an audience may become impatient when they are used in presentations. Several agencies that have sponsored films and videos for use at public hearings have reported that they seldom use them because of this problem.

## INTERACTIVE SOUND INFORMATION SYSTEM

This discussion reports on experience with a new technique for presenting noise information to decision makers and concerned citizens. The concept borrows from interactive computer training methods and digital recording technology. The system, the Interactive Sound Information System (SIS), has been used for making presentations about issues such as highway noise, noise barrier construction, outdoor loudspeakers, and the features of local ordinances proposed for controlling noise. The system uses mostly standard computer and sound reproduction equipment; however, the software and some essential hardware are proprietary and unique to the ISIS package.

The FAA's Office of Environment and Energy has sponsored production of a presentation package based on the ISIS concept that is designed for use in airport noise/land use management programs. The FAA has purchased several complete packages that are to be made available to local planners for use in planning work. The FAA actively encourages and requires community involvement as a feature of all sponsored programs. Public law requires this, and it is carried into numerous department policies, orders, and advisory circulars (*2*):

> Public hearings, public information sessions, coordination meetings and other communications conducted for the purpose of ensuring that the planning study receives input and is fully coordinated with the public, and with interested parties (i.e., planning agencies, community organizations, affected jurisdictions, airport users) are extremely important and essential activities in a planning study.

The FAA sees the ISIS package as a mechanism for communicating technical information about airport noise to citizens and decision-making groups. The program was designed for consultation with federal officials and local airport planners around the country. The programming has been structured to reflect the presentation requirements of this group.

The system is intended to be a presentation maker's tool, as an aid in addressing individuals, small groups, or larger audiences. It uses acoustic examples (recorded digitally) to illustrate a variety of points related to airport noise management. A microcomputer randomly accesses the sounds and plays them back at precisely set volumes. Sounds are correct to the nearest 0.75 db (at a reference point in terms of sound pressure level [SPL]). Images on the computer's screen dramatize presentation points and control the direction of a presentation. Selections among program options are made using a "mouse."

### The FAA Program

The FAA asked for a program that included both novice and expert levels. The novice mode is a turn-the-switch operation with a preset presentation. The expert mode allows for custom programming. It is organized in a simple loop structure with all presentation segments accessed from a central menu that shows all available program options (Figure 1). On termination, all options return to the same menu. The menu options can be selected in any order. Several features of this initial menu deserve mention. It has the graphic quality of a slide rather than a computer program. The text is in neat Helvetica type, in color and drop-shadowed on a gray background. Throughout, the program graphics have been designed to provide visual support and reinforcement to the acoustic points being made. A deliberate decision was made, however, to make very limited use of animation to avoid any resemblance to computer games.

It should also be noted that the divisions of this menu are not just a programming convenience. There is a not-so-hidden agenda here. The menu presents airport noise management issues as a collection of elements: aircraft,

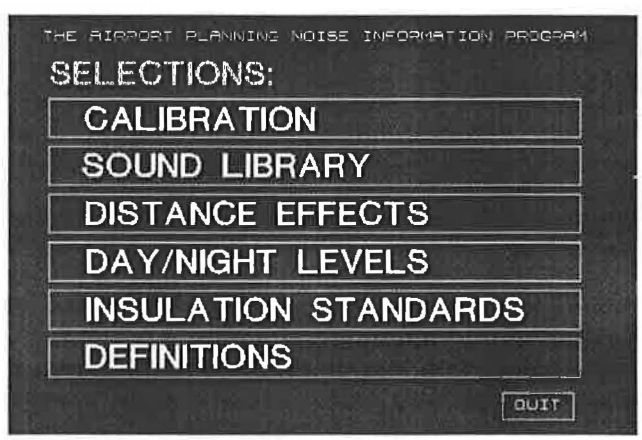


**FIGURE 1 Central menu of program options.**

flight operations, land use compatibility, and sound insulation. The idea is to offer a framework for plan making that includes the full action agenda offered with this menu. As is discussed later, community debate on airport noise problems is often more limited than this.

