Airport Land Use Compatibility Concepts

The following material is mostly excerpted from Chapter 3 of the California Airport Land Use Planning Handbook *(January 2002).*

Introduction

The airport land use compatibility concerns of ALUCs fall under two broad headings identified in state law: noise and safety. However, for the purposes of formulating airport land use compatibility policies and criteria, further dividing these basic concerns into four functional categories is more practical. These categories are:

- *Noise:* As defined by cumulative noise exposure contours describing noise from aircraft operations near an airport.
- *Overflight:* The impacts of routine aircraft flight over a community.
- *Safety:* From the perspective of minimizing the risks of aircraft accidents beyond the runway environment.
- *Airspace Protection:* Accomplished by limits on the height of structures and other objects in the airport vicinity and restrictions on other uses which potentially pose hazards to flight.

For each compatibility category, four features are outlined below:

- *Compatibility Objective:* The objective to be sought by establishment and implementation of the compatibility policies;
- *Measurement:* The scale on which attainment of the objectives can be measured;
- *Compatibility Strategies:* The types of strategies which, when formulated as compatibility policies, can be used to accomplish the objectives; and
- *Basis for Setting Criteria:* The factors which should be considered in setting the respective compatibility criteria.

In the Noise and Safety sections, additional discussion taken from elsewhere in the Handbook *or written for this appendix is included following the above four bullet items.*

Noise

Noise is one of the most basic airport land use compatibility concerns. Moreover, at major airline airports, many busy general aviation airports, and most military airfields, noise is usually the most geographically extensive form of airport impact.

- **Compatibility Objective**—The clear objective of noise compatibility criteria is to minimize the number of people exposed to frequent and/or high levels of airport noise capable of disrupting noise-sensitive activities.

- **Measurement**—For the purposes of airport land use compatibility planning, noise generated by the operation of aircraft to, from, and around an airport is primarily measured in terms of the cumulative noise levels of all aircraft operations. In California, the cumulative noise level metric established by state regulations, including for airport noise, is the Community Noise Equivalent Level (CNEL). This metric provides a single measure of the average sound level in decibels (dB) to which any point near an airport is exposed. To reflect an assumed greater community sensitivity to nighttime and evening noise, events during these periods are counted as being louder than actually measured. Cumulative noise levels are usually illustrated on airport area maps as contour lines connecting points of equal noise exposure. Mapped noise contours primarily show areas of significant noise exposures—ones affected by high concentrations of aircraft takeoffs and landings.

  The calculation of cumulative noise levels depends upon the number, type, and time of day of aircraft operations, the location of flight tracks, and other data described in Chapter 6 [of the *Handbook*]. For airports with airport traffic control towers, some of these inputs can be derived from recorded data. Noise monitoring and radar flight tracking data available for airports in most metropolitan areas are other sources of valuable information. At most airports, though, the individual input variables must be estimated. The important point to be made here is that, despite their computer-generated origin, the location of noise contours is not necessarily precise. Where extensive noise monitoring and flight tracking data are available, current contours can be accurate to within ±1 dB. Elsewhere, the level of accuracy has generally been found to be about ±3 dB. Contours representing projections of future noise levels are inherently even less precise.

- **Compatibility Strategies**—The basic strategy for achieving noise compatibility in an airport vicinity is to limit development of land uses which are particularly sensitive to noise. The most acceptable land uses are ones which either involve few people (especially people engaged in noise sensitive activities) or generate significant noise levels themselves (such as other transportation facilities or some industrial uses).

  On occasion, local considerations outweigh noise impacts and result in decisions by local land use jurisdictions or even ALUCs to allow residential development in locations where this use would normally be considered incompatible. In such circumstances, approval of the development should be conditioned upon dedication of an avigation easement and requirements for sufficient acoustic insulation of structures to assure that aircraft noise is reduced to an interior noise level of 45 dB CNEL or less.

