**Estimate of Aircraft Crash Hit Frequencies on to Facilities at the
Lawrence Livermore National Laboratory (LLNL) Site 200**

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ABSTRACT

Department of Energy (DOE) nuclear facilities are required by DOE Order 5480.23, Section 8.b.(3)(k) to consider external events as initiating events to accidents within the scope of their Safety Analysis Reports(SAR). One of the external initiating events which should be considered within the scope of a SAR is an aircraft accident, i.e., an aircraft crashing into the nuclear facility with the related impact and fire leading to penetration of the facility and to the release of radioactive and/or hazardous materials.

This report presents the results of an Aircraft Crash Frequency analysis performed for the Materials Management Area (MMA), and the National Ignition Facility (NIF) at the Lawrence Livermore National Laboratory (LLNL) Site 200. The analysis estimates only the aircraft crash hit frequency on to the analyzed facilities. No initial aircraft crash hit frequency screening, structural response calculations of the facilities to the aircraft impact, or consequence analysis of radioactive/hazardous materials released following the aircraft impact are performed.

The method used to estimate the aircraft crash hit frequencies on to facilities at the Lawrence Livermore National Laboratory (LLNL) generally follows the procedure given by the DOE Standard 3014-96 on Aircraft Crash Analysis. However, certain adjustments were made to the DOE Standard procedure because of the site specific flight environment or because of facility specific characteristics.

ESTIMATE OF AIRCRAFT CRASH HIT FREQUENCIES ON TO FACILITIES AT THE LAWRENCE LIVERMORE NATIONAL LABORATORY (LLNL) SITE 200

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1. INTRODUCTION

Department of Energy (DOE) nuclear facilities are required by DOE Order 5480.23, Section 8.b.(3)(k) to consider external events as initiating events to accidents within the scope of their Safety Analysis Reports(SAR) [Ref. 1.1]. One of the external initiating events which should be considered within the scope of a SAR is an aircraft accident, i.e., an aircraft crashing into the nuclear facility with the related impact and fire leading to penetration of the facility and to the release of radioactive and/or hazardous materials.

This report presents the results of an Aircraft Crash Frequency analysis performed for the Materials Management Area (MMA), and the National Ignition Facility (NIF) at the Lawrence Livermore National Laboratory (LLNL) Site 200. The analysis estimates only the aircraft crash hit frequency on to the analyzed facilities. No initial aircraft crash hit frequency screening, structural response calculations of the facilities to the aircraft impact, or consequence analysis of radioactive/hazardous materials released following the aircraft impact are performed.

1.1 DEFINITIONS

As the first step in the Aircraft Crash Frequency Analysis, it is important that common definitions are understood for several significant terms which are used throughout this report.

A complete list of terms are defined in the Glossary.

1.1.1 Near Airport Flight Environment

The first term which should be understood is the Near Airport Flight Environment. The Near Airport Flight Environment is defined as that airspace volume that extends from the center of the Airport outwards to a radius of approximately 5 miles to 35 miles and from the surface to a certain altitude depending on the presence or absence of a TRACON and other air traffic control considerations. The air traffic within this airspace may be under the control of the Airport Traffic Control Tower (ATCT) or the TRACON. This airspace near the Airport encompasses the local airport traffic pattern, the airport runway approach pattern(s), and the airport initial climb departure pattern(s). Generally, this is the airspace near an airport where aircraft are in the Runway Approach Flight Phase, the Landing Flight Phase, the Takeoff Flight Phase, and the Initial Climb Flight Phase. The airspace near an airport is classified as either Class B Airspace, Class C Airspace, or Class D Airspace.

Formerly called Terminal Control Areas (TCAs), Class B Airspace is generally the airspace from the surface to 10,000 feet mean sea level (MSL) surrounding U.S. airports with more than 150,000 annual instrument flight rule (IFR) operations or 650,000 annual passenger enplanements. The configuration of each Class B Airspace is individually tailored and consists of a surface area, usually 5 nautical miles in radius from the primary airport, and two or more layers extending laterally from the core at typically 3 to 10 nautical mile increments to a radius of approximately 20 nautical miles, with each layer having a prescribed altitude floor. In many respects, Class B Airspace has been likened to upside down wedding cakes. Class B Airspace is designed to contain all published instrument procedures once an aircraft enters the airspace. Operations may be under either IFR or visual flight rules (VFR) with all aircraft subject to air traffic control clearances and instructions. Air traffic control provides aircraft separation and safety advisories.

Class C Airspace, formerly called Airport Radar Service Areas (ARSAs), is generally the airspace from the surface to approximately 4,000 feet MSL surrounding U.S. airports with more than 75,000 annual IFR operations at the primary airport, or 100,000 annual IFR operations at the primary and secondary airports in the terminal hub area, or 250,000 annual passenger enplanements at the primary airport. The configuration of each Class C Airport is individually tailored and consists of a surface area of 5 nautical miles radius from the primary airport, and another layer with a prescribed altitude floor, extending laterally from the core to a radius of 10 nautical miles. Operations may be under either IFR or VFR, with all aircraft subject to air traffic control clearances and instructions. Air traffic control provides aircraft separation between IFR/IFR and IFR/special VFR (SVFR) aircraft. VFR operations are given traffic advisories and, upon request, collision resolution instructions.

Class D Airspace, formerly called Airport Traffic Areas (ATAs) and Control Zones (CZs), is the airspace from the surface to 2,500 feet above ground level (AGL) within a 5 statute mile (4.3 nautical mile) radius of the center of the airport. Operations may be under either IFR or VFR, with all aircraft subject to air traffic control clearances and instructions. Air traffic control separation service is provided to IFR aircraft only, but all aircraft will be given traffic advisories and, upon request, conflict resolution instructions.

1.1.2 Airport/Aircraft Operations

Airport Operations are Aircraft Operations that occur in the Near Airport Environment. Aircraft Operations, as defined by the Federal Aviation Administration (FAA), is the number of arrivals and

departures from the airport at which an Airport Traffic Control Tower is located. Operations which include aircraft that: 1) operate in the local traffic pattern or within sight of the airport, 2) are known to be departing for, arriving from flight in the local practice areas located within a 20-mile radius of the airport, or 3) execute simulated instrument approaches or low passes at the airport, are classified as local operations. All other operations are classified as itinerant operations.

Airports, may be classified as military or civilian. These airports may be further divided as to whether or not they have a control tower. A control tower is very important to the airport in that it not only provides control over the air traffic near the airport, it is also the location where counts are made on Airport Operations. Almost all civilian airports with a control tower are either staffed by F.A.A. personnel or under contract to the F.A.A. Most military airports with a control tower are staffed by military personnel. However, there are a few joint-use military airports where the control tower is staffed by F.A.A. personnel, e.g. Charleston AFB, SC.

1.1.3 Aircraft Categories

Air traffic controllers at the Airport Traffic Control Towers classify the Aircraft Operations into the following four categories: 1) Air Carriers (AC), 2) Air Taxis (AT), 3) General Aviation (GA), and 4) Military Aviation (MA). Air carriers are defined as aircraft in general commercial service capable of carrying 70 or more passengers, regardless of the flight rules under which the flight is conducted, e.g. 14 CFR 121 or 14 CFR 91 rules. Foreign air carriers are also included under the category of air carriers as long as the aircraft type is capable of carrying 70 or more passengers. All other aircraft in general commercial service that carry less than 70 passengers are classified as Air Taxis. However, since many Air Taxis operate small single-engine aircraft, air traffic controllers often count these flights as General Aviation flights unless the flight is identified by a flight plan or a commercial livery is carried by the aircraft. Again, air traffic controllers classify Air Taxi flights by the aircraft type (carries less than 70 passengers), regardless of the flight rules under which the flight is conducted, e.g. 14 CFR 135 or 14 CFR 91. Military Aviation operations are classified as all Aircraft Operations operated by the Armed Forces of the United States. Finally, General Aviation operations are classified as all Aircraft Operations which were not included under the previous three categories.

1.1.4 TRACON Flight Environment

TRACON or Terminal Radar Approach Control, refers to the air traffic control facility which is responsible for providing approach/departure aircraft separation, especially for IFR aircraft operations, for the airspace area from approximately 5 miles radius from the primary airport extending outwards to approximately 35 miles from the primary airport. The TRACON Flight Environment is defined as that airspace within the Near Airport Flight Environment in which the air traffic is under the control and guidance of the TRACON. The TRACON Flight Environment would be outside of the airspace which is under the control of the Airport Traffic Control Tower(s), and inside and beneath the Enroute/In-Flight Environment (which is below the minimum control altitude of the ARTCC).

1.1.5 Enroute/In-Flight Environment

The Enroute or In-Flight Environment is defined as the airspace outside and above the Near Airport Flight Environments. The Enroute/In-Flight Environment encompasses all airspace above 11,000 feet mean sea level (MSL) and most airspace above 10,000 feet MSL. Generally, this is the airspace where aircraft are in the Climb to Cruise Flight Phase, Enroute or Cruise Flight Phase, and the Descent from Cruise Flight Phase. Included within the Enroute/In-Flight Environment is Class A Airspace. All airspace over the Continental United States from 18,000 feet MSL to 60,000 feet MSL has been established as Class A Airspace (formerly called Positive Control Area or PCA) by 14 CFR 71.31 [Ref. 1.2]. For General Aviation, the Enroute/In-Flight Environment can include the airspace outside of the Near Airport Flight Environment and below 10,000 feet MSL.

In past Aircraft Crash Frequency Analyses, aircraft flights outside of the Near Airport Flight Environment were considered as flying on established airways. Airways were established to assist aircraft in their navigation in the United States. A system of air routes were established based on radio navigation facilities called VORTACs (Very high frequency Omnidirectional Radio range and Tactical Navigation). When a VOR is colocated with a TACAN navigation aid (which is basically a military version of a VOR), it is referred to as a VORTAC. Airways are classified as Low Altitude Airways or Victor Airways, High Altitude Routes or Jet Routes, and Military Training Routes. Low Altitude (Victor) Airways are the designated air routes between VOR or VORTAC stations located below 18,000 feet MSL. Air routes established in Class A Airspace from 18,000 feet MSL to 45,000 feet MSL are called Jet Routes. Jet Routes are actually available to any aircraft capable of operating at 18,000 feet or above, not just jet traffic [Ref. 1.3]. Military Training Routes are the system of designated routes used by the armed forces of the United States.

During the late 1950s and early 1960s, several serious high altitude midair accidents in the United States spurred the development of an air traffic control system which would control all high altitude air traffic and ensure a minimum separation distance between aircraft. The facilities established to provide air traffic control service to aircraft operating on Instrument Flight Rules (IFR) flight plans within controlled airspace, principally during the en route phase of flight are the Air Route Traffic Control Centers (ARTCCs). ARTCCs are the central authority for issuing IFR clearances, and provide nationwide monitoring of each IFR flight. Within the Continental United States, there are 20 ARTCCs, each responsible for handling en route traffic passing through a specific geographic area. Because of the size of the area covered by each ARTCC, each ARTCC's area is further divided into smaller blocks of airspace called Sectors. Each sector is monitored by one or more controllers who maintain lateral and/or vertical separation of aircraft within its airspace boundaries. Figure 1-1 presents the ARTCCs and their associated airspace boundaries within the Continental United States. [Refs. 1.3 to 1.6]. This situation has remained unchanged since 1976 when the Great Falls, Montana ARTCC was merged with the Salt Lake City, Utah ARTCC.

All civil aviation operations conducted in Class A Airspace must be conducted under IFR as established by 14 CFR 91.135 [Ref. 1.7]. Therefore, all air traffic in Class A Airspace including traffic in Jet Routes are under the direction and control of the ARTCCs. However, in discussions with the Federal Aviation Administration (FAA), the recent trend for routing of air traffic in Class A Airspace is toward Users Preferred Routing (UPR) or point-to-point routing at the users discretion rather than the assignment along specific Jet Routes. Beginning in 1995, all flights above 41,000 feet MSL in Class A Airspace were allowed to be routed point-to-point, if so desired. At approximately two month intervals, the lower limit for point-to-point routing in Class A Airspace was decreased. It is currently at 31,000 feet MSL as of January 1996 and can be expected to be decreased even further in the near future. As a point of explanation, point-to-point routing is not equivalent to the concept of free flight. All separation margins between aircraft in Class A Airspace are maintained by the ARTCCs in point-to-point flights. What has been changed is that the point-to-point flights are not restricted to within a 4 mile air corridor on each side of the Jet Route centerline. In contrast, the free flight concept, in its fullest application, would not be under the full time control of the ARTCCs and separation margins between aircraft in Class A Airspace would be maintained by onboard aircraft systems, perhaps an advanced version of the Traffic Alert and Collision Avoidance System (TCAS).

Data on the number of IFR aircraft handled by each ARTCC are available from the FAA Office of Aviation Policy, Plans, and Management Analysis document FAA Air Traffic Activity published annually by Fiscal Year. The FAA defines IFR Aircraft Handled by an ARTCC as including IFR Departures, and IFR Overs, where IFR Departures are defined as IFR Flights originating in the ARTCC's area, accepted by the ARTCC under Sole Enroute clearance procedures, and extended by the ARTCC. IFR Overs are defined as IFR Flights that originate outside the ARTCC area and pass through the area without landing. IFR Aircraft Handled are then the number of IFR Departures multiplied by two plus the number of IFR Overs. This definition assumes that the number of departures

(acceptances, extensions, and originations of IFR flight plans) is equal to the number of landings (IFR flight plans closed).

