APPENDIX C

AIRPORT LAND USE COMPATIBILITY CONCEPTS

INTRODUCTION

This appendix provides basic information regarding the concepts and rationale used to develop the compatibility policies and maps set forth in Chapter 2 of this *Ontario International Airport Land Use Compatibility Plan*. Some of the material is excerpted directly from the *California Airport Land Use Planning Handbook* published by the California Division of Aeronautics in January 2002. Other portions are based upon concepts that evolved from technical input obtained during review and discussion of preliminary drafts of key policies.

State law requires that airport land use commissions "be guided by" the information presented in the *Handbook*. Despite the statutory reference to it, though, the *Handbook* does not constitute formal state policy or regulation. Indeed, adjustment of the guidelines to fit the circumstances of individual airports is suggested by the *Handbook*. The *Handbook* guidance and the information in this appendix does not supersede or otherwise take precedence over the policies contained in the *Ontario International Airport Land Use Compatibility Plan*.

As outlined in the *Handbook*, the noise and safety compatibility concerns fall into four categories:

- *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 that potentially pose hazards to flight.

The documentation in the remainder of this appendix is organized under the four compatibility categories. Under each of the four compatibility category headings, the discussion is organized around four topics:

- *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.

NOISE

Noise is perhaps the most basic airport land use compatibility concern. Certainly, it is the most noticeable form of airport impact.

Compatibility Objective

The purpose of noise compatibility policies is to avoid establishment of new noise-sensitive land uses in portions of an airport influence area that are exposed to significant levels of aircraft noise, taking into account the characteristics of the airport and the community surrounding the airport.

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 measurement of airport noise, is the Community Noise Equivalent Level (CNEL). Cumulative noise level metrics measure the noise levels of all aircraft operating at an airport on an average day (1/365) of the year. The calculations take into account not only the number of operations of each aircraft type and the noise levels they produce, but also their distribution geographically (the runways and flight tracks used) and by time of day. To reflect an assumed greater community sensitivity to nighttime and evening noise, the CNEL metric counts events during these periods as being louder than actually measured.

Cumulative noise level metrics provide a single measure of the average sound level in decibels (dB) to which any point near an airport is exposed over the course of a day. Although the maximum noise levels produced by individual aircraft are a major component of the calculations, cumulative noise level metrics do not explicitly measure these peak values. 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.

For civilian airports, noise contours are typically calculated using the Federal Aviation Administration's Integrated Noise Model (INM) computer program. The input information that generate this model are of two basic types: standardized data regarding aircraft performance and noise levels generated (this data can be adjusted for a particular airport if necessary); and airport-specific data including aircraft types and number of operations, time of day of aircraft operations, runway usage distribution, and the location and usage of flight tracks. Airport elevation and surrounding topographic data can also be entered. For airports with airport traffic control towers, some of these inputs can be obtained from recorded data. Noise monitoring and radar flight tracking data available for airports in metropolitan areas are other sources of valuable information. At most airports, though, the individual input variables must be estimated.

Compatibility Strategies

The basic strategy for achieving noise compatibility in an airport's vicinity is to limit development of land uses that are particularly sensitive to noise. The most acceptable land uses are ones that 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).

California state law regards any residential land uses as normally incompatible where the noise exposure exceeds 65 dB CNEL (although the state airport noise regulations explicitly apply only to identified "noise problem airports" in the context of providing the ability of these airports to operate under a noise variance from the State, the *Handbook* and other state guidelines extend this criterion to all airports as discussed below). This standard, however, is set with respect to high-activity airports, particularly major air carrier airports, in urban locations, where ambient noise levels are generally higher than in suburban and rural areas. As also discussed below and as provided in the *Handbook,* a lower threshold of incompatibility is often appropriate at certain airports, particularly around airports in suburban or rural locations where the ambient noise levels are lower than those found in more urban areas.

In places where the noise exposure is not so severe as to warrant exclusion of new residential development, the ideal strategy is to have very low densities—that is, parcels large enough that the dwelling can be placed in a less impacted part of the property. In urban areas, however, this strategy is seldom viable. The alternative for such locations is to encourage high-density, multi-family residential development with little, if any, outdoor areas, provided that the 45 dB CNEL interior noise standard and limitations based upon safety are not exceeded. Compared to single-family subdivisions, ambient noise levels are typically higher in multi-family developments, outdoor living space is less, and sound insulation features can be more easily added to the buildings. All of these factors tend to make aircraft noise less intrusive.

Sound insulation is an important requirement for residential and other noise-sensitive indoor uses in high noise areas. The California Building Code requires that sufficient acoustic insulation be provided in any habitable rooms of new hotels, motels, dormitories, dwellings other than detached single-family residences to assure that aircraft noise is reduced to an interior noise level of 45 dB CNEL or less. To demonstrate compliance with this standard, an acoustical analysis must be done for any residential structure proposed to be located where the annual CNEL exceeds 65 dB. The *Compatibility Plan* further requires dedication of an avigation easement as a condition for development approval in locations where these standards come into play.

Basis for Setting Criteria

Compatibility criteria related to cumulative noise levels are well-established in federal and state laws and regulations. The California Airport Noise Regulations (California Code of Regulations Section 5000 *et seq.*) states that:

> "The level of noise acceptable to a reasonable person residing in the vicinity of an airport is established as a community noise equivalent level (CNEL) value of 65 dB for purposes of these regulations. This criterion level has been chosen for reasonable persons residing in urban residential areas where houses are of typical California construction and may have windows partially open. It has been selected with reference to speech, sleep and community reaction."

No airport declared by a county's board of supervisors as having a "noise problem" is to operate in a manner that result in incompatible uses being located within the 65 dB CNEL contour. Incompatible uses are defined as being: residences of all types; public and private schools; hospitals and convalescent homes; and places of worship. However, these uses are not regarded as incompatible where acoustical insulation necessary to reduce the interior noise level to 45 dB CNEL has been installed or the airport proprietor has acquired an avigation easement for aircraft noise.