- **Basis for Setting Criteria**—Compatibility criteria related to cumulative noise levels are well-established in federal and state laws and regulations. The basic state criterion sets a CNEL of 65 dB as the maximum noise level normally compatible with urban residential land uses. For many airports and many communities, 65 dB CNEL is too high for land use planning purposes. A process called "normalization" is one means of adjusting the criteria to reflect ambient sound levels, the community's previous exposure to noise, and other local characteristics as outlined in Chapter 7 [of the *Handbook*]. This process helps to determine what CNEL is of significance to that particular community. Once the baseline maximum acceptable noise level for residential uses is established, criteria for other land uses can be set in a manner consistent with this starting point.

Cumulative noise metrics such as CNEL are well-suited for use in establishing land use compatibility policy criteria and are the only metric for which widely accepted standards have been adopted. However, a different perspective on airport noise impacts can be obtained by examining sound level data for individual aircraft operations. Figure H1 depicts the typical noise "footprints" of a variety of general aviation aircraft. These footprints represent the momentary, maximum sound levels (L_{max}) experienced on the ground as the aircraft flies over while landing at and taking off from a runway. Each of these footprints is broadly representative of those produced by other aircraft similar to the ones shown. The actual sound level produced by any single aircraft takeoff or landing will vary not only among specific makes and models of aircraft, but also from one operation to another of identical aircraft.

In examining the footprints, additional two points are important to note. One is the importance of the outermost contour. This noise level—65 dBA L_{max}—is the level at which interference with speech begins to be significant. Land uses anywhere within the noise footprint of a given aircraft would experience a noise level, even if only briefly, that could be disruptive to outdoor conversation. Indoors, with windows closed, the aircraft noise level would have to be at least 20 dBA louder to present similar impacts. A second point to note concerns the differences among various aircraft, particularly business jets. As the data shows, business jets manufactured in the 1990s are much quieter than those of 10 and 20 years earlier. The impacts of the 1990s era jets are similar to those of twin-engine piston aircraft and jets being made in the 2000s are quieter yet. At many airports, the size of the CNEL contours is driven by a relatively small number of operations by the older, noisier business jets. These aircraft are gradually disappearing from the nationwide aircraft fleet and will likely be mostly gone within 20 years, but at this point in time it is uncertain when they will be completely eliminated.

Overflight

As discussed in [*Handbook*] Chapter 7, experience at many airports has shown that noise-related concerns do not stop at the boundary of the outermost mapped CNEL contour. Many people are sensitive to the frequent presence of aircraft overhead even at noise low levels. These reactions can mostly be expressed in the form of *annoyance*.

At many airports, particularly air carrier airports, complaints often come from locations beyond any of the defined noise contours. Indeed, heavily used flight corridors to and from metropolitan areas are known to generate noise complaints 50 miles or more from the associated airport. The basis for such complaints may be a desire and expectation that outside noise sources not be intrusive—or, in some circumstances, even distinctly audible—above the quiet, natural background noise level. Elsewhere, especially in locations beneath the traffic patterns of general aviation airports, a fear factor also contributes to some individuals' sensitivity to aircraft overflights.

While these impacts may be important community concerns, the question of importance here is whether any land use planning actions can be taken to avoid or mitigate the impacts or otherwise address the concerns. Commonly, when overflight impacts are under discussion in a community, the focus is on modification of the flight routes. Indeed, some might argue that overflight impacts should be addressed solely through the aviation side of the equation—not only flight route changes, but other modifications to where, when, and how aircraft are operated. ALUCs are particularly limited in their ability to deal with overflight concerns. For one, they have no authority over aircraft operations. The most they can do to bring about changes is to make requests or recommendations. Even with regard to land use, the authority of ALUCs extends only to proposed new development.

These limitations notwithstanding, there are steps which ALUCs can and should take to help minimize overflight impacts.

- **Compatibility Objective**—In an idealistic sense, the compatibility objective with respect to overflight is the same as for noise: avoid land use development which can lead to annoyance and complaints. However, given the extensive geographic area over which the impacts occur, this objective is unrealistic except relatively close to the airport. A more realistic objective therefore might be to promote conditions under which annoyance will be minimized. Possible strategies in this regard are described below.