### Calibration Sequence

The calibration sequence has been given greater graphic attention, more than is normally associated with the calibration of a technical instrument (Figure 2). In earlier versions of the ISIS package, the programming of this segment was more pedestrian. It was found that the audience for a presentation was intensely interested in how closely the sounds produced by the system match the levels illustrated on the screen. With the system's 0.75 db resolution, a near-perfect match is normal. In a typical presentation, noise meters are provided to listeners so they can verify the accuracy of the system.

The boxes on the calibration screen ("ON," "OFF," "SWITCH," etc.) can all be selected using the mouse pointer. When the left side selected is "ON," a tone of 75 db is heard. When the "ADJUST" feature is selected, the pointer can be used to alter the volume level by dragging the bar shown on the center scale to the desired decibel level. An independently controllable tone is manipulated from the right side of the screen, and sounds are produced from the corresponding left and right stereo speakers of the sound system.

The setup can also be useful for presenting acoustic fundamentals (e.g., demonstrating the perceptual "doubling" of sound that takes place with 10-db changes, or that the limit of perceived differences in SPL is around 3 db).

### Sound Library Sequence

The library sequence is the ISIS counterpart of that traditional page, found in so many consultant reports and texts, that lists the sound exposure levels of a collection of familiar sounds. The difference here is that you can hear any of these sounds individually or in pairs. The sound library includes a collection of environmental sounds as well as field recordings of the takeoffs and landings of the nation's most prevalent aircraft (Figure 3). The figure shows several screens from the collection of possible images. The underlying image represents a listing of commercial aircraft with two selected. The overlay shows images of the selected aircraft and associated peak sound ($L_{max}$) during takeoff. The sound levels presented are based on predictions produced by the FAA's Integrated Noise Model (INM).

Any sound pair could be selected, but primary use of the segment is to demonstrate the differences between stage II and stage III aircraft. The differences among aircraft can be dramatic. Most sequences include similar control boxes. In terms of general program design, it should be noted that the ISIS system makes heavy use of sounds presented as pairs. This reflects the psychoacoustic concept that sounds are perceived in relative rather than absolute terms. Perceived loudness is determined by context. As a result, people hearing the program at different distances from the equipment report similar experiences during these comparison sequences even though the sound pressure levels they hear are quite different from those heard at other room locations.

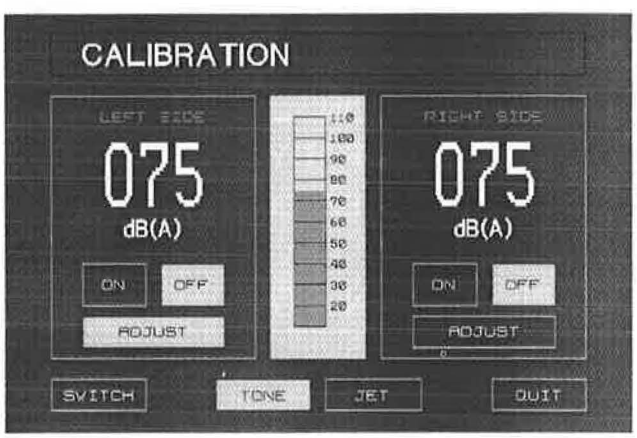


**FIGURE 2 Calibration sequence.**

### Distance Effects Sequence

The distance effects segment deals with flight-track and profile issues. The segment is quite simple in terms of its underlying structure. There is an index map that permits selections of local area maps (Figure 4). The underlying map is the index map, and the overlay shows a local area detail map. The numbered boxes in the detail maps are used to access recordings of aircraft flyovers as they might be heard at each location. Again, volumes used are based on predictions made through the grid report feature of the INM. Up to 81 locations can be coded into the maps.

Any sort of map or diagram can be inserted into the space above the controller boxes. The examples show maps originally produced by a commercial mapping system called LANDTRACK. Images can also be digitized from photos or through the use of a scanner. The presentation package includes a procedure for placing the boxes on the screens as well as for setting the volumes corresponding to each location. The presenter can choose from recordings of direct overflights, near distance, and remote aircraft flyovers.