1.2 METHODOLOGY

Numerous past studies [Refs. 1.8 to 1.14] on aircraft crash hit frequency analysis have concluded that the estimated frequency of an aircraft crashing and hitting a particular ground facility is related to the product of the number of applicable aircraft operations, the crash frequency of those aircrafts, the crash location probability, and the area presented by the facility to the aircraft (facility effective area). This is the method that was adopted by the DOE Standard 3014-96 on Aircraft Crash Analysis [Ref. 1.15].

The method used to estimate the aircraft crash hit frequencies on to facilities at the Lawrence Livermore National Laboratory (LLNL) generally follows the procedure given by the DOE Standard 3014-96 on Aircraft Crash Analysis [Ref. 1.15]. However, certain adjustments were made to the DOE Standard procedure because of the site specific flight environment or because of facility specific characteristics.

For the airport flight environment analysis, the standard four factor formula is used:

$$F = N * P * f(x,y) * A_t$$

where F = Aircraft crash hit frequency on to the facility (crash hit/year),

N = Number of relevant flight operations (operations/year),

P = Aircraft crash rate (/takeoff, /landing),

$f(x,y)$ = Aircraft crash location conditional probability (/mi.²).

A_t = Facility target area presented to aircraft during accident sequence (mi.²).

For the TRACON flight environment analysis, a modification of the standard four factor formula is used. First, an area that could be hit by an aircraft in distress is defined as the Potential Area, A_p , of radius R_p . The aircraft crash hit frequency, F_p , for the Potential Area A_p is then:

$$F_p = N * CR * L_p * A_t / A_p$$

where F_p = Aircraft crash hit frequency on to the facility in Potential Area (crash hit/year),

N = Number of relevant flight operations through Potential Area (operations/year),

CR = Aircraft crash rate (/mile of flight),

L_p = Average length of flight through Potential Area, A_p (mile),

A_t = Facility target area presented to aircraft during accident sequence (mi.²),

A_p = Area potentially affected by distress aircraft (mi.²).

The Potential Area, A_p , is equal to πR_p^2 where R_p is equal to the Radius of Potential Area affected by distressed aircraft (mile),

The average length of flight L_p through A_p , is assumed equal to the average chord length through A_p which is equal to $4R_p/\pi$.

Substituting $A_p = \pi R_p^2$ and $L_p = 4R_p/\pi$ into the equation for F_p yields:

$$F_p = N * CR * 4R_p / \pi * A_t / \pi R_p^2$$

Canceling R_p yields

$$F_p = N * CR * (4/\pi^2) * (1/R_p) * A_t$$

The radius of the potential area affected by a distressed aircraft, R_p , is set equal to the glide ratio of the aircraft, g , times the height (altitude) of the aircraft when the initiating event occurred.

For the Enroute/Cruise or ARTCC flight environment analysis, another modification of the standard four factor formula is used:

$$F = N_c * P_c * (1/A_c) * A_t$$

where F = Aircraft crash hit frequency on to the facility (crash hit/year),

N_c = Number of aircraft handled by the relevant ARTCC

P_c = Aircraft crash rate (/aircraft handled)

A_c = Area covered by relevant ARTCC (mi.²),

A_t = Facility target area presented to aircraft during accident sequence (mi.²).

For General Aviation (GA) only, the aircraft crash hit frequency is determined using a product-kernel method for estimating multidimensional probability density functions. This is a data-driven approach based on the location (given as latitude and longitude) of prior GA crashes outside of the near airport flight environment. A total of 1250 GA crash locations derived from the NTSB accident database were used to develop the probability density functions for GA crashes outside of the near airport flight environment. Once the probability density function for GA crashes outside of the near airport flight environment is determined, then the aircraft crash hit frequency at any point outside of the near airport flight environment can be determined. This method cannot be used for the other categories of aviation because there are not enough crash locations available for these other categories of aviation to develop the aircraft crash location probability density function with a reasonable degree of confidence. A SAIC developed computer program called SHARK.EXE is used to determine the non-airport (in-flight) environment aircraft crash frequency [Ref. 1.16].

The area presented by a facility to an aircraft during an accident sequence represents a proportionality with the aircraft crash location conditional probability. Normally, the area presented by a facility consists of a fly-in area and a skid-in area. These represents the probability that an aircraft will fly directly into the facility, and the probability that an aircraft will hit the ground first, then skid into the facility, respectively. The facility effective target area, A_t , is equal to the fly-in area, A_f , plus the skid-in area, A_s .

$$A_t = A_f + A_s$$

where, for a rectangular facility of length L , width W , and height H [Refs.1.16 and 1.17]

$$A_f = [(WS + R) * H * \cot \phi] + [(2 * L * W * WS)/R] + (L * W)$$

$$A_s = (WS + R) * S$$

WS = aircraft wingspan

L = facility length

W = facility width

R = diagonal dimension of the facility = $(L^2 + W^2)^{1/2}$

H = facility height

$\cot \phi$ = mean cotangent of aircraft impact angle

S = mean aircraft skid length

To account for the yearly variation in the number of aircraft operations, calculations for the Materials Management Area (MMA) and the National Ignition Facility (NIF) were done for four time periods: Fiscal Year 1995, Fiscal Years 1993-95 (3 year average), Fiscal Years 1991-95 (5 year average), and Fiscal Years 1986-95 (10 year average). Calculations for the other facilities were done based on the 5 year average because this time period tended to give the most conservative (highest frequency) results and the results between the various time periods tended to be consistent.

Figure 1.1
ARTCCs and Airspace Boundaries within the Continental United States
[Refs. 1.4 and 1.6]

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2. AIRCRAFT OPERATIONS IN THE FLIGHT ENVIRONMENT NEAR THE LAWRENCE LIVERMORE NATIONAL LABORATORY (LLNL) SITE 200

2.1 INTRODUCTION

The estimation of aircraft crash hit frequencies is strongly influenced by the quality and amount of information and data available on aircraft operations in the flight environment near the facility under consideration. As the Aircraft Crash Hit Analysis is driven by the aircraft operations data, this analysis is performed for each source of available aircraft operations data as tabulated by the Federal Aviation Administration (FAA).

This chapter describes the aircraft operations in the flight environment near the Lawrence Livermore National Laboratory (LLNL) Site 200. The flight environment near the LLNL Site 200 is affected by aircraft operations at nearby airports, aircraft approaches to major airports some distance away, and aircraft overflights. There is only one major airport, the Livermore Municipal Airport (LVK), and one minor airport, the Meadowlark Airport near the LLNL Site 200. The Livermore Municipal Airport is described further in Section 2.2. The Meadowlark Airport is a small private airport with very few aircraft operations located approximately 1.2 miles south southeast of the southeast corner of the LLNL Site 200. Because there are so few aircraft operations at the Meadowlark Airport, it is not considered further in the Aircraft Crash Hit Analysis. The LLNL Site 200 is near the major airway for aircraft entering the San Francisco Bay area. These aircraft are under the guidance and control of the Bay (O90) Terminal Radar Approach Control (TRACON) at least 30 nautical miles from the San Francisco International Airport (SFO). These aircraft operations are described further in Section 2.3. Finally, there are aircraft operations which overfly the San Francisco Bay area. These aircraft are under the guidance and control of the Oakland (ZOA) Air Route Traffic Control Center (ARTCC). These aircraft operations are described further in Section 2.4.

2.2 AIRCRAFT OPERATIONS IN THE LIVERMORE MUNICIPAL AIRPORT (LVK) FLIGHT ENVIRONMENT

In April 1942, a parcel of privately owned land approximately one mile northwest of the city of Livermore was taken over by the Federal Government under condemnation proceedings for use as a Naval Auxiliary Air Field. During World War II, this facility provided auxiliary air service to support the Livermore Naval Air Station, three and one-half miles west of Livermore and now the present site of the LLNL. After the war, the City of Livermore began to operate the facility under a lease agreement with the Navy. The airport was then known as the Livermore Sky Ranch, the predecessor of the Livermore Municipal Airport. The City of Livermore took official possession of the airport in November 1953 under the terms of the Federal Property and Administrative Services Act of 1944. Because of urban encroachment on the east and south side of the field, the City of Livermore acquired land two miles northwest of Livermore Sky Ranch for construction and development of the Livermore Municipal Airport. Aircraft operations at the Livermore Municipal Airport began on December 8, 1965 and have continued at its present site [2.1].

The Livermore Municipal Airport with the International Air Transport Association (IATA) designation LVK, is the sole major airport near LLNL. It is located approximately five statute miles directly west of LLNL and about one-third mile south of, and parallel to Interstate Highway 580, within the Livermore/Amador Valley. At the present time, the Livermore Municipal Airport has two parallel runways. Runway 7Left/25Right is 5255 feet long and 100 feet wide. Runway 7Right/25Left is 2699 feet long and 75 feet wide [Ref. 2.2]. The Livermore Municipal Airport is located on the floor of the Livermore/Amador Valley at an elevation of 397 feet at $37^{\circ} 42'$ North Latitude, $121^{\circ} 49'$ West Longitude [Ref. 2.2]. The LLNL Site 200 is located at $37^{\circ} 41'$ North Latitude, $121^{\circ} 41'$ West Longitude [Ref. 2.3]. There is one air navigation aid, the REIGA LOM (Locater at Outer Marker) located at $37^{\circ} 41.54'$ North Latitude, $121^{\circ} 41.04'$ West Longitude [Ref. 2.2]. The REIGA LOM serves to guide aircraft on an ILS (Instrument Landing System) landing approach to Runway 25 Right and to guide aircraft departing from Runways 7 Left and Right [Ref. 2.2]. The Livermore Air Traffic Control Tower (ATCT) has been designated by the FAA as a Level 2 Visual Flight Rules (VFR) facility. The airspace over the Livermore Municipal Airport has been designated a Class D Airspace and air traffic within this airspace is regulated by the Livermore ATCT up to an altitude of 2900 feet mean sea level (MSL) and out to a radius of five (5) statute miles from the center of the Livermore Municipal Airport.

Figure 2.1 shows the Lawrence Livermore National Laboratory (LLNL) Site 200 and the Livermore Municipal Airport (LVK).

Table 2.1 presents the Aircraft Operations at the Livermore Municipal Airport for Fiscal Years (FY) 1973 through 1995 based on data tabulated by the F.A.A. in their Air Traffic Activity documents [Refs. 2.19 to 2.41]. The Livermore ATCT was commissioned as a FAA Control Tower in Fiscal Year 1973. Aircraft Operations prior to FY 1973 are not available from the FAA.

2.2.1 Air Carrier Operations

For the 1995, 1993-95, and 1991-95 time periods, there were no aircraft flying under 14 CFR 121 (Air Carriers) which performed any operations from the Livermore Municipal Airport (LVK). The last time 14 CFR 121 Air Carriers performed any flight operations from LVK was in 1986 when two were performed. When these two flight operations are averaged over the 1986-95 time period, the average number of Air Carrier operations from LVK is one takeoff in 10 years and one landing in 10 years or 0.1/year for takeoff and for landing.

2.2.2 Air Taxi Operations

For 1995, the number of Air Taxi operations from the Livermore Municipal Airport (LVK) was 127. For 1993-95, the average number of Air Taxi operations from LVK was 292. For 1991-95, the average number of Air Taxi operations from LVK was 406. For 1986-95, the average number of Air Taxi operations from LVK was 410.

2.2.3 General Aviation Operations

For 1995, the total number of General Aviation (GA) airport operations from LVK was 225,370. Of this total, 146,406 were classified as local operations and 79,324 were classified as itinerant operations. Local operations are defined by FAA as operations performed by aircraft which operate in the local traffic pattern or within sight of the airport or are known to be departing for, or arriving from flight in local practice areas located within a 20 mile radius of the airport, or are executing simulated instrument approaches or low passes at the airport. All other operations are classified as itinerant. Because of the distance of the LLNL from LVK (5.1 statute miles), the LLNL can be considered outside of the local traffic pattern for LVK so only itinerant operations are considered in the Aircraft Crash Hit Analysis. Of the 79,324 itinerant operations, 39,662 are takeoffs, and 39,662 are landings. Breaking these totals down to subcategory of General Aviation aircrafts, 68.2% are single-engine piston fixed wing aircraft, 6.8% are multi-engine piston fixed wing aircraft, 2.4% are turboprop fixed wing aircraft, 1.4% are turbojet fixed wing aircraft, and 21.2 % are helicopters. These percentages are based on the distribution of General Aviation flights for the FAA Western-Pacific Region for calendar year 1994. Applying these percentages to the 39,662 itinerant takeoffs yields 27,065 performed by single-engine piston, 2,705 performed by multi-engine piston, 903 performed by turboprops, 558 performed by turbojets, and 8,404 performed by helicopters. Itinerant landings by General Aviation subcategory would be identical.

For the 1993-95 time period, the average number of GA airport operations from LVK was 252,192 of which 160,442 were local, and 91,750 were itinerant. Of these 91,750 itinerant operations, 45,875 were takeoffs, and 45,875 were landings. Applying the GA subcategory percentages from 1995 operations, yields for takeoffs, 31,304 by single-engine piston, 3,129 by multi-engine piston, 1,076 by turboprops, 645 by turbojets, and 9,720 by helicopters. Itinerant landings by GA subcategory would be identical.