As noted in the regulations, the 65 dB CNEL standard is set with respect to urban areas. For many airports and many communities, 65 dB CNEL is too high to be considered acceptable to "reasonable persons." Through a process called "normalization," adjustments can be made to take into account such factors as the background noise levels of the community and previous exposure to particular noise sources. This process suggests, for example, that 60 dB CNEL may be a more suitable criterion for suburban communities not exposed to significant industrial noise and 55 dB CNEL may be appropriate for quiet suburban or rural communities remote from industrial noise and truck traffic. On the other hand, even though exceeding state standards, 70 dB CNEL may be regarded as an acceptable noise exposure in noisy urban residential communities near industrial areas and busy roads.

Industrial activity and transportation noise are undoubtedly two of the most prominent contributors to background noise levels in a community. According to a U.S. Environmental Protection Agency (EPA) study however, the variable that correlates best with ambient noise levels across a broad range of communities is population density (*Population Distribution of the United States as a Function of Outdoor Noise Level*, EPA Report No. 550/9-74-009, June 1974). This study established the following formula as a means of estimating the typical background noise level of a community:

$$DNL_{EPA} = 22 + 10 * \log(p)$$

where "p" is the population density measured in people per square statute mile.

These factors are reflected in the policies of this *Compatibility Plan*. The *Compatibility Plan* considers the 70 dB CNEL the maximum normally acceptable noise exposure for new multi-family residential and 65 dB CNEL for new single-family residential development near LA/Ontario International Airport. The *Compatibility Plan* also establishes noise insulation standards for residential and nonresidential development in areas exposed to noise levels of 65 dB CNEL or greater. Based upon the above EPA equation, these criteria are a minimum of 5 dB above the predicted ambient noise levels in the respective communities.

Similar considerations come into play with respect to establishing maximum acceptable noise exposure for nonresidential land uses, particularly those that are noise sensitive. For schools, lodging, and other such uses, a higher noise exposure may be tolerated in noisy urban communities than in quieter suburban and rural areas. For uses that are not noise sensitive or which generate their own noise, the maximum acceptable noise exposure levels tend to be the same regardless of ambient noise conditions. The criteria listed in Chapter 2 of this *Compatibility Plan* are set with these various factors in mind.

OVERFLIGHT

Experience at many airports has shown that noise-related concerns do not stop at the boundary of the outermost mapped CNEL contours. Many people are sensitive to the frequent presence of aircraft overhead even at low levels of noise. These reactions can mostly be expressed in the form of *annoyance*.

The *Handbook* notes that 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. Such changes are not always possible because of terrain, aircraft performance capabilities, FAA regulations, and other factors. In any case, though, ALUCs, or other designated bodies, are particularly limited in their ability to deal with overflight concerns. Most significantly, 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/designated bodies extends only to proposed new development and the delineation of an airport's overall influence area. The authority and responsibility for implementing the *Compatibility Plan*'s policies and criteria rests with the local governments.

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

Compatibility Objective

The compatibility objective with respect to overflight is the same as for noise: avoid new land use development that can disrupt activities and 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 feasible objective of overflight compatibility policies therefore is to help notify people about the presence of overflights near airports so that they can make informed decisions regarding acquisition or lease of property in the affected areas.

Measurement

Cumulative noise metrics such as CNEL are well-suited for use in establishing land use compatibility policy criteria and are the only noise metrics for which widely accepted standards have been adopted. However, these metrics are not very helpful in determining the extent of overflight impact areas. Locations where overflight concerns may be significant are typically well beyond where noise contours can be drawn with precision. Flight tracks tend to be quite divergent and noise monitoring data is seldom available. Moreover, even if the contours could be drawn precisely, the noise levels they would indicate may not be much above the ambient noise levels.

For the purposes of airport land use compatibility planning, two other forms of noise exposure information are more useful. One measure is the momentary, maximum sound level (L_{max}) experienced on the ground as the aircraft flies over while landing at and taking off from a runway. These noise levels can be depicted in the form of a noise "footprint" as shown in Figure C1 for a variety of airline and general aviation aircraft. 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, two additional 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 general aviation 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 are likely to be gone within 20 years, but at this point in time it is uncertain when they will be completely eliminated.

Another useful form of overflight information is a mapping of the common flight tracks used by aircraft when approaching and departing an airport. Where available, recorded radar data is an ideal source for flight track mapping. Even more revealing is to refine the simple flight track mapping with data such as the frequency of use and/or aircraft altitudes. Chapter 1 includes a sample of actual flight tracks and flight altitudes of aircraft using Ontario International Airport.

Compatibility Strategies

The ideal land use compatibility strategy with respect to overflight annoyance is to avoid development of new residential and other noise-sensitive uses in the affected locations. However, as mentioned before this approach is not practical and other strategies need to be explored.

The strategy emphasized in this *Compatibility Plan* 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 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, however, generally do not remain in place beyond the initial sales period and therefore are of little long-term value).

A second strategy is to minimize annoyance by promoting land uses that tend to mask or reduce the intrusiveness of aircraft noise. Although this strategy does not directly appear in the overflight policies of this *Compatibility Plan*, the objectives of the plan would be well-served if local jurisdictions take this concept into consideration in their own planning efforts. For example, multi-family residential uses would be a better choice to place within aircraft overflight areas 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. However, low-density single family residential with densities of 1 unit per acre are discouraged since background noise levels are likely to be low making residents more susceptible to aircraft noise.

Basis for Setting Criteria

In California, definitive guidance on where overflight impacts are significant or what actions should be taken in response comes from a state law that went into effect on January 2004. California statutes (Business and Profession Code Section 11010 and Civil Code Sections 1103 and 1353) now require most residential real estate transactions, including new subdivisions, to include disclosure that an airport is nearby. The area encompassed by the disclosure requirements is two miles from the airport or the airport influence area established by the county's airport land use commission. The law defines the airport influence area as "the area in which current or future airport-related noise, overflight, safety, or airspace protection factors may significantly affect land uses or necessitate restrictions on those uses as determined by an airport land use commission." This *Compatibility Plan* requires that the disclosure of airport proximity be applied to all new residential development within the airport influence area and recommends that disclosure be provided as part of all real estate transactions involving private property, especially any sale, lease, or rental of residential property.