### Day/Night Levels Sequence

Day/night sound exposures are cumulative, twenty-four-hour composites where nighttime sounds are weighted with a 10-db penalty (Figure 5). This is a nationally

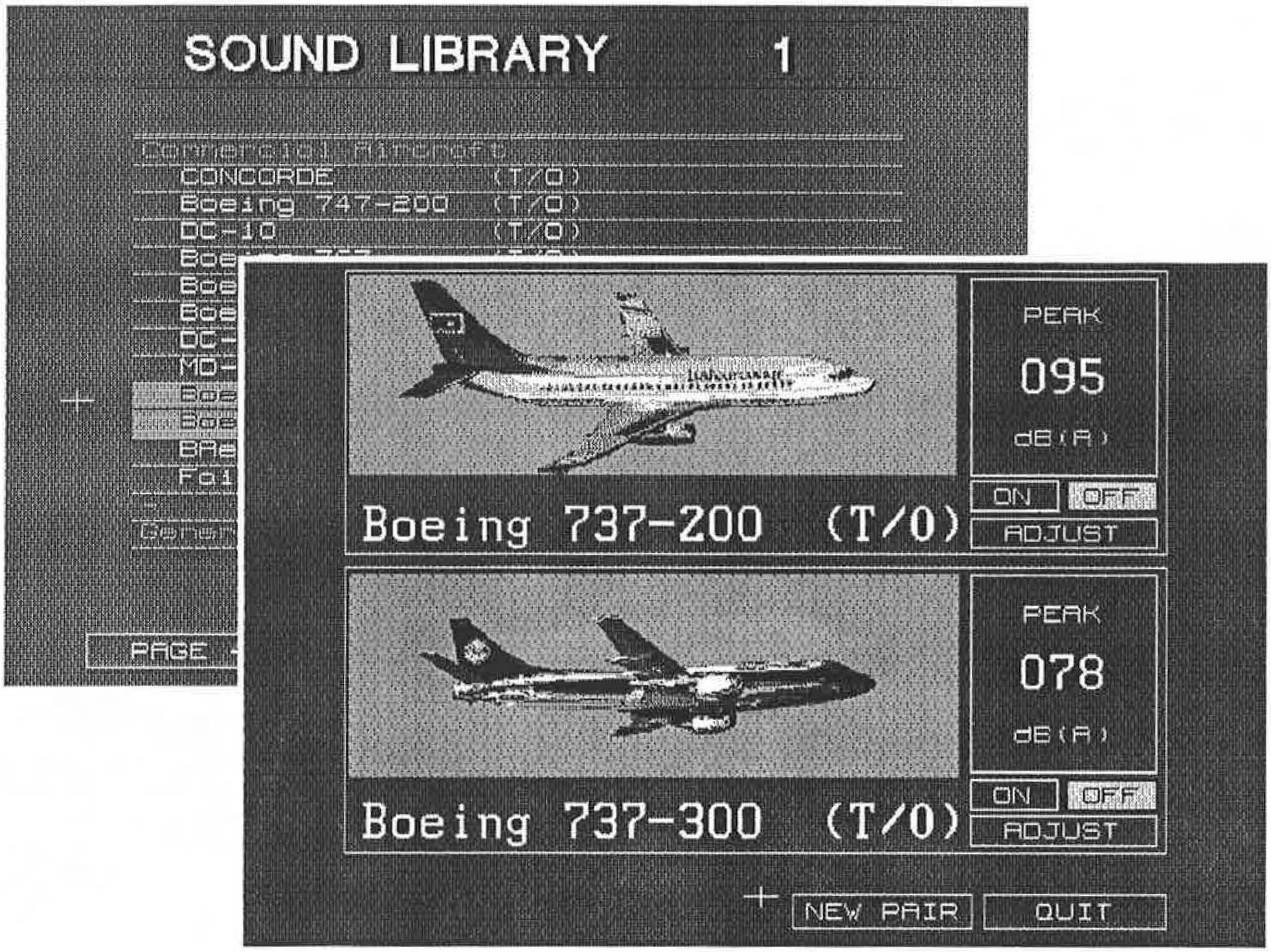


**FIGURE 3 Sound library sequence: underlay shows the options; overlay shows how selections are presented.**

recognized and useful standard for measuring airport noise but one that is exceptionally difficult to explain, particularly when it is presented as contour lines on a map. The underlying image shows daily flight operations for aircraft that are representative of operations at an airport.