- **Measurement**—Determining where to draw boundaries around areas of potentially significant overflight noise exposure is difficult because these locations extend beyond the well-defined CNEL contours which indicate areas of high noise exposure. CNEL contours are not very precise at low noise levels, especially where aircraft flight tracks are widely divergent. The general locations over which aircraft regularly fly as they approach and depart an airport are thus a better indicator of overflight annoyance concerns. For general aviation airports, such locations include areas beneath the standard airport traffic patterns, the portions of the pattern entry and departure routes flown at normal traffic pattern altitude, and perhaps additional places which experience a high concentration of overflights. Also, at all types of airports, common IFR arrival and departure routes can produce overflight concerns, sometimes many miles from the airport.

- **Compatibility Strategies**—As noted above, the ideal land use compatibility strategy with respect to overflight annoyance is to avoid development of residential and other noise-sensitive uses in the affected locations. To the extent that this approach is not practical, three different (but not mutually exclusive) strategies are apparent.

  - One strategy is to help people with above-average sensitivity to aircraft overflights—people who are highly *annoyed* by overflights—to avoid living in locations where frequent overflights occur. This strategy involves making people more aware of an airport's proximity and its current and potential aircraft noise impacts on the community before they move to the area. This can be accomplished through buyer awareness measures such as dedication of avigation or overflight easements, recorded deed notices, and/or real estate disclosure statements. In new residential developments, posting of signs in the real estate sales office and/or at key locations in the subdivision itself can be further means of alerting the initial purchasers about the impacts (signs are of little long-term value, however).

  - A second strategy is to minimize annoyance by reducing the intrusiveness of aircraft noise above normal background noise levels. Because ALUCs and local land use authorities have no way of regulating aircraft noise levels, the other option is to promote types of residential land uses which tend to mask the intrusive noise. In this regard, multi-family residences—because they tend to have comparatively little outdoor living areas, fewer external walls through which aircraft noise can intrude, and relatively high noise levels of their own—are preferable to single-family dwellings. Particularly undesirable are "ranchette" style residential areas consisting of large (about an acre on average) lots. Such developments are dense enough to expose many people to overflight noise, yet sufficiently rural in character that background noise levels are likely to be low.

  - Finally, for highly noise-sensitive uses, acoustical treatment of the structures, together with dedication of an avigation easement, may be appropriate.

- **Basis for Setting Criteria**—The basis for setting criteria is primarily the experience and knowledge that airport proprietors and airport land use commissions have about the noise sensitivity of the specific communities involved.

Safety

Compared to noise, safety is in many respects a more difficult concern to address in airport land use compatibility policies. A major reason for this difference is that safety policies address uncertain events which *may occur* with *occasional* aircraft operations, whereas noise policies deal with known, more or less predictable events which *do occur* with *every* aircraft operation. Because aircraft accidents happen infrequently and the time, place, and consequences of their occurrence cannot be predicted, the concept of *risk* is central to the assessment of safety compatibility. From the standpoint of land use planning, two variables determine the degree of risk posed by potential aircraft accidents:

- *Accident Frequency:* Where and when aircraft accidents occur in the vicinity of an airport; and
- *Accident Consequences:* Land uses and land use characteristics which affect the severity of an accident when one occurs.

- **Compatibility Objective**—The overall objective of safety compatibility criteria is simply to minimize the risks associated with potential aircraft accidents. There are two components to this objective, however:
  - *Safety on the Ground:* The most fundamental safety compatibility component is to provide for the safety of people and property on the ground in the event of an aircraft accident near an airport.
  - *Safety for Aircraft Occupants:* The other important component is to enhance the chances of survival of the occupants of an aircraft involved in an accident which takes place beyond the immediate runway environment.