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 that 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 an individual accident's occurrence cannot be predicted, the concept of risk is central to the assessment of safety compatibility.

Compatibility Objective

The overall objective of safety compatibility criteria is to minimize the risks associated with potential off-airport aircraft accidents and emergency landings beyond the runway environment. There are two components to this objective:

- *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 that takes place beyond the immediate runway environment.

Measurement

Because aircraft accidents happen infrequently, measuring the risks associated with their occurrence is difficult. It is necessary to look beyond an individual airport in order to assemble enough data to be statistically valid. It is beyond the intent of this discussion to provide statistical data about aircraft accidents. Much can be found on that topic in the *Handbook*. However, certain aspects of aircraft accidents are necessary to discuss in that they have a direct bearing on land use compatibility strategies.

From the standpoint of land use planning, two variables determine the degree of risk posed by potential aircraft accidents: frequency and consequences.

The frequency variable measures *where* and *when* aircraft accidents occur in the vicinity of an airport. More specifically, these two elements can be described as follows:

- *Spatial Element:* The spatial element describes *where* aircraft accidents can be expected to occur. Of all the accidents that take place in the vicinity of airports, what percentage occurs 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?

Spatial Distribution of Aircraft Accidents

Of these two elements, the spatial element is the one most meaningfully applied to land use compatibility planning around an individual airport. Looking at airports nationwide, enough accidents have occurred to provide useful data regarding where accidents are most likely to occur. The *Handbook* uses accident data to define a set of safety zones. Additionally, the relative concentration of accidents in certain parts of the airport environs is a key consideration in the establishment of compatibility criteria applicable within those zones.

In contrast, the time element is not very useful for land use compatibility planning purposes for several reasons. First, at any given airport, the number of accidents is, with rare exceptions, too few to be statistically meaningful in determining where future accidents might occur. Secondly, a calculation of accident frequency over time depends upon the size of the area under consideration—the smaller the area examined, the less likely it is that an accident will occur in that spot. Lastly, even if the accident frequency over a period of time is calculated, there are no clear baselines with which to compare the results.

The *Handbook* presents a set of diagrams indicating where accidents are most likely to occur around airline and general aviation airports. Figures C2 and C3 show the spatial distribution of general aviation aircraft accidents in the vicinity of airports. (Note that these charts show data for all general aviation accidents in the *Handbook* database. Data on accidents associated with different lengths of runway is also provided. The *Handbook* accident distribution data plus the generic safety zones for air carrier runways is considered in delineation of the safety zones depicted in Chapter 1 of this *Compatibility Plan*.)

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 wide at the inner edge to 1,750 feet in width at the outer end). This fact lends validity to the importance of the runway protection zones as an area within which land use activities should be minimal.
- Although accident risk levels are the highest within the runway protection zones, 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 2.0 miles of a runways end.
- Arrival accidents tend to be concentrated relatively close to the extended runway centerline. Approximately 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 feet from the runway centerline and 6,000 feet beyond the runway end or adjacent to the runway.

To provide some sense of order to the scatter of individual accident points, an analysis 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—Figure C2 shows arrival accident risks and Figure C3 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. However, the risk contours can serve as the basis for creating geometric shapes that can then be used as safety zones and the *Handbook* contains several examples.

The *Handbook* takes the additional step of translating the risk contours into several sets of generic safety zones having regular geometric shapes. Generic safety zones are illustrated for different types and lengths of runways. The shapes of these zones reflect not just the accident distribution data, but also the ways in which different phases of aircraft operations create different accident risk characteristics near an airport. For most runways, the *Handbook* suggests creation of six safety zones. The locations, typical dimensions, and characteristics of the accident risks within each zone are outlined in Table C1. The degree of risk exposure within each safety zone is listed below.

- *Zone 1* clearly is exposed to the greatest risk of aircraft accidents. For civilian airports, the dimensions of this zone are established by FAA standards. FAA encourages airport ownership of this zone and provides specific land use standards. Where the land is not airport owned, the FAA says these standards serve as recommendations.
- *Zone 2* lies beyond Zone 1 and also has a significant degree of risk as reflected in both national and local accident location data.
- *Zone 3* has less risk than Zone 2, but more than Zones 4, 5, or 6. Zone 3 encompasses locations where aircraft often turn at low altitude while approaching or departing the runway.
- *Zone 4* lies along the extended runway centerline beyond Zone 2 and is especially significant at airports that have straight-in instrument approach procedures or a high volume of operations that results in an extended traffic pattern.
- *Zone 5* is a unique area lying adjacent to the runway and, for most airports, lies on airport property. The risk is comparable to Zone 4.
- *Zone 6* contains the aircraft traffic pattern. Although a high percentage of accidents occur within Zone 6, for any given runway Zone 6 is larger than all the other zones combined. Relative to the other zones, the risks in Zone 6 are much less, but are still greater than in locations more distant from the airport.

Although accident location data, together with information on how aircraft flight parameters affect where accidents occur, are the bases for delineation of the generic safety zones, the *Handbook* indicates that adjustments to the zone sizes and shapes must be made in recognition of airport-specific characteristics. Among these characteristics are:

- The particular mix of aircraft types operating at the airport. Larger aircraft generally are faster than smaller planes and thus fly longer and wider traffic patterns or make straight-in approaches.
- The overall volume of aircraft operations. At busy airports, a larger traffic pattern is common because aircraft have to get in sequence for landing.
- Nearby terrain or other airports. These physical features may, for example, limit a traffic pattern to a single side of the airport or dictate "nonstandard" approach and departure routes.
- Instrument approach procedures. Aircraft following these procedures typically fly long, straight-in, gradual descents to the runway. In some cases, though, an approach route may be aligned at an angle to the runway rather than straight in.
- Existence of an air traffic control tower. When a tower is present, controllers may direct or allow pilots to fly unusual routes in order to expedite traffic flow. By comparison, at relatively busy but non-towered airports, aircraft mostly follow the "standard" pattern dictated by federal aviation regulations.