Aircraft can be highlighted with the pointer. If the box labeled "Listen" is selected from the options arranged along the bottom of the screen, a picture of the highlighted plane will appear and a takeoff (or landing) will be heard, as shown in the overlay image. By selecting the "Edit" box, the numbers of day or night operations can be changed for any aircraft and, with these, the cumulative $L_{dn}$. The "Info" box produces a plane picture accompanied by some lines of text describing the aircraft's size and performance.

The control box labeled "Screen" swaps the entire page of listed aircraft with an alternate list of planes and operations. This feature permits a presenter to step quickly between alternate scenarios of flight operations. The feature is used to illustrate such concepts as differences between present and future airport use patterns. While it is not possible to hear $L_{dn}$, the sequence does permit an audience to hear individual noise events and, by adding them to and subtracting them from the airport mix, to see how the events affect $L_{dn}$.

### Insulation Sequence

This sequence illustrates how sounds are heard outdoors and indoors at various levels of reduction reflecting acoustic insulation (Figure 6). The noise reduction levels shown correspond to FAA recommendations for noise-compatible land uses in different noise exposure areas.

This segment has a special comparative feature, a "TV" with an adjustable volume control. The TV volume can be adjusted to whatever the user thinks is a comfortable listening level, and the sounds of a flyover can be produced, attenuated to correspond to the specified level of sound insulation.

### Other Details

The Definition Sequence is a collection of graphic screens designed to illustrate technical concepts and themes. The