- **Measurement**—In measuring the degree of safety concerns around an airport, the frequency component of risk assessment is most important: what is the potential for an accident to occur? As mentioned above, there are both *where* and *when* variables to the frequency equation:
  - *Spatial Element:* The spatial element describes *where* aircraft accidents can be expected to occur. Of all the accidents which occur in the vicinity of airports, what percentage occur in any given location?
  - *Time Element:* The time element adds a *when* variable to the assessment of accident frequency. In any given location around a particular airport, what is the chance that an accident will occur in a specified period of time?

- **Compatibility Strategies**—Safety compatibility strategies focus on the *consequences* component of risk assessment. Basically, the question is: what land use planning measures can be taken to reduce the severity of an aircraft accident if one occurs in a particular location near an airport? Although there is a significant overlap, specific strategies must consider both components of the safety compatibility objective: protecting people and property on the ground; and enhancing safety for aircraft occupants. In each case, the primary strategy is to limit the intensity of use (the number of people concentrated on the site) in locations most susceptible to an off-airport aircraft accident. This is accomplished by:
  - *Density and Intensity Limitations:* Establishment of criteria limiting the maximum number of dwellings or people in areas close to the airport is the most direct method of reducing the potential severity of an aircraft accident.
  - *Open Land Requirements:* Creation of requirements for open land near an airport addresses the objective of enhancing safety for the occupants of an aircraft forced to make an emergency landing away from a runway.
  - *Highly Risk-Sensitive Uses:* Certain critical types of land uses—particularly schools, hospitals, and other uses in which the mobility of occupants is effectively limited—should be avoided near the ends of runways regardless of the number of people involved. Aboveground storage of large quantities of highly flammable or hazardous materials also should be avoided near airports.

- **Basis for Setting Criteria**—Setting safety compatibility criteria presents the fundamental question of what is safe. Expressed in another way: what is an *acceptable risk*? In one respect, it may seem ideal to reduce risks to a minimum by prohibiting most types of land use development from areas near airports. However, as addressed later in [Chapter 3 of the *Handbook*], there are usually costs associated with such high degrees of restrictiveness. In practice, safety criteria are set on a progressive scale with the greatest restrictions established in locations with the greatest potential for aircraft accidents.
  - *Established Guidance:* As noted in [*Handbook*] Chapter 9, little established guidance is available to ALUCs regarding how restrictive to make safety criteria for various parts of an airport's environs. Unlike the case with noise, there are no formal federal or state laws or regulations which set safety criteria for airport area land uses for civilian airports except within *runway protection zones* (and with regard to airspace obstructions as described separately in the next section). Federal Aviation Administration safety criteria primarily are focused on the runway and its immediate environment. Runway protection zones—then called *clear zones*—were originally established mostly for the purpose of protecting the occupants of aircraft which overrun or land short of a runway. Now, they are defined by the FAA as intended to enhance the protection of people and property on the ground.
  - *New Research:* To provide a better foundation for establishment of safety criteria in other portions of the airport environs, extensive research into the distribution of general aviation aircraft accident locations was conducted in conjunction with the 1993 edition of this *Handbook* and expanded as an initial step in preparation of the present edition. The results are outlined in [*Handbook*] Appendix G and further examined in Chapter 9. Available information regarding air carrier aircraft accidents is presented as well. However, even with this new data on which to base safety compatibility decisions, the question is still ultimately one of what is acceptable to the local community.

One of the analyses presented in the *Handbook* involves aggregating the accident location points (the scatter diagrams of where accidents have occurred relative to the runway) in a manner that better identifies where the accident sites are most concentrated. The results are presented as risk intensity contours—Figures H2 shows arrival accident risks and Figure H3 portrays departure accident risks. The two drawings divide the near-airport accident location points into five groups of 20% each (note that only accident sites that were not on a runway, but were within 5 miles of an airport are included in the database). The 20% contour represents the highest or most concentrated risk intensity, the 40% contour represents the next highest risk intensity, and so on up to 80%. The final 20% of the accident sites are beyond the 80% contour. Each contour is drawn so as to encompass 20% of the points within the most compact area. The contours are irregular in shape. No attempt has been made to create geometric shapes.