- A dominant direction of traffic flow. As reflected in the Handbook analysis of accident locations, landing aircraft tend to follow routes directly in line with the runway during final descent and thus accident sites also are concentrated along this alignment. Departing aircraft are more likely to turn to head to their intended destination and the accident pattern is thus more dispersed. On runways where the flow of aircraft operations is almost always in one direction, this distinction in accident patterns is considered.

Radar data is particularly helpful in showing exactly where aircraft fly when approaching or departing an airport. This data can be used to further support adjustments to the safety zones based upon the above characteristics.

Accident Consequences

The consequences variable describes *what* happens when an aircraft accident occurs. Specific measures can be defined in terms of deaths, injuries, property damage, or other such characteristics. In many respects, the consequences component of aircraft accident risk assessment is a more important variable than accident frequency. Not only can a single accident cost many lives, it can indirectly force operational changes or even airport closure.

Relatively little data is available specifically documenting the consequences of aircraft accidents. Except with regard to numbers of deaths or injuries to people on the ground, data on various aspects of aircraft accidents must be used to infer what the consequences have been. Swath size is one useful piece of information. It indicates the area over which accident debris is spread. Swath size in turn depends upon the type of aircraft and the nature of the accident: was the aircraft in controlled flight (an engine failure for example), but then collided with something on the ground or did a catastrophic event (such as a mid-air collision or stall-spin) result in the aircraft making an uncontrolled descent? For small general aviation aircraft, the swath size data suggests that a controlled emergency landing in which the aircraft occupants have a strong chance of surviving is possible in an area about the size of a football field: 75 feet by 300 feet or about 0.5 acre. For larger aircraft, the minimum flight speed is so much higher that the consequences for people on board and anyone on the ground are likely to be high regardless of the land use or terrain characteristics.

Compatibility Strategies

The relatively low numbers of deaths and injuries from aircraft accidents is sometimes cited as indicating that the risks are low. Clearly, though, the more people occupying the critical areas around airports, the greater the risks are. Aircraft accidents may be rare occurrences, but when they occur, the consequences can be severe.

From a land use compatibility perspective, it is therefore essential to avoid conditions that can lead to catastrophic results. 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, primarily for general aviation airports, 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 three types of criteria.

Density and Intensity Limitations

Establishing criteria that limits 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. In setting these criteria, consideration must be given to the two different forms of aircraft accidents: those in which the aircraft is descending, but is flying and under directional control of the pilot; and those in which the aircraft is out of control as it falls. Limits on usage intensity—the number of people per acre—must take into account both types of potential aircraft accidents. The policies in Chapter 2 address both of these circumstances. Limiting the average usage intensity over a site reduces the risks associated with either type of accident. In most types of land use development, though, people are not spread equally throughout the site. To minimize the risks from an uncontrolled accident, the policies also limit the extent to which people can be concentrated and development can be clustered in any small area.

Open Land Requirements

Requirements of undeveloped 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. If sufficiently large and clear of obstacles, open land areas can be valuable for light aircraft anywhere near an airport. For large and high-performance aircraft, however, open land has little value for emergency landing purposes and is useful primarily where it is an extension of the clear areas immediately adjoining 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. Critical community infrastructure also should be avoided near airports. These types of facilities include power plants, electrical substations, public communications facilities and other facilities, the damage or destruction of which could cause significant adverse effects to public health and welfare well beyond the immediate vicinity of the facility. Lastly, aboveground storage of large quantities (6,000 gallons or greater) of highly flammable or hazardous materials may pose high risks if involved in an aircraft accident and therefore are incompatible close to runway ends.

Basis for Setting Criteria

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 compatibility policies 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.

Data useful in defining the geographic extent of airport safety areas was discussed above. To set safety compatibility criteria applicable within these zones 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 in 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.

Little established guidance is available to ALUCs/designated bodies 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.

The most useful place from which ALUCs/designated bodies can begin to determine appropriate safety compatibility criteria for airport environs is the *Handbook* itself. Although not regulatory in nature, state law obligates ALUCs/designated bodies to "be guided by" the information presented in the *Handbook*. Suggested usage intensity limitations, measured in terms of people per acre, are set forth along with other safety criteria. Reference should be made to that document for detailed description of the suggested criteria. Three risk-related variables discussed in the *Handbook* are worth noting here, however.

- *Runway Proximity:* In general, the areas of highest risk are closest to the runway ends and secondarily along the extended runway centerline. However, many common aircraft flight tracks do not follow along the runway alignment, particularly on departures. Also, where an aircraft crashes may not be along the flight path that was intended to be followed. As indicated in Figures C2 and C3, these factors affect the risk distribution.
- *Urban versus Rural Areas:* Irrespective of airports, people living in urban areas face different types of risks than those living in rural areas. The cost of avoiding risks differs between these two settings as well. The *Handbook* acknowledges these differences by indicating that usage intensities can be higher in heavily developed urban areas compared to partially undeveloped suburban areas or minimally developed rural locations, yet be equivalent in terms of the level of acceptable risk.
- *Existing versus Proposed Uses:* Another distinction in compatibility policies can be drawn between existing and proposed development. It is reasonable for safety-related policies to be established which prohibit certain types of new development while considering identical existing development to be acceptable. The *Handbook* notes that cost is an important factor in this regard. The range of risks can be divided into three levels (see page 9-15 of the *Handbook*). At the bottom of this scale are negligible and acceptable risks for which no action is necessary. At the top are intolerable risks for which action is necessary regardless of the cost. In between are risks that are significant, but tolerable. Whether action should be taken to reduce these risks depends upon the costs involved. Typically, the cost of removing an incompatible development is greater than the cost of avoiding its construction in the first place.

Preparation of this *Compatibility Plan* has been greatly guided by the *Handbook* information. The *Handbook*, though, also recognizes the importance of tailoring compatibility plans to local circumstances. Such has been the case with the safety compatibility criteria included in this *Compatibility Plan*.