For the 1991-95 time period, the average number of GA airport operations from LVK was 246,184 of which 152,076 were local, and 94,108 were itinerant. Of these 94,108 itinerant operations, 47,054 were takeoffs, and 47,054 were landings. Applying the GA subcategory percentages from 1995 operations, yields for takeoffs, 32,089 by single-engine piston, 3,208 by multi-engine piston, 1,103 by turboprops, 662 by turbojets, and 9,964 by helicopters. Itinerant landings by GA subcategory would be identical.

For the 1986-95 time period, the average number of GA airport operations from LVK was 223,288 of which 129,237 were local and 94,051 were itinerant. Of these 94,051 itinerant operations, 47,026 were takeoffs, and 47,026 were landings. Applying the GA subcategory percentages from 1995 operations, yields for takeoffs, 32,071 by single-engine piston, 3,198 by multi-engine piston, 1,128 by turboprops, 658 by turbojets, and 9,969 by helicopters. Itinerant landings by GA subcategory would be identical.

2.2.4 Military Aviation Operations

For 1995, the total number of Military Aviation (MA) airport operations from LVK was 1,098 of which 663 were local and 434 were itinerant. As for GA, only itinerant MA operations will be considered in the Aircraft Crash Hit Analysis. Half of the itinerant MA operations were takeoffs and half were landings or 217. Because of the short runway lengths of the LVK runways, all MA aircraft are considered as small MA aircraft in this analysis. For the 1993-95 time period, the average number of MA itinerant operations from LVK was 598 of which 299 were takeoffs, and 299 were landings. For the 1991-95 time period, the average number of MA itinerant operations from LVK was 624 of which 312 were takeoffs, and 312 were landings. For the 1986-95 time period, the average number of MA itinerant operations from LVK was 522 of which 261 were takeoffs, and 261 were landings.

2.3 AIRCRAFT OPERATIONS IN THE BAY TRACON FLIGHT ENVIRONMENT

Overlying the Livermore Municipal Airport (LVK) Class D Airspace is the San Francisco Class B Airspace. This airspace extends up to 8000 feet MSL, and outwards to a radius of 30 nautical miles from the San Francisco International Airport. All air traffic is required to obtain permission from the air traffic controllers before entering any Class B Airspace so most aircraft contact air traffic control approximately 20 miles outside of the Class B Airspace. All air traffic within the San Francisco Class B Airspace is controlled by the Bay Area (O90) Terminal Radar Approach Control or TRACON facility located near the Oakland International Airport (OAK), except for the airspace controlled by the individual airports such as the Livermore Municipal Airport. The San Francisco Class B Airspace does not extend from the ground to 8000 feet outwards to 30 nautical miles but instead is stepped in increments of 5 miles outward. The San Francisco Class B Airspace can be visualized as an upside down stepped wedding cake with cylindrical holes (representing the airport airspaces) cut out from the bottom. Because of the peculiarities of the topography in the San Francisco Bay area and the air traffic patterns which have developed, much of the air traffic entering the San Francisco Bay area from the Southeast, East, and Northeast is directed by the Bay TRACON (O90) to the V195 Airway located within 5 miles of LLNL. This air traffic is then directed to intersect the SUNOL intersection where Bay TRACON directs the air traffic to their respective airport. In the TRACON Flight Environment, the air traffic control of the TRACON serves to concentrate and space the air traffic within TRACON airspace in Low Altitude Airways and on approaches to airport runways. In actual practice, most air traffic is maintained at or above 11,000 feet MSL on approach to the San Francisco Bay area until the SUNOL intersection is reached [Ref. 2.2].

Air traffic being directed by the Bay TRACON are not be counted as Airport Operations at the Livermore Municipal Airport unless that air traffic actually enters the airport controlled airspace, which is up to 2900 feet MSL and five (5) statute miles radius from the Livermore Municipal Airport. The number of aircraft handled by Bay TRACON could be used as an estimate of air traffic handled by the Bay TRACON near the LLNL Site 200 except for two important reasons. One is the that the number of aircraft handled by a TRACON refers to only the number of instrument operations handled by the TRACON and does not include visual flight rules (VFR) flights. The second reason is that the TRACON count includes the total number of instrument operations coming into the TRACON airspace from all directions. Directionality is not considered in the TRACON counts. So for the case of LLNL Site 200, the Bay TRACON undercounts due to the exclusion of VFR flights, then overcounts due to counting of flights coming into the San Francisco Bay area from the South, West and North. The airspace over the LLNL Site 200 is primarily affected by domestic air traffic approaching and departing to the southeast, east, and northeast. International air traffic would approach and depart the San Francisco Bay area airports to and from the south, west, and north. Because of the orientation of the San Jose International Airport (SJC) runways, its air traffic tends to be guided in from the south or from the north. For these reasons, no international air traffic and no air traffic from SJC is included in the count of Air Carriers flight near the LLNL Site 200. The number of Air Carrier operations at the Oakland International Airport (OAK) and the San Francisco International Airport (SFO) are combined for the total Air Carrier Operations. Five per cent (5%) of this total is assumed to be international flights (based on FAA Air Carriers RSPA data) and are subtracted from this total. From the remaining number of Air Carriers operations, 75% are conservatively assumed to approach and depart from the San Francisco Bay area from the southeast, east and northeast.

Figure 2.2 shows the Lawrence Livermore National Laboratory (LLNL) Site 200 and the airspace controlled by the Bay TRACON.

Table 2.2 presents the Instrument Operations recorded by Bay TRACON for Fiscal Years 1973 through 1995 based on data tabulated by the F.A.A. in their Air Traffic Activity documents [Refs. 2.19 to 2.41]. Table 2.3 presents the Instrument Operations recorded by the Oakland International Airport (OAK) for Fiscal Years 1968 through 1995 based on data tabulated by the F.A.A. in their Air Traffic Activity documents [Refs. 2.14 to 2.41]. Table 2.4 presents the Instrument Operations recorded by the San

Francisco International Airport (SFO) for Fiscal Years 1968 through 1996 based on data tabulated by the F.A.A. in their Air Traffic Activity documents [Refs. 2.14 to 2.41].

An Instrument Operation is an Aircraft Operation in accordance with an IFR (Instrument Flight Rules) flight plan or an operation where IFR separation between aircraft is provided by a terminal control facility or an Air Route Traffic Control Center (ARTCC). Unfortunately, not all Aircraft Operations at an airport are Instrument Operations, as aircraft which have filed IFR flight plans can cancel their flight plans even while on approach to an airport. However, aircraft which cancel their IFR flight plans are generally General Aviation and Military Aviation flights. Air Carrier and Air Taxi flights maintain their IFR flight plans although adjustments to their approaches to airports are made in VFR (Visual Flight Rules) conditions. Table 2.5 presents the Aircraft Operations recorded by the Oakland International Airport (OAK) for Fiscal Years 1968 through 1995 based on data tabulated by the F.A.A. in their Air Traffic Activity documents [Refs. 2.14 to 2.41]. Table 2.6 presents the Aircraft Operations recorded by the San Francisco International Airport (SFO) for Fiscal Years 1968 through 1995 based on data tabulated by the F.A.A. in their Air Traffic Activity documents [Refs. 2.14 to 2.41]. Note that the Air Carrier Instrument Operations and Air Taxi Instrument Operations at the OAK from Table 2.3 and at the SFO from Table 2.4 are very close to the number of Air Carrier Aircraft Operations and Air Taxi Aircraft Operations at the OAK from Table 2.5 and at the SFO from Table 2.6.

2.3.1 Air Carrier Operations

From Table 2.3, for Fiscal Year 1995, OAK had 164,384 Air Carrier instrument operations. From Table 2.4 for Fiscal Year 1995, SFO had 299,444 Air Carrier instrument operations. The combined total for OAK and SFO for Fiscal Year 1995 is of 463,828 Air Carrier instrument operations. Reducing this figure by 5% to account for international flights yields 440,637 Air Carrier instrument operations. Considering 75% of this figure as approaches and departures over and near the LLNL Site 200 gives 330,477 Air Carrier instrument operations. Half of these instrument operations are departures or 165,239, and half are approaches or 165,239.

From Table 2.3 for the Fiscal Year 1993-95 time period, OAK averaged 139,020 Air Carrier instrument operations. From Table 2.4 for the Fiscal Year 1993-95 time period, SFO averaged 291,530 Air Carrier instrument operations. The combined total for OAK and SFO averaged for Fiscal Years 1993-95 is 430,550 Air Carrier instrument operations. Reducing this figure by 5% to account for international flights yields 409,023 Air Carrier instrument operations. Considering 75% of this figure as approaches and departures over and near the LLNL Site 200 gives 306,767 Air Carrier instrument operations. Half of these instrument operations are departures or 153,383, and half are approaches or 153,383.

From Table 2.3 for the Fiscal Year 1991-95 time period, OAK averaged 126,641 Air Carrier instrument operations. From Table 2.4 for the Fiscal Year 1991-95 time period, SFO averaged 296,301 Air Carrier instrument operations. The combined total for OAK and SFO averaged for Fiscal Years 1991-95 is 422,942 Air Carrier instrument operations. Reducing this figure by 5% to account for international flights yields 401,795 Air Carrier instrument operations. Considering 75% of this figure as approaches and departures over and near the LLNL Site 200 gives 301,346 Air Carrier instrument operations. Half of these instrument operations are departures or 150,673, and half are approaches or 150,673.

From Table 2.3 for the Fiscal Year 1986-95 time period, OAK averaged 102,880 Air Carrier instrument operations. From Table 2.4 for the Fiscal Year 1986-95 time period, SFO averaged 306,653 Air Carrier instrument operations. The combined total for OAK and SFO averaged for Fiscal Years 1986-95 is 409,533 Air Carrier instrument operations. Reducing this figure by 5% to account for international flights yields 389,056 Air Carrier instrument operations. Considering 75% of this figure as approaches and departures over and near the LLNL Site 200 gives 291,792 Air Carrier instrument operations. Half of these instrument operations are departures or 145,896, and half are approaches or 145,897.

2.3.2 Air Taxi Operations

The logic and process used for determining the number of Air Carrier flights in the Bay TRACON flight environment was also used for determining the number of Air Taxi flights in the Bay TRACON environment except that no 5% reduction for international flights was applied for Air Taxis. The reason for this is that most Air Taxi aircraft types do not have the range to perform international flights to the San Francisco Bay area.

From Table 2.3 for Fiscal Year 1995, OAK had 52,554 Air Taxi instrument operations. From Table 2.4 for Fiscal Year 1995, SFO had 96,937 Air Taxi instrument operations. The combined total for OAK and SFO for Fiscal year 1995 is 149,491 Air Taxi instrument operations. Considering 75% of this figure as approaches and departures over and near the LLNL Site 200 gives 112,118 Air Taxi instrument operations. Half of these instrument operations are departures or 56,059, and half are approaches or 56,059.

From Table 2.3 for the Fiscal Year 1993-95 time period, OAK averaged 55,344 Air Taxi instrument operations. From Table 2.4 for the Fiscal Year 1993-95 time period, SFO averaged 101,479 Air Taxi instrument operations. The combined total for OAK and SFO averaged for Fiscal Years 1993-95 is 156,823 Air Taxi instrument operations. Considering 75% of this figure as approaches and departures over and near the LLNL Site 200 gives 117,617 Air Taxi instrument operations. Half of these instrument operations are departures or 58,809, and half are approaches or 58,809.

From Table 2.3 for the Fiscal Year 1991-95 time period, OAK averaged 53,869 Air Taxi instrument operations. From Table 2.4 for the Fiscal Year 1991-95 time period, SFO averaged 96,651 Air Taxi instrument operations. The combined total for OAK and SFO averaged for Fiscal Years 1991-95 is 150,520 Air Taxi instrument operations. Considering 75% of this figure as approaches and departures over and near the LLNL Site 200 gives 112,890 Air Taxi instrument operations. Half of these instrument operations are departures or 56,445, and half are approaches or 56,445.

From Table 2.3 for the Fiscal Year 1986-95 time period, OAK averaged 49,474 Air Taxi instrument operations. From Table 2.4 for the Fiscal Year 1986-95 time period, SFO averaged 90,270 Air Taxi instrument operations. The combined total for OAK and SFO averaged for Fiscal Years 1986-95 is 139,744 Air Taxi instrument operations. Considering 75% of this figure as approaches and departures over and near the LLNL Site 200 gives 104,808 Air Taxi instrument operations. Half of these instrument operations are departures or 52,404, and half are approaches or 52,404.

2.3.3 General Aviation Operations

The number of General Aviation (GA) operations in the Bay TRACON (O90) flight environment is not required because the SHARK.EXE computer program is used to determine the GA aircraft crash density function.

2.3.4 Military Aviation Operations

In the recent past, most Military Aviation (MA) air traffic in the San Francisco Bay area was directed to airports other than OAK and SFO, i.e. Moffet Naval Air Station (NAS), Alameda NAS and Travis Air Force Base (AFB). With the drawdown of U.S. military forces, both the Moffet NAS and Alameda NAS have been closed as active military bases. Any attempt to estimate the number of MA flights in the San Francisco Bay area based on historical data is likely to grossly overestimate the number of MA flights.

The number of Military Aviation (MA) flights in the Bay TRACON (O90) flight environment is taken directly from Table 2.2, Bay TRACON Instrument Operations. Again, this is expected to be grossly

conservative because this assigns all MA flights to approaches to and departures from the San Francisco Bay region from/to the southeast, east, and northeast.