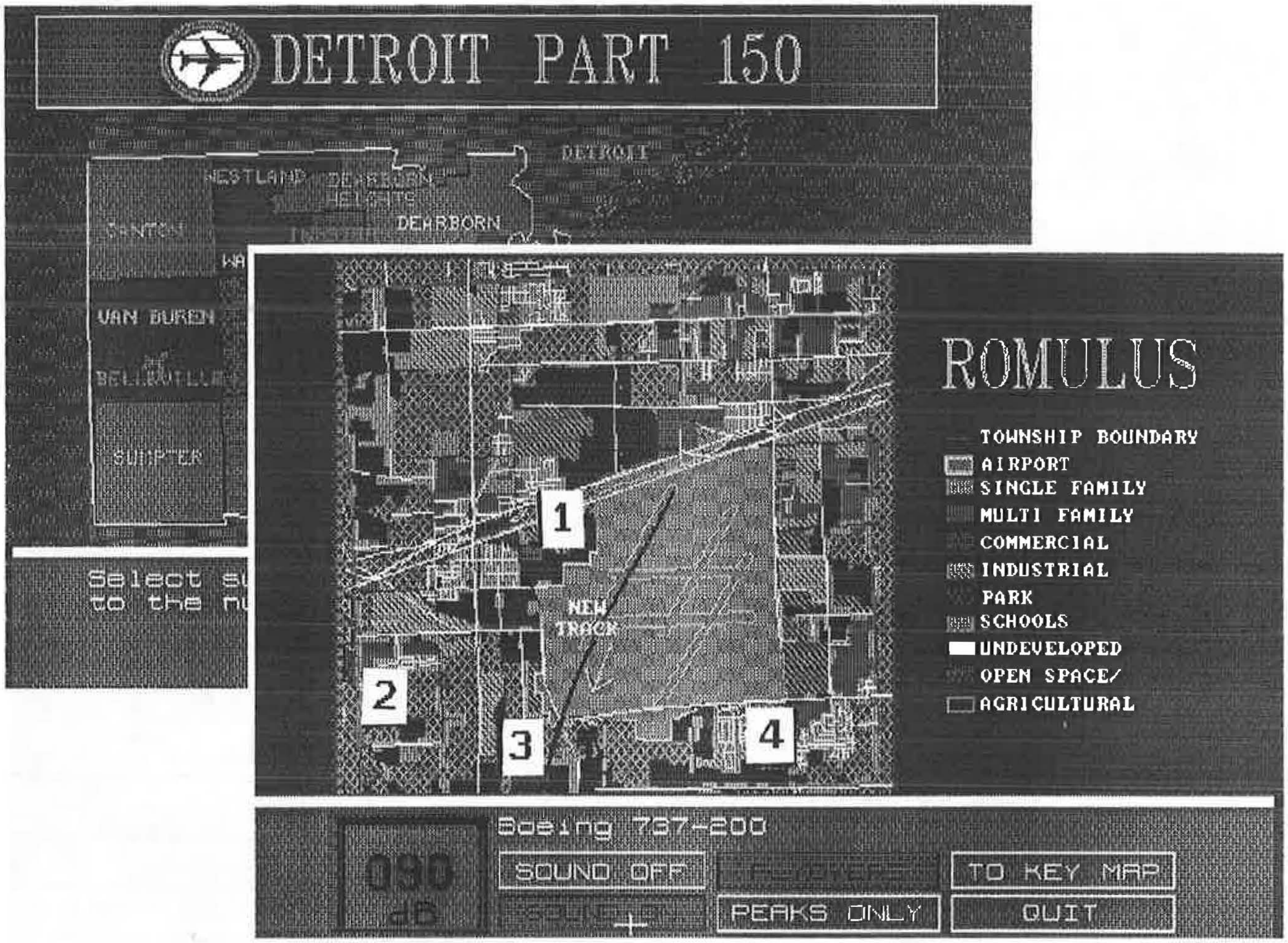


**FIGURE 4 Distance effects sequence: underlay shows the key map; overlay shows one of the selectable detailed maps.**

computer used is an IBM-compatible machine. The display is in a high-resolution, EGA mode and can be shown on a monitor or projected onto a screen. The program and graphics are stored on the system's hard disk. Sounds are recorded on a conventional compact disc being read by a CD-ROM drive. The sounds in the library were digitally recorded and digitally mastered. As mentioned, users can customize their presentations. The presentation sequences follow a "script" that approximates conventional English. Thus it is not necessary to change the program code to modify the pictures, numbers, and text that make up a presentation.

## SYSTEM EFFECTS ON THE DECISION ENVIRONMENT

### Credibility

The system has the power to command total credibility. Even fellow professionals, well seasoned in the difficult business of extracting sensible information from computers, seem disposed to accept the truth of the system's pronouncements. In presentations the calibration sequence is used to establish the correctness of the match between screen display and reproduced sounds. This demonstration, combined with the general mystique of computers and the popular belief that, being emotionless, they cannot lie, produces a willingness to accept as truth the information the system produces. The sounds and visual displays change simultaneously, and the drop-shadowed Helvetica text is boldly assertive. The images have the substantial quality of pages in a reference text.

### Interest

The program has commanded total attention wherever it has been used. Some part of this has to do with its complete novelty, part to the program content, and part to the nature of an interactive session with a computer-moderated presentation system. A person entering a meeting room where a presentation will be made sees the unfamiliar but recognizable equipment: some impressive audio equipment and a computer with a monitor (or several) positioned to be seen. Yellow tape marks some seats or areas on the floor (where sound will be produced at volumes corresponding to those shown on the screen). The