AIRSPACE PROTECTION

Relatively few aircraft accidents are caused by land use conditions that are hazards to flight. The potential exists, however, and protecting against it is essential to airport land use safety compatibility. In addition, and importantly, land use conditions that are hazards to flight may impact the continued viability of airport operations and limit the ability of an airport to operate in the manner identified by the airport proprietor in an adopted airport master plan and airport layout plan.

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 that, 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 that pose other potential hazards to flight by creating visual or electronic interference with air navigation.

The purpose of airspace protection policies is to ensure that structures and other uses do not cause hazards to aircraft in flight within the airport vicinity. Hazards to flight include physical obstructions to the navigable airspace, wildlife hazards (particularly bird strikes), and land use characteristics that create visual or electronic interference with aircraft navigation or communication. This is accomplished by creating policies that place limits on the height of structures and other objects within the airport vicinity and restrictions on other uses that potentially pose hazards to flight.

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 two factors: 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 Federal Aviation Regulations (FAR) Part 77, *Objects Affecting Navigable Airspace*. 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. Additionally, as described below, another set of airspace protection surfaces is defined by the *U.S. Standard for Terminal Instrument Procedures*, known as TERPS. Although the intended function of these standards is in design of instrument approach and departure procedures, they can be important in land use compatibility planning in situations where ground elevations near an airport exceed the FAR Part 77 criteria.
- *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 directly associated with 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 that may create other types of hazards to aircraft in flight near an airport should be avoided or modified to remove the potential hazard.

Basis for Setting Criteria

The criteria for determining airspace obstructions have been long-established in FAR Part 77. Also, state of California regulation of obstructions under the State Aeronautics Act (Public Utilities Code, Section 21659) is based on FAR Part 77 criteria. A shortcoming of FAR Part 77 criteria, however, is that they often are too generic to fit the conditions specific to individual airports. The airspace protection surfaces defined in these regulations can be either more or less restrictive than appropriate for a particular airport. The surfaces can be less restrictive than essential in instances where an instrument approach procedure or its missed approach segment are not aligned with the runway. FAR Part 77 also does not take into account instrument departure procedures which, at some airports, can have critical airspace requirements. Oppositely, FAR Part 77 provides no useful guidance as to acceptable heights of objects located where the ground level already penetrates the airspace surfaces.

To define airspace protection surfaces better suited to these situations, reference must be made the TERPS standards mentioned above. These standards are used for creation of instrument approach and departure procedures. Thus they exactly match the procedures in effect at an individual airport. Unlike the FAR Part 77 surfaces, the elevations of which are set relative to the runway end elevations irrespective of surrounding terrain and obstacles, the TERPS surface elevations are directly determined by the location and elevation of critical obstacles. By design, neither the ground nor any obstacles can penetrate a TERPS surface. However, construction of a tall object that penetrates a TERPS surface can dictate immediate modifications to the location and elevation of the surfaces and directly cause minimum flight visibility and altitudes to be raised or the instrument course to be realigned. In severe instances, obstructions can force a procedure to be cancelled altogether. A significant downside to use of TERPS surfaces for compatibility planning purposes is that they are highly complex compared to the relative simplicity of FAR Part 77 surfaces. Also, the configuration and/or elevations of TERPS surfaces can change not only in response to new obstacles, but as implementation of new navigational technologies permits additional or modified instrument procedures to be established at an airport.

In the Compatibility Policy Map: Airspace Protection Zones presented in Chapter 2 of this *Compatibility Plan*, primary reliance is placed upon FAR Part 77 criteria. Where an instrument approach procedure is established, the associated TERPS surfaces are depicted as well. In most locations, the TERPS surfaces are well above the underlying terrain and present no significant constraint on land use development. As a precaution to help ensure that tall towers or antennas located on high terrain do not penetrate a TERPS surface, places where the ground elevation comes within 100 feet of a TERPS surface are shown on the map.

Among other hazards to flight, bird strikes no doubt represent the most widespread concern. The FAA recommends that uses known to attract birds—sanitary landfills being a primary example—be kept at least 10,000 feet away from any runway used by turbine-powered aircraft. More information regarding criteria for avoidance of uses that can attract wildlife to airports can be found in FAA Advisory Circulars 150/5200-34 and 150/5300-33.

Other flight hazards include land uses that may cause visual or electronic hazards to aircraft in flight or taking off or landing at the airport. Specific characteristics to be avoided include sources of glare or bright lights, distracting lights that could be mistaken for airport lights, sources of dust, steam, or smoke that may impair pilot visibility, and sources of electrical interference with aircraft communications or navigation.