From Table 2.2, for Fiscal Year 1995, Bay TRACON handled 22,255 MA aircraft of which 11,128 were approaches and 11,128 were departures.

From Table 2.2, for the Fiscal Year 1993-95 time period, Bay TRACON handled an average of 28,529 MA aircraft per year of which 14,265 were approaches and 14,265 were departures.

From Table 2.2 for the Fiscal Year 1991-95 time period, Bay TRACON handled an average of 32,704 MA aircraft per year of which 16,352 were approaches and 16,352 were departures.

From Table 2.2 for the Fiscal year 1986-95 time period, Bay TRACON handled an average of 56,707 MA aircraft per year of which 28,354 were approaches and 28,354 were departures.

2.4 AIRCRAFT OPERATIONS IN THE OAKLAND ARTCC (ZOA) FLIGHT ENVIRONMENT

Above the San Francisco Airport Class B Airspace is the airspace controlled by the Oakland (ZOA) Air Route Traffic Control Center (ARTCC) located in Fremont, California. Only IFR air traffic above 18,000 feet MSL (Class A Airspace) is required to be controlled by an ARTCC. In practice, all IFR air traffic and most VFR air traffic above the roof of a Class B Airspace are controlled by the ARTCC. In the case of the San Francisco Bay area, All IFR air traffic above 11,000 feet MSL and most VFR air traffic above 11,000 feet but below 18,000 feet MSL are controlled by Oakland ARTCC. All air traffic above 18,000 feet MSL are IFR flights as required by 14 CFR 91.135 [Ref. 2.42]

Figure 2.3 shows the Lawrence Livermore National Laboratory (LLNL) Site 200 and the airspace covered by the Oakland ARTCC.

Table 2.7 presents the Aircraft Handled recorded by the Oakland ARTCC for Fiscal Years 1958 through 1995 based on data tabulated by the F.A.A. in their Air Traffic Activity documents [Refs. 2.4 to 2.41]. Prior to Fiscal Year 1972, Air Taxi were not classified as a separate category of aviation.

2.4.1 Air Carrier Operations

For Fiscal Year 1995, the number of Air Carrier aircraft handled by the Oakland ARTCC is 961,986. For the Fiscal Year 1993-95 time period, an average of 905,884 Air Carrier aircraft were handled per year. For the Fiscal Year 1991-95 time period, an average of 886,927 Air Carrier aircraft were handled per year. For the Fiscal Year 1986-95 time period, for an average of 843,660 Air Carrier aircraft were handled per year.

2.4.2 Air Taxi Operations

For Fiscal Year 1995, the number of Air Taxi aircraft handled by the Oakland ARTCC is 217,531. For the Fiscal Year 1993-95 time period, an average of 217,680 Air Taxi aircraft were handled per year. For the Fiscal Year 1991-95 time period, an average of 210,548 Air Taxi aircraft were handled per year. For the Fiscal Year 1986-95 time period, an average of 196,979 Air Taxi aircraft were handled per year.

2.4.3 General Aviation Operations

The number of General Aviation (GA) operations in the Oakland ARTCC (ZOA) flight environment is not required because the SHARK.EXE computer program is used to determine the GA aircraft crash density function.

2.4.4 Military Aviation Operations

For Fiscal 1995, the number of Military Aviation (MA) aircraft handled by Oakland is 195,476. For the Fiscal Year 1993-95 time period, an average of 207,251 MA aircraft were handled per year. For the Fiscal Year 1991-95 time period, an average of 273,821 MA aircraft were handled per year. For the Fiscal Year 1986-95 time period, an average of 322,092 MA aircraft were handled per year. As these numbers indicate, the number of MA flights handled by the Oakland ARTCC has been declining in recent years. This reduction is due to the drawdown of U.S. military activities in general and is expected to continue in the near future.

Figure 2.1
LLNL and Livermore Municipal Airport (LVK)

Figure 2.3

LLNL and Oakland ARTCC (ZOA)

Table 2.1
Livermore Municipal Airport (LVK) Aircraft Operations
 [Refs. 2.18 to 2.40]

Fiscal Year	Air Carrier Operations			Air Taxi Operations			General Aviation Operations			Military Aviation Operations			Total Operations			Pct. Change
	Itinerant [1]	Local [1]	Total	Itinerant [1]	Local [1]	Total	Itinerant [1]	Local [1]	Total	Itinerant [1]	Local [1]	Total	Itinerant [1]	Local [1]	Total	
1968																
1969																
1970																
1971																
1972																
1973	0	0	0	126	0	126	14,346	20,015	34,361	70	63	133	14,542	20,078	34,620	
1974	0	0	0	860	0	860	69,481	94,846	164,327	215	239	454	70,556	95,085	165,641	378.5%
1975	0	0	0	1,025	0	1,025	75,161	92,116	167,277	181	163	344	76,367	92,279	168,646	1.8%
1976	0	0	0	3,107	0	3,107	77,640	102,523	180,163	178	122	300	80,925	102,645	183,570	8.8%
1977	0	0	0	3,033	0	3,033	82,553	113,614	196,167	168	153	321	85,754	113,767	199,521	8.7%
1978	0	0	0	2,307	0	2,307	84,027	121,973	206,000	240	187	427	86,574	122,160	208,734	4.6%
1979	0	0	0	2,405	0	2,405	88,919	120,072	208,991	259	245	504	91,583	120,317	211,900	1.5%
1980	0	0	0	1,926	0	1,926	88,584	116,961	205,545	198	68	266	90,708	117,029	207,737	-2.0%
1981	0	0	0	1,497	0	1,497	90,860	114,577	205,437	261	175	436	92,618	114,752	207,370	-0.2%
1982	0	0	0	1,392	0	1,392	72,097	88,471	160,568	333	345	678	73,822	88,816	162,638	-21.6%
1983	0	0	0	1,865	0	1,865	74,914	93,298	168,212	604	446	1,050	77,383	93,744	171,127	5.2%
1984	0	0	0	980	0	980	83,019	92,928	175,947	578	280	858	84,577	93,208	177,785	3.9%
1985	7	0	7	539	0	539	81,433	82,596	164,029	397	98	495	82,376	82,694	165,070	-7.2%
1986	2	0	2	426	0	426	89,336	93,887	183,223	520	197	717	90,284	94,084	184,368	11.7%
1987	0	0	0	381	0	381	102,524	96,925	199,449	439	201	640	103,344	97,126	200,470	8.7%
1988	0	0	0	432	0	432	91,526	101,112	192,638	501	94	595	92,459	101,206	193,665	-3.4%
1989	0	0	0	357	0	357	91,250	116,072	207,322	369	36	405	91,976	116,108	208,084	7.4%
1990	0	0	0	473	0	473	95,335	123,994	219,329	276	35	311	96,084	124,029	220,113	5.8%
1991	0	0	0	690	0	690	95,684	133,419	229,103	421	139	560	96,795	133,558	230,353	4.7%
1992	0	0	0	467	0	467	99,605	145,634	245,239	904	228	1,132	100,976	145,862	246,838	7.2%
1993	0	0	0	626	0	626	101,710	179,614	281,324	790	42	832	103,126	179,656	282,782	14.6%
1994	0	0	0	122	0	122	94,215	155,307	249,522	570	78	648	94,907	155,385	250,292	-11.5%
1995	0	0	0	127	0	127	79,324	146,406	225,730	434	664	1,098	79,885	147,070	226,955	-9.3%
1996																
3 Yr. (93-95) Sum:	0	0	0	875	0	875	275,249	481,327	756,576	1,794	784	2,578	277,918	482,111	760,029	
3 Yr. (93-95) Avg.:	0	0	0	292	0	292	91,750	160,442	252,192	598	261	859	92,639	160,704	253,343	-2.1%
5 Yr. (91-95) Sum:	0	0	0	2,032	0	2,032	470,538	760,380	1,230,918	3,119	1,151	4,270	475,689	761,531	1,237,220	
5 Yr. (91-95) Avg.:	0	0	0	406	0	406	94,108	152,076	246,184	624	230	854	95,138	152,306	247,444	1.1%
10 Yr. (86-95) Sum:	2	0	2	4,101	0	4,101	940,509	1,292,370	2,232,879	5,224	1,714	6,938	949,836	1,294,084	2,243,920	
10 Yr. (86-95) Avg.:	0	0	0	410	0	410	94,051	129,237	223,288	522	171	694	94,984	129,408	224,392	3.6%
15 Yr. (81-95) Sum:	9	0	9	10,374	0	10,374	1,342,832	1,764,240	3,107,072	7,397	3,058	10,455	1,360,612	1,767,298	3,127,910	
15 Yr. (81-95) Avg.:	1	0	1	692	0	692	89,522	117,616	207,138	493	204	697	90,707	117,820	208,527	1.1%
20 Yr. (76-95) Sum:	9	0	9	23,152	0	23,152	1,764,555	2,339,383	4,103,938	8,440	3,833	12,273	1,796,156	2,343,216	4,139,372	
20 Yr. (76-95) Avg.:	0	0	0	1,158	0	1,158	88,228	116,969	205,197	422	192	614	89,808	117,161	206,969	1.9%
25 Yr. (71-95) Sum:	9	0	9	25,163	0	25,163	1,923,543	2,546,360	4,469,903	8,906	4,298	13,204	1,957,621	2,550,658	4,508,279	
25 Yr. (71-95) Avg.:	0	0	0	1,094	0	1,094	83,632	110,711	194,344	387	187	574	85,114	110,898	196,012	19.0%

Table 2.2
Bay TRACON (O90) Instrument Operations
[Ref. 2.18 to 2.40]