The charts reveal several facts:

- About half of arrival accidents and a third of departure accidents take place within the FAA-defined runway protection zone for a runway with a low-visibility instrument approach procedure (a 2,500-foot long trapezoid, varying from 1,000 feet to 1,750 feet in total width). This fact lends validity to the importance of the runway protection zones as an area within which land use activities should be minimal.

- Although the runway protection zones represent the locations within which risk levels are highest, a significant degree of risk exists well beyond the runway protection zone boundaries. Among all near-airport (within 5 miles) accidents, over 80% are concentrated within 1.5 to 2 miles of a runway end.

- Arrival accidents tend to be concentrated relatively close to the extended runway centerline. Some 80% occur within a strip extending 10,000 feet from the runway landing threshold and 2,000 feet to each side of the runway centerline.

- Departure accidents are comparatively more dispersed laterally from the runway centerline, but are concentrated closer to the runway end. Many departure accidents also occur lateral to the runway itself, particularly when the runway is long. Approximately 80% of the departure accident sites lie within an area 2,500 from the runway centerline and 6,000 feet beyond the runway end or adjacent to the runway.

This data does not address the other major components of aircraft accident risk: the potential consequences of accidents when they occur and the frequency with which they occur. The intent is merely to illustrate the relative intensity of the risks on a geographic scale.

Furthermore, as with noise contours, risk data by itself does not answer the question of what degree of land use restrictions should be established in response to the risks. Although most ALUCs have policies that restrict certain land use activities in locations beyond the runway protection zones, the size of the area in which restrictions are established and the specific restrictions applied vary from one county to another.

Airspace Protection

Relatively few aircraft accidents are caused by land use conditions which are hazards to flight. The potential exists, however, and protecting against it is essential to airport land use safety compatibility.

- **Compatibility Objective**—Because airspace protection is in effect a safety factor, its objective can likewise be thought of in terms of risk. Specifically, the objective is to avoid development of land use conditions which, by posing hazards to flight, can increase the risk of an accident occurring. The particular hazards of concern are:
  - Airspace obstructions;
  - Wildlife hazards, particularly bird strikes; and
  - Land use characteristics which pose other potential hazards to flight by creating visual or electronic interference with air navigation.

- **Measurement**—The measurement of requirements for airspace protection around an airport is a function of several variables including: the dimensions and layout of the runway system; the type of operating procedures established for the airport; and, indirectly, the performance capabilities of aircraft operated at the airport.
  - *Airspace Obstructions:* Whether a particular object constitutes an airspace obstruction depends upon the height of the object relative to the runway elevation and its proximity to the airport. The acceptable height of objects near an airport is most commonly determined by application of standards set forth in Part 77 of the Federal Aviation Regulations. These regulations establish a three-dimensional space in the air above an airport. Any object which penetrates this volume of airspace is considered to be an obstruction and may affect the aeronautical use of the airspace.
  - *Wildlife and Other Hazards to Flight:* The significance of other potential hazards to flight is principally measured in terms of the hazards' specific characteristics and their distance from the airport and/or its normal traffic patterns.

- **Compatibility Strategies**—Compatibility strategies for the protection of airport airspace are relatively simple and are directly associated with the individual types of hazards:
  - *Airspace Obstructions:* Buildings, antennas, other types of structures, and trees should be limited in height so as not to pose a potential hazard to flight.
  - *Wildlife and Other Hazards to Flight*: Land uses which may create other types of hazards to flight near an airport should be avoided or modified so as not to include the offending characteristic.
- **Basis for Setting Criteria**—The criteria for determining airspace obstructions and other hazards to flight have been long-established in FAR Part 77 and other Federal Aviation Administration regulations and guidelines. Also, state of California regulation of obstructions under the State Aeronautics Act (Public Utilities Code, Section 21659) is based on FAR Part 77 criteria.