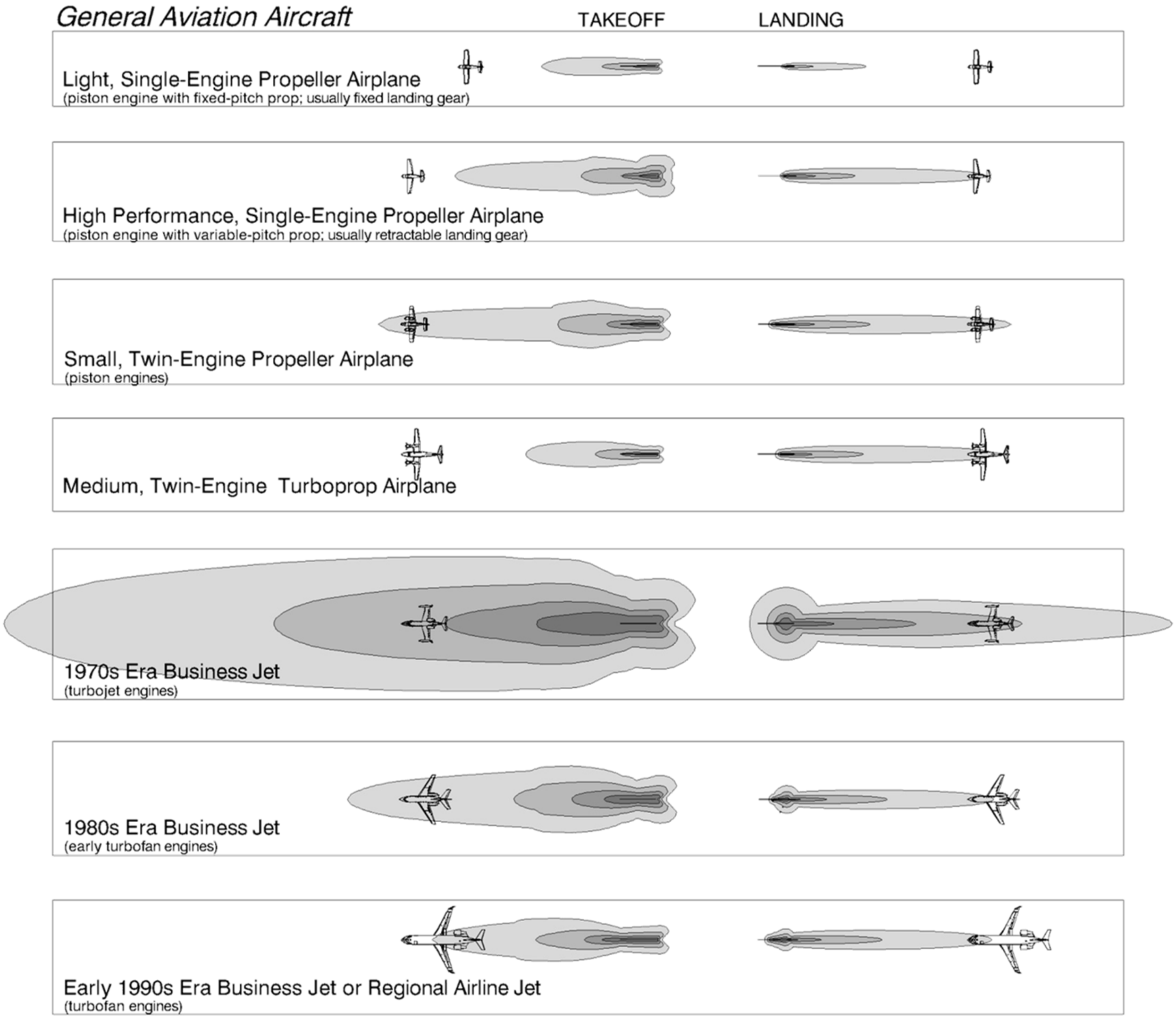
Table C1

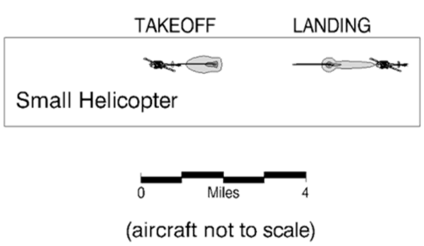
Safety Zone Aircraft Accident Risk Characteristic

Zone	*Description*	***Nominal Dimensions*** (California Airport Land Use Planning Handbook)	***Relative Risk Level***	***Nature of Accident Risk***	***% of Accidents in Zone*** (Handbook Database)
1	Runway Protection Zone and within Runway Primary Surface primarily on airport property; airport ownership encouraged	Depending upon approach visibility minimums: 1,200 feet minimum, 2,700 feet maximum beyond runway ends; 125 to 500 feet from centerline adjacent to runway (zone dimensions established by FAA standards) Acreage (one runway end): 8 to 79 (RPZ only)	Very High	Landing undershoots and overshoots; overruns on aborted takeoffs; loss of control on takeoff	Arrivals: 28%–56% Departures: 23%–29% Total: 33%–39%
2	Inner Safety Zone	Along extended runway centerline, to a distance of 2,000 feet minimum, 6,000 feet maximum beyond runway ends Acreage (one runway end): 44 to 114	High	Aircraft at low altitude with limited directional options in emergencies: typically under 400 feet on landing; on takeoff, engine at maximum stress	Arrivals: 9%–15% Departures: 3%–28% Total: 8%–22%
3	Inner Turning Zone	Fan-shaped area adjacent to Zone 2 extending 2,000 feet minimum, 4,000 feet maximum from runway ends Acreage (one runway end): 50 to 151	Moderate	Turns at low altitude on arrival for aircraft flying tight base leg present stall-spin potential; likely touchdown area if emergency at low altitude on takeoff, especially to left of centerline	Arrivals: 2%–6% Departures: 5%–9% Total: 4%–7%
4	Outer Safety Zone	Along extended runway centerline extending 3,500 feet minimum, 10,000 feet maximum beyond runway ends Acreage (one runway end): 35 to 92	Low to Moderate	Low altitude overflight for aircraft on straight-in approaches, especially instrument approaches; on departure, aircraft normally complete transition from takeoff power and flap settings to climb mode and begin turns to en route heading	Arrivals: 3%–8% Departures: 2%–4% Total: 2%–6%
5	Sideline Zone primarily on airport property	Adjacent to runway, 500 feet minimum, 1,000 feet maximum from centerline Acreage: varies with runway length	Low to Moderate	Low risk on landing; moderate risk from loss of directional control on takeoff, especially with twin-engine aircraft	Arrivals: 1%–3% Departures: 5%–8% Total: 3%–5%
6	Traffic Pattern Zone (applicable only to general aviation runways)	Oval area around other zones: 5,000 feet minimum, 10,000 feet maximum beyond runway ends; 4,500 feet minimum, 6,000 feet maximum from runway centerline Acreage: varies with runway length	Low	Significant percentage of accidents, but spread over wide area; widely varied causes	Arrivals: 10%–21% Departures: 24%–39% Total: 18%–29%

Figure C1

Noise Footprints of Selected Aircraft





The drawings on these two pages show the relative noise levels produced by different types of aircraft during landing and takeoff.

The contours represent the momentary maximum sound level experienced on the ground as the aircraft flies over. The outermost contour for each aircraft indicates a 65 dBA sound level. Additional contours are at 10 dBA increments (75, 85, and in most cases 95 dBA).