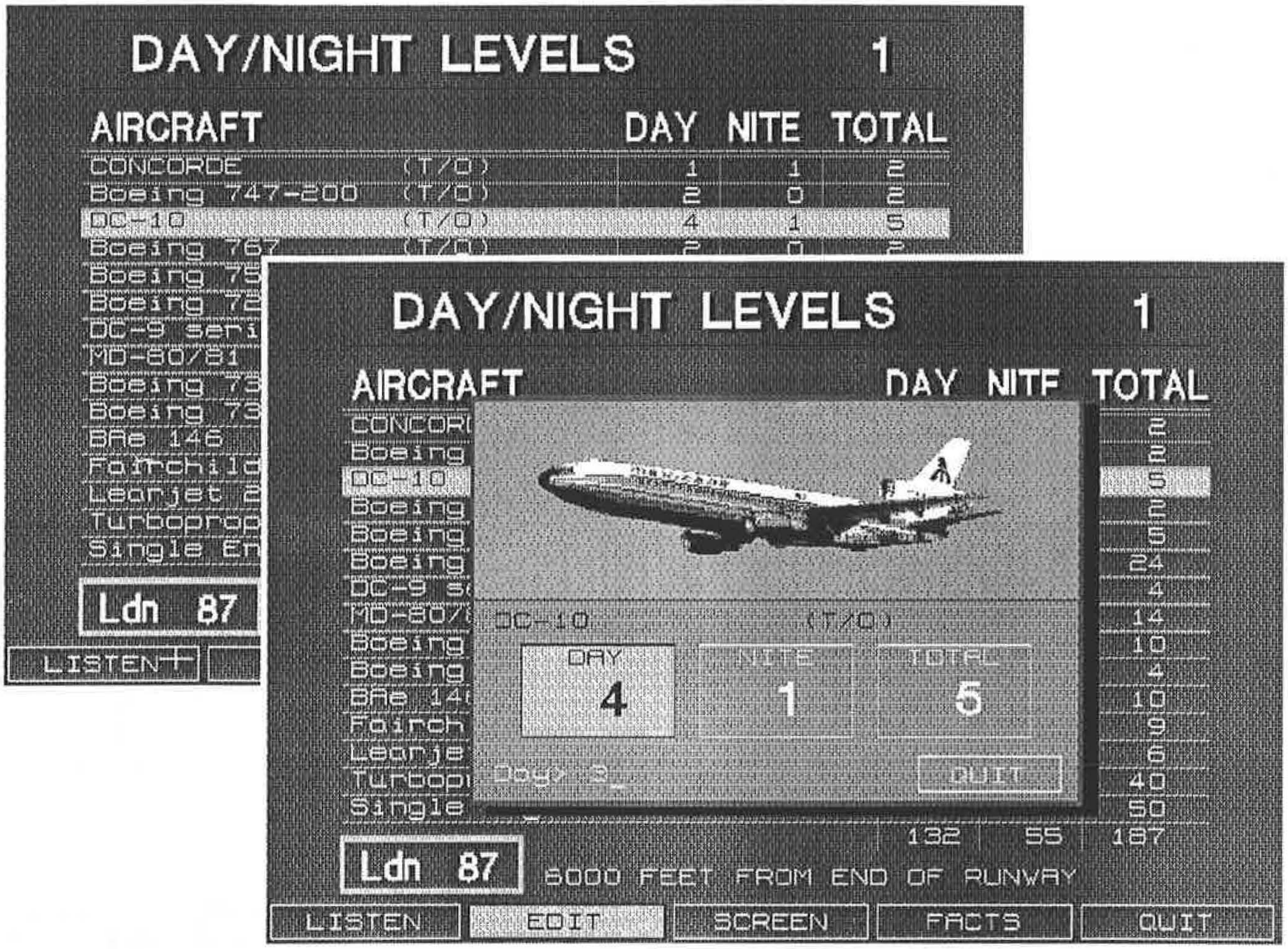


**FIGURE 5 Day/night levels sequence: underlay shows aircraft mix and $L_{dn}$ at an airport; overlay image shows the screen with an aircraft selected for editing.**

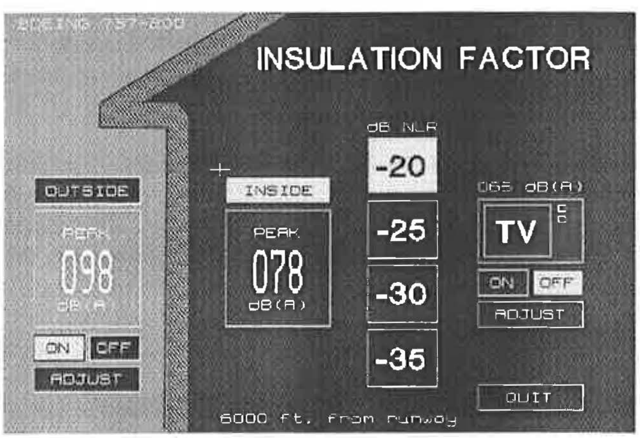


**FIGURE 6 Insulation sequence; noise level reduction selections are arranged at the center.**

council or commission may be moved to these special seats just before a presentation.

A well-organized, computer-moderated presentation is far more interesting than equally competent programs using slides or an overhead projector. A presentation has a live performance quality, in contrast to the predefined unfolding of a slide or video program. The screen responds to instructions. Elements can be delivered in any order at any speed. A presenter can answer "what if" questions, with appropriate displays and sounds seemingly created on the spot. With proper planning, the distance or insulation sequences can be used to give highly personalized reports on exactly what would be heard at specified locations. This feature of the system, the ability to personalize reports on noise exposure, has political significance, as is discussed in the next section.