Fiscal Year	Air Carrier Instrument Operations				Air Taxi Instrument Operations				General Aviation Instrument Operations				Military Aviation Instrument Operations				Total Instrument Operations			
	Primary [1]	Secondary [1]	Overflights [1]	Total	Primary [1]	Secondary [1]	Overflights [1]	Total	Primary [1]	Secondary [1]	Overflights [1]	Total	Primary [1]	Secondary [1]	Overflights [1]	Total	Primary [1]	Secondary [1]	Overflights [1]	Total
1968																				
1969																				
1970																				
1971																				
1972																				
1973	46,224	323,730	133	370,087	1,246	9,494	113	10,853	25,513	60,633	7,523	93,669	1,481	57,059	1,478	60,018	74,464	450,916	9,247	534,627
1974	43,205	303,527	133	346,865	2,491	21,813	192	24,496	28,287	86,394	14,312	128,993	1,133	52,775	1,639	55,547	75,116	464,509	16,276	555,901
1975	41,227	304,104	129	345,460	3,560	28,269	230	32,059	30,149	99,691	21,868	151,708	717	45,914	1,710	48,341	75,653	477,978	23,937	577,568
1976	39,654	299,274	1,488	340,416	4,187	33,130	943	38,260	31,588	98,093	24,675	154,356	987	41,146	2,071	44,204	76,416	471,643	29,177	577,236
1977	39,505	309,079	1,565	350,149	3,951	34,840	761	39,552	43,183	117,521	31,277	191,981	1,091	39,272	2,757	43,120	87,730	500,712	36,360	624,802
1978	48,746	321,343	2,029	372,118	6,074	28,096	781	34,951	44,671	116,659	36,988	198,318	989	34,077	2,856	37,922	100,480	500,175	42,654	643,309
1979	51,264	328,048	3,498	382,810	9,022	15,973	1,263	26,258	76,092	137,490	71,724	285,306	1,711	32,041	4,593	38,345	138,089	513,552	81,078	732,719
1980	36,876	326,388	2,838	366,102	6,669	35,613	2,453	44,735	49,852	118,023	63,159	231,034	1,277	28,229	3,549	33,055	94,674	508,253	71,999	674,926
1981	33,186	262,351	3,062	298,599	10,107	66,578	3,696	80,381	40,584	108,648	69,403	218,635	882	27,966	3,767	32,615	84,759	465,543	79,928	630,230
1982	41,510	289,830	2,390	333,730	11,760	18,437	3,544	33,741	34,886	94,185	42,504	171,575	618	27,148	3,533	31,299	88,774	429,600	51,971	570,345
1983	50,427	325,943	2,735	379,105	9,433	25,815	5,252	40,500	27,756	92,160	54,889	174,805	621	26,884	3,273	30,778	88,237	470,802	66,149	625,188
1984	59,789	353,786	2,389	415,964	9,517	54,512	7,680	71,709	25,996	91,063	68,835	185,894	634	28,568	3,571	32,773	95,936	527,929	82,475	706,340
1985	58,816	338,080	2,471	399,367	19,354	78,961	8,560	106,875	36,267	95,810	54,768	186,845	808	30,740	18,036	49,584	115,245	543,591	83,835	742,671
1986	64,466	398,110	3,022	465,598	19,770	76,142	7,732	103,644	32,480	93,815	19,560	145,855	952	31,052	54,318	86,322	117,668	599,119	84,632	801,419
1987	78,501	432,601	8,672	519,774	22,071	84,066	15,098	121,235	82,182	84,023	35,442	201,647	2,234	32,340	75,829	110,403	184,988	633,030	135,041	953,059
1988	77,115	423,381	3,435	503,931	32,049	119,293	21,617	172,959	89,429	76,835	42,860	209,124	1,595	31,899	88,375	121,869	200,188	651,408	156,287	1,007,883
1989	74,653	401,625	807	477,085	41,039	121,848	7,524	170,411	143,340	178,932	27,022	349,294	1,043	32,995	16,563	50,601	260,075	735,400	51,916	1,047,391
1990	85,133	393,229	3,128	481,490	43,114	141,139	1,279	185,532	166,150	193,599	23,231	382,980	4,770	26,205	3,381	34,356	299,167	754,172	31,019	1,084,358
1991	95,034	371,001	183	466,218	58,076	163,932	3,629	225,637	190,616	129,280	19,209	339,105	7,367	28,371	3,602	39,340	351,093	692,584	26,623	1,070,300
1992	89,575	376,762	368	466,705	49,040	147,247	5,730	202,017	183,774	124,981	27,135	335,890	9,411	25,965	3,217	38,593	331,800	674,955	36,450	1,043,205
1993	97,761	353,804	134	451,699	46,237	161,068	5,955	213,260	154,676	121,485	31,783	307,944	8,755	23,024	3,027	34,806	307,429	659,381	40,899	1,007,709
1994	106,317	376,188	167	482,672	44,533	137,119	6,069	187,721	152,918	119,728	39,302	311,948	9,559	14,960	4,008	28,527	313,327	684,595	49,546	1,010,868
1995	127,768	374,009	199	501,976	60,982	149,485	6,506	216,973	144,763	110,433	40,080	295,276	7,799	10,281	4,175	22,255	341,312	644,208	50,960	1,036,480
1996																				
93-95																				
Sum:	331,846	1,104,001	500	1,436,347	151,752	447,672	18,530	617,954	452,357	351,646	111,165	915,168	26,113	48,265	11,210	85,588	962,068	1,951,584	141,405	3,055,057
Avg.:	110,615	368,000	167	478,782	50,584	149,224	6,177	205,985	150,786	117,215	37,055	305,056	8,704	16,088	3,737	28,529	320,689	650,528	47,135	1,018,352
91-95																				
Sum:	516,455	1,851,764	1,051	2,369,270	258,868	758,851	27,889	1,045,608	826,747	605,907	157,509	1,590,163	42,891	102,601	18,029	163,521	1,644,961	3,319,123	204,478	5,168,562
Avg.:	103,291	370,353	210	473,854	51,774	151,770	5,578	209,122	165,349	121,181	31,502	318,033	8,578	20,520	3,606	32,704	328,992	663,825	40,896	1,033,712
86-95																				
Sum:	896,323	3,900,710	20,115	4,817,148	416,911	1,301,339	81,139	1,799,389	1,340,328	1,233,111	305,624	2,879,063	53,485	257,092	256,495	567,072	2,707,047	6,692,252	663,373	10,062,672
Avg.:	89,632	390,071	2,012	481,715	41,691	130,134	8,114	179,939	134,033	123,311	30,562	287,906	5,349	25,709	25,650	56,707	270,705	669,225	66,337	1,006,267
81-95																				
Sum:	1,140,051	5,470,700	33,162	6,643,913	477,082	1,545,642	109,871	2,132,595	1,505,817	1,714,977	596,023	3,816,817	57,048	398,398	288,675	744,121	3,179,998	9,129,717	1,027,731	13,337,446
Avg.:	76,003	364,713	2,211	442,928	31,805	103,043	7,325	142,173	100,388	114,332	39,735	254,454	3,803	26,560	19,245	49,608	212,000	608,648	68,515	889,163
76-95																				
Sum:	1,356,096	7,054,832	44,580	8,455,508	506,985	1,693,294	116,072	2,316,351	1,751,203	2,302,763	823,846	4,877,812	63,103	573,163	304,501	940,767	3,677,387	11,624,052	1,288,999	16,590,438
Avg.:	67,805	352,742	2,229	422,775	25,349	84,665	5,804	115,818	87,560	115,138	41,192	243,891	3,155	28,658	15,225	47,038	183,869	581,203	64,450	829,522
71-95																				
Sum:	1,486,752	7,986,193	44,975	9,517,920	514,282	1,752,870	116,607	2,383,759	1,835,152	2,549,481	867,549	5,252,182	66,434	728,911	309,328	1,104,673	3,902,620	13,017,455	1,338,459	18,258,534
Avg.:	64,641	347,226	1,955	413,823	22,360	76,212	5,070	103,642	79,789	110,847	37,720	228,356	2,888	31,692	13,449	48,029	169,679	565,976	58,194	793,849

Table 2.3
Oakland International Airport (OAK) Instrument Operations
[Refs. 2.14 to 2.41]

Fiscal Year	Air Carrier Instrument Operations				Air Taxi Instrument Operations				General Aviation Instrument Operations				Military Aviation Instrument Operations				Total Instrument Operations			
	Primary (1)	Secondary (1)	Overflights (1)	Total	Primary (1)	Secondary (1)	Overflights (1)	Total	Primary (1)	Secondary (1)	Overflights (1)	Total	Primary (1)	Secondary (1)	Overflights (1)	Total	Primary (1)	Secondary (1)	Overflights (1)	Total
1968	94,496	176,521		271,017					18,793	7,757		26,550	14,378	14,364		28,742	127,667	198,642		326,309
1969	45,922	317,145		363,067					23,744	32,305		56,049	2,864	38,996		41,860	72,530	388,446		460,976
1970	43,704	318,732		362,436					17,237	42,567		59,804	383	31,599		31,982	61,324	392,898		454,222
1971	38,040	312,645		350,685					17,156	41,769		58,925	284	34,240		34,524	55,480	388,654		444,134
1972	37,092	298,164	27	335,283	547	6,960	16	7,523	15,444	31,091	754	47,289	1,051	52,023	1,480	54,554	54,134	388,238	2,277	444,649
1973	46,565	0	0	46,565	1,276	0	0	1,276	23,517	0	0	23,517	1,481	0	0	1,481	72,839	0	0	72,839
1974	43,748	0	0	43,748	2,505	0	0	2,505	28,494	0	0	28,494	1,153	0	0	1,153	75,900	0	0	75,900
1975	42,330	0	0	42,330	5,755	0	0	5,755	27,789	0	0	27,789	737	0	0	737	76,611	0	0	76,611
1976	40,529	0	0	40,529	5,881	0	0	5,881	31,868	0	0	31,868	1,019	0	0	1,019	79,297	0	0	79,297
1977	40,981	0	0	40,981	4,198	0	0	4,198	46,508	0	0	46,508	1,122	0	0	1,122	92,809	0	0	92,809
1978	45,309	0	0	45,309	5,506	0	0	5,506	42,258	0	0	42,258	842	0	1,214	2,056	93,915	0	1,214	95,129
1979	50,117	0	0	50,117	4,543	0	0	4,543	52,164	0	513	52,677	2,572	279	4,006	6,857	109,396	279	4,519	114,194
1980	36,194	0	0	36,194	8,524	0	22	8,546	59,274	0	11,294	70,568	943	0	6,151	7,094	104,935	0	17,467	122,402
1981	33,212	0	0	33,212	12,563	0	299	12,862	59,200	0	11,014	70,214	1,016	0	5,862	6,878	105,991	0	17,175	123,166
1982	38,764	0	0	38,764	25,977	0	1,042	27,019	42,049	0	13,793	55,842	1,046	0	5,435	6,481	107,836	0	20,270	128,106
1983	47,999	0	0	47,999	29,575	0	1,956	31,531	35,306	0	29,721	65,027	1,107	0	4,876	5,983	113,987	0	36,553	150,540
1984	61,086	0	0	61,086	29,917	0	736	30,653	35,484	0	34,607	70,091	659	0	5,881	6,540	127,146	0	41,224	168,370
1985	69,116	0	18	69,134	31,080	0	1,120	32,200	42,123	0	42,701	84,824	633	0	1,851	2,484	142,952	0	45,690	188,642
1986	72,648	119	1,063	73,830	28,855	124	1,377	30,356	40,624	659	36,575	77,858	867	512	4,801	6,180	142,994	1,414	43,816	188,224
1987	80,602	0	145	80,747	27,458	0	1,671	29,129	36,208	0	37,681	73,889	750	0	8,477	9,227	145,018	0	47,974	192,992
1988	81,205	0	94	81,299	52,514	0	580	53,094	146,186	0	31,618	177,804	940	0	8,209	9,149	280,845	0	40,501	321,346
1989	74,698	0	51	74,749	57,393	0	467	57,860	145,848	0	28,638	174,486	803	0	7,872	8,675	278,742	0	37,028	315,770
1990	84,932	0	37	84,969	54,446	0	507	54,953	139,436	0	32,304	171,740	1,550	0	6,354	7,904	280,364	0	39,202	319,566
1991	108,406	0	38	108,444	50,780	0	265	51,045	140,407	0	34,482	174,889	601	0	9,055	9,656	300,194	0	43,840	344,034
1992	107,660	0	39	107,699	51,992	0	276	52,268	140,227	0	41,141	181,368	766	0	8,054	8,820	300,645	0	49,510	350,155
1993	121,953	0	29	121,982	55,165	0	336	55,501	136,773	0	47,035	183,808	847	0	6,080	6,927	314,738	0	53,480	368,218
1994	130,335	0	359	130,694	57,712	0	266	57,978	142,358	0	47,330	189,688	702	0	5,213	5,915	331,107	0	53,168	384,275
1995	164,371	0	13	164,384	52,343	0	211	52,554	142,616	0	43,221	185,837	727	0	6,124	6,851	360,057	0	49,569	409,626
3 Yr. (93-95)																				
Sum:	416,659	0	401	417,060	165,220	0	813	166,033	421,747	0	137,586	559,333	2,276	0	17,417	19,693	1,005,902	0	156,217	1,162,119
Avg.:	138,886	0	134	139,020	55,073	0	271	55,344	140,582	0	45,862	186,444	759	0	5,806	6,564	335,301	0	52,072	387,373
5 Yr. (91-95)																				
Sum:	632,725	0	478	633,203	267,992	0	1,354	269,346	702,381	0	213,209	915,590	3,643	0	34,526	38,169	1,606,741	0	249,567	1,856,308
Avg.:	126,545	0	96	126,641	53,598	0	271	53,869	140,476	0	42,642	183,118	729	0	6,905	7,634	321,348	0	49,913	371,262
10 Yr. (86-95)																				
Sum:	1,026,810	119	1,868	1,028,797	488,658	124	5,956	494,738	1,210,683	659	380,025	1,591,367	8,553	512	70,239	79,304	2,734,704	1,414	458,088	3,194,206
Avg.:	102,681	12	187	102,880	48,866	12	596	49,474	121,068	66	38,003	159,137	855	51	7,024	7,930	273,470	141	45,809	319,421
15 Yr. (81-95)																				
Sum:	1,276,987	119	1,886	1,278,992	617,770	124	11,109	629,003	1,424,845	659	511,861	1,937,365	13,014	512	94,144	107,670	3,332,616	1,414	619,000	3,953,030
Avg.:	85,132	8	126	85,266	41,185	8	741	41,934	94,990	44	34,124	129,158	868	34	6,276	7,178	222,174	94	41,267	263,535
20 Yr. (76-95)																				
Sum:	1,490,117	119	1,886	1,492,122	646,422	124	11,131	657,677	1,656,917	659	523,668	2,181,244	19,512	791	105,515	125,818	3,812,968	1,693	642,200	4,456,861
Avg.:	74,506	6	94	74,606	32,321	6	557	32,884	82,846	33	26,183	109,062	976	40	5,276	6,291	190,648	85	32,110	222,843
25 Yr. (71-95)																				
Sum:	1,697,892	610,928	1,913	2,310,733	656,505	7,084	11,147	674,736	1,769,317	73,519	524,422	2,367,258	24,218	87,054	106,995	218,267	4,147,932	778,585	644,477	5,570,994
Avg.:	67,916	24,437	80	92,429	27,354	295	464	28,114	70,773	2,941	21,851	94,690	969	3,482	4,458	8,731	165,917	31,143	26,853	222,840

Table 2.4
San Francisco International Airport (SFO) Instrument Operations
[Refs. 2.14 to 2.41]