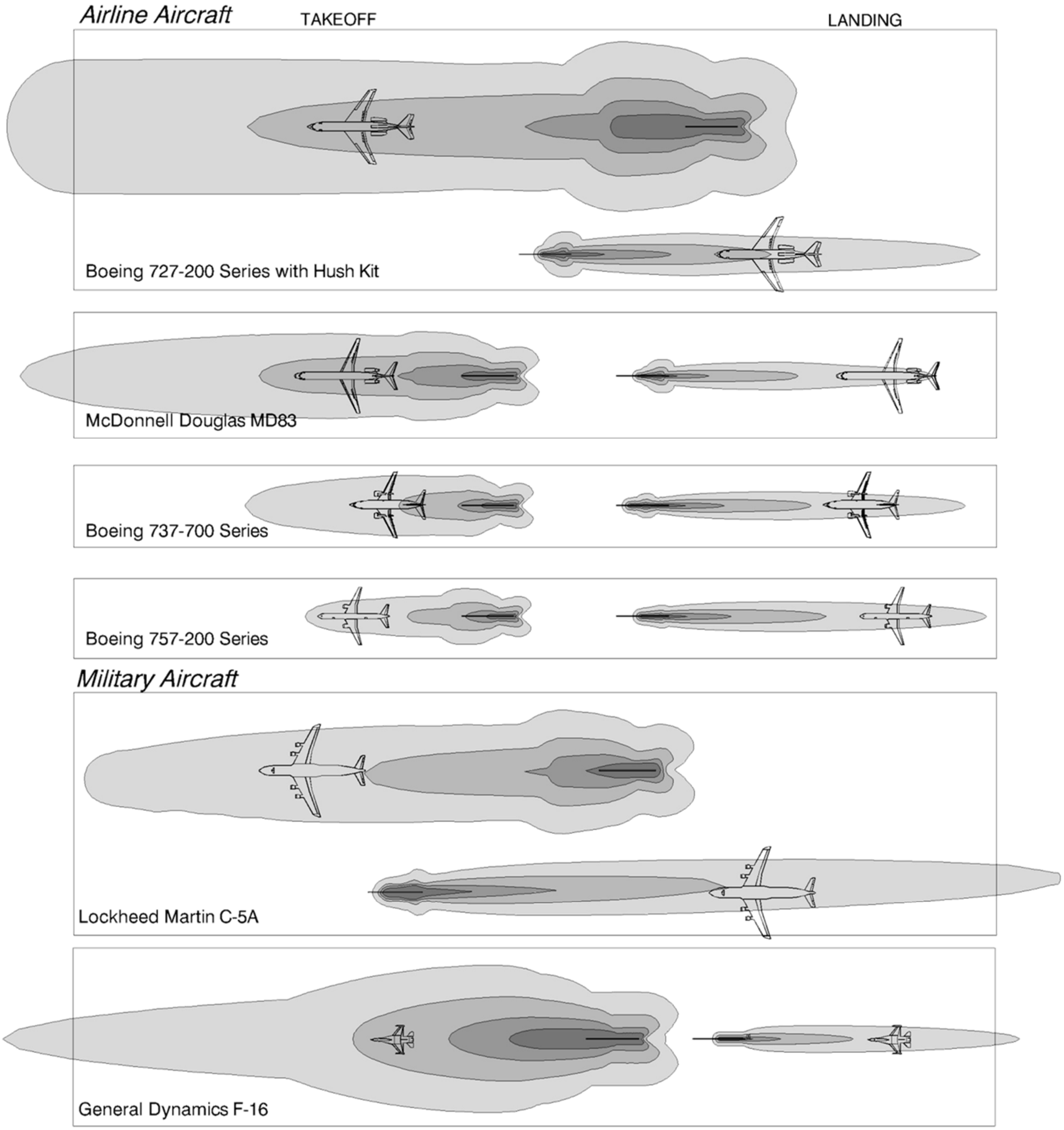
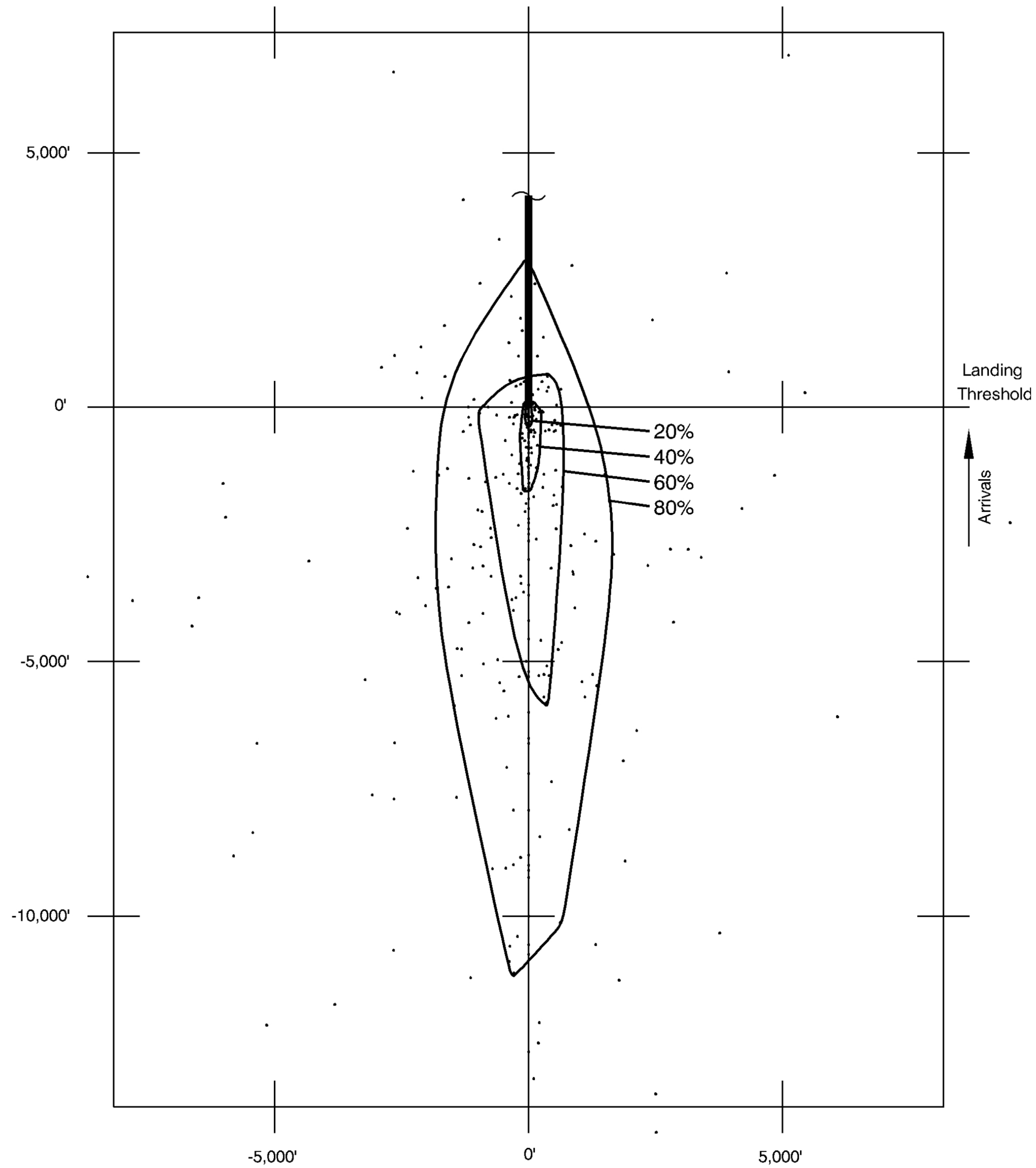