## SYSTEM EFFECTS ON THE DECISION PROCESS

The political environment surrounding airport noise management issues is undeniably rich and complex. Typically it involves economic trade-offs, contests between city and suburb, personalities, and egos, as well as groups using "airport noise" as a means of building their power base. Factual information about airport noise, however presented, can be only one element of the decision environment, facts about noise are weighed along with other facts, such things as facts about the likelihood of lawsuits, facts about how decisions could affect voters in the next elections, or facts about the preferences of influential groups.

The ISIS system includes some novel components that make it more than just another way of organizing a technical presentation. Two ISIS package features could work changes in the larger political setting for airport noise management decisions. These have to do with extending the agenda for decision making and what might be termed the individualization of issues.

In considering the ISIS package in the context of noise issue politics, it would be helpful to detour momentarily and consider the basics of community political organization as they have been presented by the dean of community organizers, the late Saul Alinsky. Alinsky's writings are noteworthy because of both their broad acceptance and their outspoken directness (*3*). "An organizer must stir up dissatisfaction and discontent: provide a channel into which people can angrily plow their frustrations." He suggested ten fundamental rules for organizers. These include two of special interest to technical presenters: the need to find issues that can be reduced to simple, easily understood demands and issues that involve broadly shared self-interest within a community. It is of interest that Alinsky viewed the issues as only a means to an end—the end being creation of an organized political force. Although Alinsky aimed his efforts at organizing depressed urban neighborhoods, his concepts can easily be applied in any setting and certainly apply to some noise protest movements.

The effect of issue simplification is apparent in the national pattern of airport noise controversies where policy contentions so typically focus on single issues or concepts. Proposals have been made for passenger enplanement caps, restrictions on particular aircraft, nighttime curfews, reductions in flight operations, redirection of flights to other airports, relocation of flight tracks, and changes in takeoff and landing procedures. While a robust noise management program could include all of these features, however, noise protest movements typically focus on the advocacy of single policies. This is so much the case that a listing of strategies immediately brings to mind a corresponding list of airports where these policies have achieved political dominance. As Alinsky observed, issues must be reduced to simple, easily understood demands if they are to be useful as a motivating force.

The initial menu of the ISIS system that lists multiple strategies for noise management is a quiet declaration that the management program ought to be comprehensive and consider multiple aspects of problems. It invites more comprehensive approaches, more subtle and complex solutions. Although this is comfortable for technical specialists, it works against interest groups that would build coalitions around simple, easily defined issues and solutions. In composing one custom ISIS presentation, the authors were asked to produce an opening menu showing fewer available options. The requester suggested that it was "too late" to look at some of the alternatives.

The system's ability to produce highly individualized reports of noise impact also has political significance. Community organizers of the Alinsky mode recognize self-interest as the dynamo energizing any protest movement. The ISIS system has the unique capability of being able to inform persons directly how much their self-interest might be affected by a noise source or a proposed solution alternative. The map distance sequence can give acoustic examples of sounds at specific locations, and the insulation sequence allows adjustment according to personal tastes. In a series of public hearings where citizens were given an opportunity to hear the noise that a controversial project would produce as it would sound from their property, those who were least affected dropped out of the political process. Although there is attrition in any lengthy hearing sequence, it could well be that individualized presentations can accelerate this. It is also possible that, as the differential impacts of alternate policies become better understood, it will be more difficult to create a consensus around particular solutions.

## CONCLUSION

The ISIS package, as developed for the FAA, meets its basic objectives of informing people about airport noise and the acoustic consequences of various noise management strategies. It invites a comprehensive approach to airport noise management, and its interactive features permit a decision-making group to experiment with policy alternatives and sample the results.

With its ability to produce understandable, believable, and defensible approximations of sounds as they would be heard at specific locations under specified conditions, ISIS responds to the basic questions that bring people to public hearings about airport noise. It can demonstrate how a particular decision can affect an individual's self-interest. In doing this, it can clarify who in the affected communities will feel the greatest impact from decision alternatives. The features of the system have the potential to exert an important influence on the decision process.

Although experience with the ISIS package in airport management decisions is still quite limited, it is expected that the system's political impact on the decision process will approximate initial experiences. Undoubtedly, the political system will work its own influences on the ISIS package and the presentation scripts. The authors look forward to learning more about how acoustical examples can benefit the decision process.

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