Fiscal Year	Air Carrier Instrument Operations				Air Taxi Instrument Operations				General Aviation Instrument Operations				Military Aviation Instrument Operations				Total Instrument Operations			
	Primary (1)	Secondary (1)	Overflights (1)	Total	Primary (1)	Secondary (1)	Overflights (1)	Total	Primary (1)	Secondary (1)	Overflights (1)	Total	Primary (1)	Secondary (1)	Overflights (1)	Total	Primary (1)	Secondary (1)	Overflights (1)	Total
1968	238,535	0		238,535					1,606	0		1,606	8,636	0		8,636	248,777	0		248,777
1969	267,143	0		267,143					13,425	40		13,465	1,184	0		1,184	281,752	40		281,792
1970	277,937	0		277,937					20,750	0		20,750	812	0		812	299,499	0		299,499
1971	276,241	0		276,241					21,262	0		21,262	3,501	0		3,501	301,004	0		301,004
1972	254,797	0	0	254,797	4,418	0	0	4,418	11,335	0	0	11,335	1,016	0	0	1,016	271,566	0	0	271,566
1973	285,038	0	0	285,038	6,105	0	0	6,105	27,696	0	0	27,696	3,528	0	0	3,528	322,367	0	0	322,367
1974	275,096	0	0	275,096	15,843	0	0	15,843	40,192	0	3,435	43,627	4,801	0	0	4,801	335,932	0	3,435	339,367
1975	273,423	0	0	273,423	16,825	0	0	16,825	37,730	0	3,948	41,678	4,794	0	0	4,794	332,772	0	3,948	336,720
1976	245,355	0	0	245,355	20,903	0	0	20,903	37,812	0	2,273	40,085	4,413	0	0	4,413	308,483	0	2,273	310,756
1977	254,659	0	0	254,659	32,645	0	0	32,645	48,993	0	2,399	51,392	3,339	0	0	3,339	339,636	0	2,399	342,035
1978	265,720	0	0	265,720	28,915	0	0	28,915	52,566	0	203	52,769	2,874	0	0	2,874	350,075	0	203	350,278
1979	263,789	0	0	263,789	28,415	0	0	28,415	68,491	0	1,807	70,298	2,794	0	550	3,344	363,489	0	2,357	365,846
1980	253,259	0	0	253,259	53,606	0	0	53,606	61,467	0	1,559	63,026	2,303	0	1,016	3,319	370,635	0	2,575	373,210
1981	236,101	0	0	236,101	32,173	0	0	32,173	57,792	0	1,091	58,883	2,317	0	862	3,179	328,383	0	1,953	330,336
1982	219,056	0	0	219,056	44,372	0	0	44,372	48,945	0	1,000	49,945	2,417	0	832	3,249	314,790	0	1,832	316,622
1983	231,354	375	0	231,729	54,405	0	0	54,405	53,866	0	1,377	55,243	7,772	0	1,203	8,975	347,397	375	2,580	350,352
1984	270,805	0	0	270,805	75,292	0	0	75,292	51,656	0	2,425	54,081	2,724	0	1,829	4,553	400,477	0	4,254	404,731
1985	267,180	0	0	267,180	74,633	0	0	74,633	50,075	0	4,682	54,757	2,955	0	0	2,955	394,843	0	4,682	399,525
1986	308,311	0	0	308,311	67,880	0	0	67,880	41,594	0	5,684	47,278	2,743	0	0	2,743	420,528	0	5,684	426,212
1987	329,197	0	0	329,197	82,908	0	0	82,908	36,344	0	6,835	43,179	2,684	0	0	2,684	451,133	0	6,835	457,968
1988	322,020	0	0	322,020	104,895	0	0	104,895	30,238	0	7,771	38,009	2,531	0	0	2,531	459,684	0	7,771	467,455
1989	311,430	0	0	311,430	85,209	0	0	85,209	29,883	0	8,000	37,883	2,563	0	0	2,563	429,085	0	8,000	437,085
1990	314,070	0	0	314,070	77,807	0	747	78,554	32,298	0	10,513	42,811	2,574	0	0	2,574	426,749	0	11,260	438,009
1991	310,011	0	0	310,011	85,969	0	0	85,969	26,195	0	10,771	36,966	2,361	0	0	2,361	424,536	0	10,771	435,307
1992	296,904	0	0	296,904	92,850	0	0	92,850	22,870	0	9,786	32,656	2,412	0	0	2,412	415,036	0	9,786	424,822
1993	287,404	0	0	287,404	101,983	0	0	101,983	22,211	0	9,485	31,696	2,322	0	0	2,322	413,920	0	9,485	423,405
1994	287,742	0	0	287,742	105,516	0	0	105,516	24,427	0	9,987	34,414	2,671	0	0	2,671	420,356	0	9,987	430,343
1995	299,444	0	0	299,444	96,937	0	0	96,937	25,664	0	12,398	38,062	2,465	0	0	2,465	424,510	0	12,398	436,908
3 Yr. (93-95)																				
Sum:	874,590	0	0	874,590	304,436	0	0	304,436	72,302	0	31,870	104,172	7,458	0	0	7,458	1,258,786	0	31,870	1,290,656
Avg.:	291,530	0	0	291,530	101,479	0	0	101,479	24,101	0	10,623	34,724	2,486	0	0	2,486	419,595	0	10,623	430,219
5 Yr. (91-95)																				
Sum:	1,481,505	0	0	1,481,505	483,255	0	0	483,255	121,367	0	52,427	173,794	12,231	0	0	12,231	2,098,358	0	52,427	2,150,785
Avg.:	296,301	0	0	296,301	96,651	0	0	96,651	24,273	0	10,485	34,759	2,446	0	0	2,446	419,672	0	10,485	430,157
10 Yr. (86-95)																				
Sum:	3,066,533	0	0	3,066,533	901,954	0	747	902,701	291,724	0	91,230	382,954	25,326	0	0	25,326	4,285,537	0	91,977	4,377,514
Avg.:	306,653	0	0	306,653	90,195	0	75	90,270	29,172	0	9,123	38,295	2,533	0	0	2,533	428,554	0	9,198	437,751
15 Yr. (81-95)																				
Sum:	4,291,029	375	0	4,291,404	1,182,829	0	747	1,183,576	554,058	0	101,805	655,863	43,511	0	4,726	48,237	6,071,427	375	107,278	6,179,080
Avg.:	286,069	25	0	286,094	78,855	0	50	78,905	36,937	0	6,787	43,724	2,901	0	315	3,216	404,762	25	7,152	411,939
20 Yr. (76-95)																				
Sum:	5,573,811	375	0	5,574,186	1,347,313	0	747	1,348,060	823,387	0	110,046	933,433	59,234	0	6,292	65,526	7,803,745	375	117,085	7,921,205
Avg.:	278,691	19	0	278,709	67,366	0	37	67,403	41,169	0	5,502	46,672	2,962	0	315	3,276	390,187	19	5,854	396,060
25 Yr. (71-95)																				
Sum:	6,938,406	375	0	6,938,781	1,390,504	0	747	1,391,251	961,602	0	117,429	1,079,031	76,874	0	6,292	83,166	9,367,386	375	124,468	9,492,229
Avg.:	277,536	15	0	277,551	57,938	0	31	57,969	38,464	0	4,693	43,161	3,075	0	262	3,327	374,695	15	5,186	379,689

Table 2.5
Oakland International Airport (OAK) Aircraft Operations
[Refs. 2.14 to 2.41]

Fiscal Year	Air Carrier Operations			Air Taxi Operations			General Aviation Operations			Military Aviation Operations			Total Operations			Pct. Change
	Itinerant [1]	Local [1]	Total	Itinerant [1]	Local [1]	Total	Itinerant [1]	Local [1]	Total	Itinerant [1]	Local [1]	Total	Itinerant [1]	Local [1]	Total	
1968	58,590	0	58,590				174,809	195,568	370,377	1,936	5,177	7,113	235,335	200,745	436,080	
1969	70,076	0	70,076				161,148	137,925	299,073	1,254	4,692	5,946	232,478	142,617	375,095	-14.0%
1970	72,813	0	72,813				163,558	126,330	289,888	1,340	3,111	4,451	237,711	129,441	367,152	-2.1%
1971	63,621	0	63,621				150,543	155,233	305,766	1,559	2,440	3,999	215,723	157,663	373,386	1.7%
1972	57,041	0	57,041	2,407	0	2,407	140,112	143,581	283,693	1,325	2,774	4,099	200,885	146,355	347,240	-7.0%
1973	58,689	0	58,689	4,880	0	4,880	126,758	161,041	287,799	1,838	2,954	4,792	192,165	163,995	356,160	2.6%
1974	57,054	0	57,054	5,890	0	5,890	124,422	147,252	271,674	1,910	2,814	4,724	189,276	150,066	339,342	-4.7%
1975	53,607	0	53,607	7,752	0	7,752	131,104	137,372	268,476	1,531	2,739	4,270	193,994	140,111	334,105	-1.5%
1976	52,910	0	52,910	11,513	0	11,513	136,568	162,168	298,736	1,595	4,114	5,709	202,586	166,282	368,868	10.4%
1977	41,097	0	41,097	12,412	0	12,412	159,675	234,077	393,752	1,528	3,519	5,047	214,712	237,596	452,308	22.6%
1978	46,990	0	46,990	18,920	0	18,920	157,706	220,590	378,296	1,132	3,318	4,450	224,748	223,908	448,656	-0.8%
1979	45,266	0	45,266	18,609	0	18,609	181,915	274,144	456,059	1,177	2,342	3,519	246,967	276,486	523,453	16.7%
1980	36,156	0	36,156	15,876	0	15,876	180,072	253,522	433,594	907	1,051	1,958	233,011	254,573	487,584	-6.9%
1981	33,291	0	33,291	22,146	0	22,146	176,933	225,493	402,426	978	813	1,791	233,348	226,306	459,654	-5.7%
1982	39,026	0	39,026	35,336	0	35,336	149,652	161,065	310,717	919	330	1,249	224,933	161,395	386,328	-16.0%
1983	47,814	0	47,814	38,052	0	38,052	129,982	143,565	273,547	867	274	1,141	216,715	143,839	360,554	-6.7%
1984	59,564	0	59,564	41,600	0	41,600	136,189	135,759	271,948	943	414	1,357	238,296	136,173	374,469	3.9%
1985	69,240	0	69,240	39,318	0	39,318	134,340	126,612	260,952	876	233	1,109	243,774	126,845	370,619	-1.0%
1986	72,561	0	72,561	37,836	0	37,836	136,180	123,176	259,356	1,079	96	1,175	247,656	123,272	370,928	0.1%
1987	80,608	0	80,608	41,258	0	41,258	143,693	130,747	274,440	1,150	202	1,352	266,709	130,949	397,658	7.2%
1988	81,209	0	81,209	52,256	0	52,256	146,196	121,482	267,678	979	139	1,118	280,640	121,621	402,261	1.2%
1989	74,682	0	74,682	57,281	0	57,281	144,980	125,304	270,284	802	164	966	277,745	125,468	403,213	0.2%
1990	84,945	0	84,945	54,540	0	54,540	139,440	108,501	247,941	1,545	173	1,718	280,470	108,674	389,144	-3.5%
1991	108,401	0	108,401	50,772	0	50,772	140,407	113,667	254,074	601	68	669	300,181	113,735	413,916	6.4%
1992	107,669	0	107,669	51,982	0	51,982	140,227	118,415	258,642	838	102	940	300,716	118,517	419,233	1.3%
1993	121,953	0	121,953	55,164	0	55,164	136,876	124,356	261,232	847	18	865	314,840	124,374	439,214	4.8%
1994	130,335	0	130,335	57,770	0	57,770	142,389	139,563	281,952	702	142	844	331,196	139,705	470,901	7.2%
1995	164,371	0	164,371	52,357	0	52,357	142,621	142,530	285,151	727	346	1,073	360,076	142,876	502,952	6.8%
1996																
3 Yr. (93-95) Sum:	416,659	0	416,659	165,291	0	165,291	421,886	406,449	828,335	2,276	506	2,782	1,006,112	406,955	1,413,067	
3 Yr. (93-95) Avg.:	138,886	0	138,886	55,097	0	55,097	140,629	135,483	276,112	759	169	927	335,371	135,652	471,022	6.3%
5 Yr. (91-95) Sum:	632,729	0	632,729	268,045	0	268,045	702,520	638,531	1,341,051	3,715	676	4,391	1,607,009	639,207	2,246,216	
5 Yr. (91-95) Avg.:	126,546	0	126,546	53,609	0	53,609	140,504	127,706	268,210	743	135	878	321,402	127,841	449,243	5.3%
10 Yr. (86-95) Sum:	1,026,734	0	1,026,734	511,216	0	511,216	1,413,009	1,247,741	2,660,750	9,270	1,450	10,720	2,960,229	1,249,191	4,209,420	
10 Yr. (86-95) Avg.:	102,673	0	102,673	51,122	0	51,122	141,301	124,774	266,075	927	145	1,072	296,023	124,919	420,942	3.2%
15 Yr. (81-95) Sum:	1,275,669	0	1,275,669	687,668	0	687,668	2,140,105	2,040,235	4,180,340	13,853	3,514	17,367	4,117,295	2,043,749	6,161,044	
15 Yr. (81-95) Avg.:	85,045	0	85,045	45,845	0	45,845	142,674	136,016	278,689	924	234	1,158	274,486	136,250	410,736	0.4%
20 Yr. (76-95) Sum:	1,498,088	0	1,498,088	764,998	0	764,998	2,956,041	3,184,736	6,140,777	20,192	17,858	38,050	5,239,319	3,202,594	8,441,913	
20 Yr. (76-95) Avg.:	74,904	0	74,904	38,250	0	38,250	147,802	159,237	307,039	1,010	893	1,903	261,966	160,130	422,096	2.4%
25 Yr. (71-95) Sum:	1,788,100	0	1,788,100	785,927	0	785,927	3,628,980	3,929,205	7,558,185	28,355	31,579	59,934	6,231,362	3,960,784	10,192,146	
25 Yr. (71-95) Avg.:	71,524	0	71,524	32,747	0	32,747	145,159	157,168	302,327	1,134	1,263	2,397	249,254	158,431	407,686	1.6%

Table 2.6
San Francisco International Airport (SFO) Aircraft Operations
[Refs. 2.14 to 2.41]