Figure C1, continued

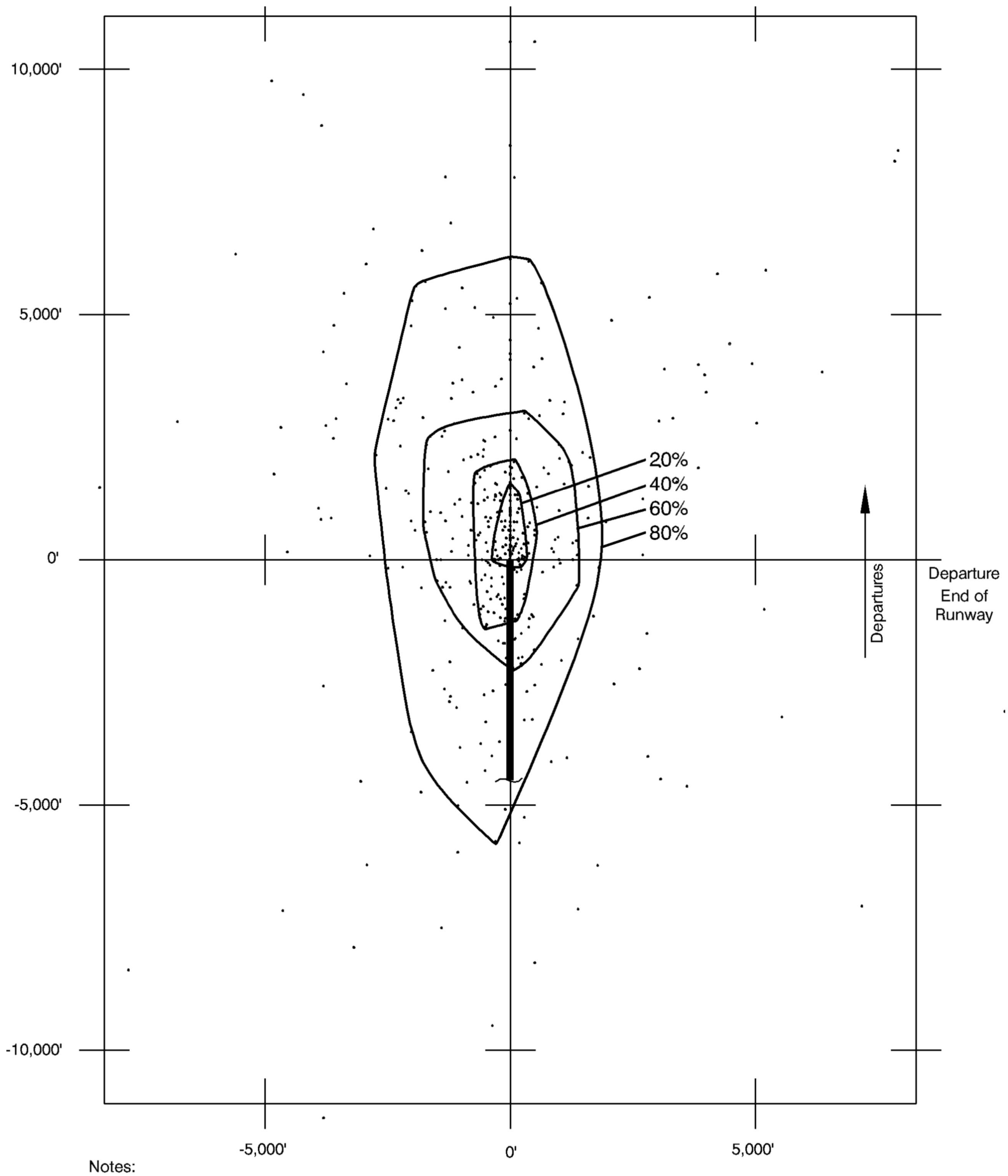


Notes:
445 arrival accidents in database - each dot represents one accident site.
contours represent relative intensities (highest concentrations) of points in 20% increments.

Figure C2

General Aviation Accident Distribution Contours

All Arrivals



Notes:
428 departure accidents in database - each dot represents one accident site.
contours represent relative intensities (highest concentrations) of points in 20% increments.

Figure C3

General Aviation Accident Distribution Contours

All Departures

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