Fiscal Year	Air Carrier Operations			Air Taxi Operations			General Aviation Operations			Military Aviation Operations			Total Operations			Pct. Chage
	Itinerant [1]	Local [1]	Total	Itinerant [1]	Local [1]	Total	Itinerant [1]	Local [1]	Total	Itinerant [1]	Local [1]	Total	Itinerant [1]	Local [1]	Total	
1968	283,920	0	283,920				51,083	1,198	52,281	4,926	102	5,028	339,929	1,300	341,229	
1969	305,284	0	305,284				57,889	317	58,206	5,540	45	5,585	368,713	362	369,075	8.2%
1970	308,053	0	308,053				82,343	348	82,691	5,909	2	5,911	396,305	350	396,655	7.5%
1971	297,424	0	297,424				73,194	68	73,262	5,955	1	5,956	376,573	69	376,642	-5.0%
1972	279,474	0	279,474	18,529	0	18,529	51,491	47	51,538	5,866	6	5,872	355,360	53	355,413	-5.6%
1973	297,462	0	297,462	9,719	0	9,719	46,605	4	46,609	6,067	0	6,067	359,853	4	359,857	1.3%
1974	275,096	0	275,096	15,843	0	15,843	40,192	2,149	42,341	4,801	0	4,801	335,932	2,149	338,081	-6.1%
1975	271,389	0	271,389	16,825	0	16,825	37,730	0	37,730	4,794	0	4,794	330,738	0	330,738	-2.2%
1976	269,027	0	269,027	22,795	0	22,795	40,943	0	40,943	4,985	0	4,985	337,750	0	337,750	2.1%
1977	254,660	0	254,660	32,649	0	32,649	50,434	0	50,434	4,835	0	4,835	342,578	0	342,578	1.4%
1978	265,720	0	265,720	28,738	0	28,738	53,780	0	53,780	4,411	0	4,411	352,649	0	352,649	2.9%
1979	263,782	0	263,782	28,415	0	28,415	68,491	309	68,800	2,794	0	2,794	363,482	309	363,791	3.2%
1980	253,260	0	253,260	53,606	0	53,606	61,462	600	62,062	2,294	0	2,294	370,622	600	371,222	2.0%
1981	236,101	0	236,101	32,174	0	32,174	57,850	670	58,520	2,317	0	2,317	328,442	670	329,112	-11.3%
1982	219,092	0	219,092	44,371	0	44,371	48,959	168	49,127	2,413	0	2,413	314,835	168	315,003	-4.3%
1983	231,454	0	231,454	64,721	0	64,721	48,968	1,171	50,139	2,728	0	2,728	347,871	1,171	349,042	10.8%
1984	270,805	0	270,805	75,291	0	75,291	51,656	850	52,506	2,724	0	2,724	400,476	850	401,326	15.0%
1985	267,228	0	267,228	73,632	0	73,632	49,745	2,595	52,340	2,961	0	2,961	393,566	2,595	396,161	-1.3%
1986	307,751	0	307,751	67,880	0	67,880	41,594	2,702	44,296	2,736	0	2,736	419,961	2,702	422,663	6.7%
1987	329,196	0	329,196	82,909	0	82,909	36,344	0	36,344	2,683	0	2,683	451,132	0	451,132	6.7%
1988	321,420	0	321,420	104,884	0	104,884	30,218	2,160	32,378	2,531	0	2,531	459,053	2,160	461,213	2.2%
1989	311,430	0	311,430	85,209	0	85,209	29,878	5,218	35,096	2,563	0	2,563	429,080	5,218	434,298	-5.8%
1990	313,300	0	313,300	77,617	0	77,617	32,204	11,260	43,464	2,574	0	2,574	425,695	11,260	436,955	0.6%
1991	310,013	0	310,013	85,969	0	85,969	26,195	10,771	36,966	2,361	0	2,361	424,538	10,771	435,309	-0.4%
1992	296,904	0	296,904	92,850	0	92,850	22,870	9,786	32,656	2,419	0	2,419	415,043	9,786	424,829	-2.4%
1993	287,404	0	287,404	101,982	0	101,982	22,211	9,485	31,696	2,322	0	2,322	413,919	9,485	423,404	-0.3%
1994	287,742	0	287,742	105,492	0	105,492	24,427	10,047	34,474	2,672	0	2,672	420,333	10,047	430,380	1.6%
1995	299,444	0	299,444	96,936	0	96,936	25,664	12,398	38,062	2,465	0	2,465	424,509	12,398	436,907	1.5%
1996																
3 Yr. (93-95) Sum:	874,590	0	874,590	304,410	0	304,410	72,302	31,930	104,232	7,459	0	7,459	1,258,761	31,930	1,290,691	
3 Yr. (93-95) Avg.:	291,530	0	291,530	101,470	0	101,470	24,101	10,643	34,744	2,486	0	2,486	419,587	10,643	430,230	0.9%
5 Yr. (91-95) Sum:	1,481,507	0	1,481,507	483,229	0	483,229	121,367	52,487	173,854	12,239	0	12,239	2,098,342	52,487	2,150,829	
5 Yr. (91-95) Avg.:	296,301	0	296,301	96,646	0	96,646	24,273	10,497	34,771	2,448	0	2,448	419,668	10,497	430,166	0.0%
10 Yr. (86-95) Sum:	3,064,604	0	3,064,604	901,728	0	901,728	291,605	73,827	365,432	25,326	0	25,326	4,283,263	73,827	4,357,090	
10 Yr. (86-95) Avg.:	306,460	0	306,460	90,173	0	90,173	29,161	7,383	36,543	2,533	0	2,533	428,326	7,383	435,709	1.0%
15 Yr. (81-95) Sum:	4,289,284	0	4,289,284	1,191,917	0	1,191,917	548,783	79,281	628,064	38,469	0	38,469	6,068,453	79,281	6,147,734	
15 Yr. (81-95) Avg.:	285,952	0	285,952	79,461	0	79,461	36,586	5,285	41,871	2,565	0	2,565	404,564	5,285	409,849	1.3%
20 Yr. (76-95) Sum:	5,595,733	0	5,595,733	1,358,120	0	1,358,120	823,893	80,190	904,083	57,788	0	57,788	7,835,534	80,190	7,915,724	
20 Yr. (76-95) Avg.:	279,787	0	279,787	67,906	0	67,906	41,195	4,010	45,204	2,889	0	2,889	391,777	4,010	395,786	1.6%
25 Yr. (71-95) Sum:	7,016,578	0	7,016,578	1,419,036	0	1,419,036	1,073,105	82,458	1,155,563	85,271	7	85,278	9,593,990	82,465	9,676,455	
25 Yr. (71-95) Avg.:	280,663	0	280,663	59,127	0	59,127	42,924	3,298	46,223	3,411	0	3,411	383,760	3,299	387,058	0.5%

Table 2.7
Oakland ARTCC (ZOA) Aircraft Handled
[Refs. 2.4 to 2.41]

Fiscal Year	AIR CARRIER						AIR TAXI						GENERAL AVIATION					
	Departures	Domestic Overs	Oceanic Overs	Aircraft Handled	Pct. of Total	Pct. Change	Departures	Domestic Overs	Oceanic Overs	Aircraft Handled	Pct. of Total	Pct. Change	Departures	Domestic Overs	Oceanic Overs	Aircraft Handled	Pct. of Total	Pct. Change
1958	51,381	2,702	6,792	112,256	42.3%								6,608	253	194	13,663	5.2%	
1959	75,839	3,102	10,316	165,096	45.8%	47.1%							7,206	324	213	14,949	4.1%	9.4%
1960	78,564	3,788	11,396	172,312	49.1%	4.4%							6,625	465	314	14,029	4.0%	-6.2%
1961	73,186	3,828	10,009	160,209	46.6%	-7.0%							10,043	524	1,699	22,309	6.5%	59.0%
1962	77,289	3,585	11,838	170,001	46.6%	6.1%							10,632	670	2,108	24,042	6.6%	7.8%
1963	85,789	4,146	13,328	189,052	46.9%	11.2%							11,140	511	1,766	24,557	6.1%	2.1%
1964	95,330	4,223	16,668	211,551	44.3%	11.9%							9,044	573	654	19,315	4.0%	-21.3%
1965	113,493	5,123	21,194	253,303	47.8%	19.7%							11,536	666	705	24,443	4.6%	26.5%
1966	144,770	7,463	30,908	327,911	53.6%	29.5%							15,130	822	267	31,349	5.1%	28.3%
1967	163,283	10,437	41,489	378,492	55.2%	15.4%							21,349	1,401	312	44,411	6.5%	41.7%
1968	192,866	16,865	52,048	454,645	56.3%	20.1%							26,806	2,265	248	56,125	7.0%	26.4%
1969	238,261	24,687	54,988	556,197	58.3%	22.3%							38,279	3,011	304	79,873	8.4%	42.3%
1970	259,420	30,153	65,298	614,291	60.8%	10.4%							38,266	2,831	506	79,869	7.9%	0.0%
1971	247,026	35,654	61,184	590,890	57.9%	-3.8%							41,912	3,307	368	87,499	8.6%	9.6%
1972	203,819	26,604	60,363	494,605	52.6%	-16.3%	9,262	26	0	18,550	2.0%		36,251	2,951	481	75,934	8.1%	-13.2%
1973	217,902	22,843	51,137	509,784	57.0%	3.1%	6,781	15	2	13,579	1.5%	-26.8%	43,266	2,824	681	90,037	10.1%	18.6%
1974	203,926	25,002	41,282	474,136	53.1%	-7.0%	10,767	48	358	21,940	2.5%	61.6%	53,393	2,799	2,795	112,380	12.6%	24.8%
1975	204,561	17,473	47,245	473,840	53.2%	-0.1%	15,947	53	17	31,964	3.6%	45.7%	58,038	2,026	1,119	119,221	13.4%	6.1%
1976	203,483	27,352	40,984	475,302	49.9%	0.3%	22,583	97	3	45,266	4.8%	41.6%	77,805	4,340	839	160,789	16.9%	34.9%
1977	219,275	28,505	45,148	512,203	49.3%	7.8%	30,359	113	3	60,834	5.9%	34.4%	101,769	5,666	554	209,758	20.2%	30.5%
1978	238,882	33,761	45,706	557,231	49.7%	8.8%	37,759	133	8	75,659	6.8%	24.4%	114,491	6,209	719	235,910	21.1%	12.5%
1979	242,948	40,245	47,766	573,907	46.5%	3.0%	47,886	921	267	96,960	7.9%	28.2%	147,762	8,782	1,687	305,993	24.8%	29.7%
1980	227,446	47,826	48,749	551,467	39.2%	-3.9%	94,526	1,775	12	190,839	13.6%	96.8%	168,430	13,119	840	350,819	24.9%	14.6%
1981	188,086	43,001	44,819	463,992	34.0%	-15.9%	112,073	638	9	224,793	16.5%	17.8%	157,916	13,785	930	330,547	24.2%	-5.8%
1982	199,157	44,358	44,537	487,209	40.5%	5.0%	70,345	1,888	91	142,669	11.9%	-36.5%	136,886	13,017	872	287,661	23.9%	-13.0%
1983	215,100	40,895	47,113	518,208	41.2%	6.4%	83,698	3,570	1,248	172,214	13.7%	20.7%	125,082	11,538	595	262,297	20.9%	-8.8%
1984	247,007	41,936	79,921	615,871	45.5%	18.8%	78,095	3,522	798	160,510	11.9%	-6.8%	117,643	13,744	1,124	250,154	18.5%	-4.6%
1985	249,426	48,228	112,129	659,209	46.4%	7.0%	71,331	5,872	491	149,025	10.5%	-7.2%	114,404	13,651	2,757	245,216	17.2%	-2.0%
1986	283,978	55,459	124,539	747,954	50.8%	13.5%	63,049	6,639	524	133,261	9.1%	-10.6%	103,797	11,583	2,365	221,542	15.0%	-9.7%
1987	308,748	60,449	140,323	818,268	51.5%	9.4%	83,026	8,199	633	174,884	11.0%	31.2%	102,701	12,352	2,922	220,676	13.9%	-0.4%
1988	300,927	68,291	142,344	812,489	50.7%	-0.7%	109,764	5,038	590	225,156	14.0%	28.7%	100,635	11,566	2,577	215,413	13.4%	-2.4%
1989	290,025	64,767	153,482	798,299	49.1%	-1.7%	110,077	3,362	754	224,270	13.8%	-0.4%	107,060	12,491	3,504	230,115	14.2%	6.8%
1990	291,944	74,589	166,482	824,959	48.7%	3.3%	127,334	3,989	849	259,506	15.3%	15.7%	105,384	12,150	3,482	226,400	13.4%	-1.6%
1991	310,275	73,148	175,231	868,929	51.6%	5.3%	109,695	675	237	220,302	13.1%	-15.1%	97,341	10,892	3,974	209,548	12.4%	-7.4%
1992	294,679	74,085	184,612	848,055	52.1%	-2.4%	107,324	523	332	215,503	13.2%	-2.2%	95,055	10,369	3,208	203,687	12.5%	-2.8%
1993	299,671	67,508	191,916	858,766	56.7%	1.3%	113,984	926	220	229,114	15.1%	6.3%	92,707	11,453	3,233	200,100	13.2%	-1.8%
1994	311,986	74,060	198,867	896,899	59.6%	4.4%	105,872	1,039	364	213,147	14.2%	-7.0%	90,736	11,606	3,567	196,645	13.1%	-1.7%
1995	346,819	87,611	180,737	961,986	61.3%	7.3%	104,187	1,591	367	210,332	13.4%	-1.3%	92,842	12,181	2,852	200,717	12.8%	2.1%
1996																		
3 Year (1993-95) Sum:	958,476	229,179	571,520	2,717,651			324,043	3,556	951	652,593			276,285	35,240	9,652	597,462		
3 Year (1993-95) Avg.:	319,492	76,393	190,507	905,884	59.2%	4.3%	108,014	1,185	317	217,531	14.2%	-0.7%	92,095	11,747	3,217	199,154	13.0%	-0.5%
5 Year (1991-95) Sum:	1,563,430	376,412	931,363	4,434,635			541,062	4,754	1,520	1,088,398			468,681	56,501	16,834	1,010,697		
5 Year (1991-95) Avg.:	312,686	75,282	186,273	886,927	56.1%	3.2%	108,212	951	304	217,680	13.8%	-3.9%	93,736	11,300	3,367	202,139	12.8%	-2.3%
10 Year (1986-95) Sum:	3,039,052	699,967	1,658,533	8,436,604			1,034,312	31,981	4,870	2,105,475			988,258	116,643	31,684	2,124,843		
10 Year (1986-95) Avg.:	303,905	69,997	165,853	843,660	53.1%	4.0%	103,431	3,198	487	210,548	13.3%	4.5%	98,826	11,664	3,168	212,484	13.4%	-1.9%
15 Year (1981-95) Sum:	4,137,828	918,385	1,987,052	11,181,093			1,449,854	47,471	7,507	2,954,686			1,640,189	182,378	37,962	3,500,718		
15 Year (1981-95) Avg.:	275,855	61,226	132,470	745,406	49.7%	4.1%	96,657	3,165	500	196,979	13.1%	2.2%	109,346	12,159	2,531	233,381	15.6%	-3.5%
20 Year (1976-95) Sum:	5,269,862	1,096,074	2,215,405	13,851,203			1,682,967	50,510	7,800	3,424,244			2,250,446	220,494	42,601	4,763,987		
20 Year (1976-95) Avg.:	263,493	54,804	110,770	692,560	49.0%	3.8%	84,148	2,526	390	171,212	12.1%	12.9%	112,522	11,025	2,130	238,199	16.9%	3.5%
25 Year (1971-95) Sum:	6,347,096	1,223,650	2,476,616	16,394,458			1,725,724	50,652	8,177	3,510,277			2,483,306	234,401	48,045	5,249,058		
25 Year (1971-95) Avg.:	253,884	48,946	99,065	655,778	49.9%	2.1%	71,905	2,111	341	146,262	11.1%	14.8%	99,332	9,376	1,922	209,962	16.0%	4.6%

Table 2.7 (continued)
Oakland ARTCC (ZOA) Aircraft Handled
[Refs. 2.4 to 2.41]

Oakland, CA ARTCC (ZOA)	Fiscal Year	MILITARY AVIATION						TOTAL											
		Departures	Domestic Overs	Oceanic Overs	Aircraft Handled	Pct. of Total	Pct. Change	Departures	Rank	Pct. Change	Domestic Overs	Oceanic Overs	Total Overs	Rank	Pct. Change	Aircraft Handled	Rank	Pct. Change	
	1958	58,045	14,337	8,849	139,276	52.5%		116,034			17,292	15,835	33,127			265,195			
	1959	72,872	20,231	14,817	180,792	50.1%	29.8%	155,917		34.4%	23,657	25,346	49,003		47.9%	360,837		36.1%	
	1960	66,699	17,880	13,357	164,635	46.9%	-8.9%	151,888		-2.6%	22,133	25,067	47,200		-3.7%	350,976		-2.7%	
	1961	64,841	17,731	14,095	161,508	46.9%	-1.9%	148,070	8	-2.5%	22,083	25,803	47,886	22	1.5%	344,026	11	-2.0%	
	1962	67,768	14,772	20,846	171,154	46.9%	6.0%	155,689	8	5.1%	19,027	34,792	53,819	22	12.4%	365,197	11	6.2%	
	1963	80,257	13,829	15,242	189,585	47.0%	10.8%	177,186	5	13.8%	18,486	30,336	48,822	21	-9.3%	403,194	9	10.4%	
	1964	100,201	24,614	21,275	246,291	51.6%	29.9%	204,575	7	15.5%	29,410	38,597	68,007	19	39.3%	477,157	9	18.3%	
	1965	99,977	24,989	27,203	252,146	47.6%	2.4%	225,006	9	10.0%	30,778	49,102	79,880	17	17.5%	529,892	10	11.1%	
	1966	100,986	19,717	30,847	252,536	41.3%	0.2%	260,886	9	15.9%	28,002	62,022	90,024	15	12.7%	611,796	9	15.5%	
	1967	102,497	24,223	34,105	263,322	38.4%	4.3%	287,129	9	10.1%	36,061	75,906	111,967	14	24.4%	686,225	9	12.2%	
	1968	107,954	42,719	37,552	296,179	36.7%	12.5%	327,626	11	14.1%	61,849	89,848	151,697	13	35.5%	806,949	10	17.6%	
	1969	107,907	62,428	39,998	318,240	33.3%	7.4%	384,447	10	17.3%	90,126	95,290	185,416	12	22.2%	954,310	11	18.3%	
	1970	100,023	81,478	33,892	315,416	31.2%	-0.9%	397,709	10	3.4%	114,462	99,696	214,158	10	15.5%	1,009,576	11	5.8%	
	1971	110,531	83,536	37,137	341,735	33.5%	8.3%	399,469	10	0.4%	122,497	98,689	221,186	11	3.3%	1,020,124	11	1.0%	
	1972	137,827	49,405	26,918	351,977	37.4%	3.0%	387,159	10	-3.1%	78,986	87,762	166,748	17	-24.6%	941,066	14	-7.7%	
	1973	118,891	22,390	20,829	281,001	31.4%	-20.2%	386,840	11	-0.1%	48,072	72,649	120,721	18	-27.6%	894,401	15	-5.0%	
	1974	119,623	24,635	19,922	283,803	31.8%	1.0%	387,709	11	0.2%	52,484	64,357	116,841	18	-3.2%	892,259	16	-0.2%	
	1975	114,288	18,880	18,412	265,868	29.8%	-6.3%	392,834	13	1.3%	38,432	66,793	105,225	18	-9.9%	890,893	16	-0.2%	
	1976	112,706	27,079	18,360	270,851	28.4%	1.9%	416,577	11	6.0%	58,868	60,186	119,054	18	13.1%	952,208	15	6.9%	
	1977	105,956	30,126	13,492	255,530	24.6%	-5.7%	457,359	12	9.8%	64,410	59,197	123,607	18	3.8%	1,038,325	15	9.0%	
	1978	102,672	32,573	13,725	251,642	22.5%	-1.5%	493,804	12	8.0%	72,676	60,158	132,834	18	7.5%	1,120,442	15	7.9%	
	1979	101,277	39,078	14,703	256,335	20.8%	1.9%	539,873	10	9.3%	89,026	64,423	153,449	18	15.5%	1,233,195	15	10.1%	
	1980	106,606	82,734	17,903	313,849	22.3%	22.4%	597,008	10	10.6%	145,454	67,504	212,958	16	38.8%	1,406,974	13	14.1%	
	1981	105,438	118,539	16,790	346,205	25.4%	10.3%	563,513	10	-5.6%	175,963	62,548	238,511	16	12.0%	1,365,537	14	-2.9%	
	1982	92,688	83,431	15,259	284,066	23.6%	-17.9%	499,076	10	-11.4%	142,694	60,759	203,453	16	-14.7%	1,201,605	14	-12.0%	
	1983	98,899	93,458	13,678	304,934	24.2%	7.3%	522,779	11	4.7%	149,461	62,634	212,095	15	4.2%	1,257,653	16	4.7%	
	1984	95,713	95,301	20,782	327,509	24.2%	7.4%	548,458	12	4.9%	154,503	102,625	257,128	15	21.2%	1,354,044	16	7.7%	
	1985	111,506	111,995	33,089	368,096	25.9%	12.4%	546,667	12	-0.3%	179,746	148,466	328,212	13	27.6%	1,421,546	14	5.0%	
	1986	109,015	118,583	33,025	369,638	25.1%	0.4%	559,839	14	2.4%	192,264	160,453	352,717	13	7.5%	1,472,395	14	3.6%	
	1987	106,662	130,257	32,163	375,744	23.6%	1.7%	601,137	15	7.4%	211,257	176,041	387,298	13	9.8%	1,589,572	15	8.0%	
	1988	99,084	126,012	26,732	350,912	21.9%	-6.6%	610,410	15	1.5%	210,907	172,243	383,150	13	-1.1%	1,603,970	16	0.9%	
	1989	98,504	147,535	28,700	373,243	23.0%	6.4%	605,666	16	-0.8%	228,155	186,440	414,595	13	8.2%	1,625,927	15	1.4%	
	1990	95,758	161,848	28,917	382,281	22.6%	2.4%	620,420	14	2.4%	252,576	199,730	452,306	12	9.1%	1,693,146	15	4.1%	
	1991	110,761	141,453	22,973	385,948	22.9%	1.0%	628,072	11	1.2%	226,168	202,415	428,583	13	-5.2%	1,684,727	12	-0.5%	
	1992	106,125	124,506	24,649	361,405	22.2%	-6.4%	603,183	16	-4.0%	209,483	212,801	422,284	13	-1.5%	1,628,650	15	-3.3%	
	1993	81,028	44,751	20,412	227,219	15.0%	-37.1%	587,990	16	-2.6%	124,638	215,781	340,419	16	-19.4%	1,515,199	16	-7.0%	
	1994	72,500	35,826	18,231	199,057	13.2%	-12.4%	581,094	17	-1.1%	122,531	221,029	343,560	16	0.9%	1,505,748	16	-0.6%	
	1995	73,414	32,154	16,494	195,476	12.5%	-1.8%	617,262	16	6.2%	133,537	200,450	333,987	16	-2.8%	1,568,511	16	4.2%	
	1996																		
	3 Year (1993-95) Sum:	226,942	112,731	55,137	621,752			1,785,746			380,706	637,260	1,017,966			4,589,458			
	3 Year (1993-95) Avg.:	75,647	37,577	18,379	207,251	13.5%	-17.1%	595,249		0.8%	126,902	212,420	339,322		-7.1%	1,529,819		-1.1%	
	5 Year (1991-95) Sum:	443,828	378,690	102,759	1,369,105			3,017,001			816,357	1,052,476	1,868,833			7,902,835			
	5 Year (1991-95) Avg.:	88,766	75,738	20,552	273,821	17.3%	-11.3%	603,400		0.0%	163,271	210,495	373,767		-5.6%	1,580,567		-1.4%	
	10 Year (1986-95) Sum:	952,851	1,062,925	252,296	3,220,923			6,014,473			1,911,516	1,947,383	3,858,899			15,887,845			
	10 Year (1986-95) Avg.:	95,285	106,293	25,230	322,092	20.3%	-5.2%	601,447		1.3%	191,152	194,738	385,890		0.6%	1,588,785		1.1%	
	15 Year (1981-95) Sum:	1,467,095	1,565,649	351,894	4,851,733			8,694,966			2,713,883	2,384,415	5,098,298			22,488,230			
	15 Year (1981-95) Avg.:	97,806	104,377	23,460	323,449	21.6%	-2.2%	579,664		0.3%	180,926	158,961	339,887		3.7%	1,499,215		0.9%	
	20 Year (1976-95) Sum:	1,996,312	1,777,239	430,077	6,199,940			11,199,587			3,144,317	2,695,883	5,840,200			28,239,374			
	20 Year (1976-95) Avg.:	99,816	88,862	21,504	309,997	22.0%	-0.7%	559,979		2.4%	157,216	134,794	292,010		6.7%	1,411,969		3.1%	
	25 Year (1971-95) Sum:	2,597,472	1,976,085	553,295	7,724,324			13,153,598			3,484,788	3,086,133	6,570,921			32,878,117			
	25 Year (1971-95) Avg.:	103,899	79,043	22,132	308,973	23.5%	-1.1%	526,144		1.9%	139,392	123,445	262,837		2.9%	1,315,125		2.0%	

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3. AIRCRAFT CRASH RATES AND AIRCRAFT CRASH LOCATION DISTRIBUTIONS

3.1 INTRODUCTION

To estimate an accident or crash rate, P , required for the Aircraft Crash Hit Analysis, one must obtain the number of accidents or crashes that occurred during the performance of some number of operational measures. The National Transportation Safety Board (NTSB) in 49 CFR 830.2 defines an aircraft accident as an occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, and in which any person suffers a fatal or serious injury as a result of being in or upon the aircraft or by direct contact with the aircraft or anything attached thereto, or in which the aircraft receives substantial damage [Ref. 3.1]. For the Aircraft Crash Hit Analysis, the extent of injuries or fatalities is irrelevant to the analysis. The damage state of the aircraft is the primary concern since it is the impact of the aircraft with the facility which leads to damage or destruction of the facility and resulting release of radioactive and/or hazardous materials. Therefore, for the Aircraft Crash Hit Analysis, Aircraft Crashes are defined as Aircraft Accidents which result in destruction or major damage to the aircraft. Accidents which result in minor or no damage to the aircraft but results in a fatality or an serious injury are not considered as crashes. Operational measures could be defined in terms of number of departures or flights, number of aircraft hours flown, or the distance the aircrafts have flown (in terms of miles, nautical miles, kilometers, etc.).

The aircraft crash location distribution, $f(x,y)$, is the approximate value of the crash location probability density function (pdf) integrated over one square mile areas near airports [Ref. 3.2]. The pdf of $f(x,y)$ is derived from tabulated accident location data which is used to develop the aircraft crash location distribution tables [Ref. 3.3].

The chapter presents the aircraft crash rates, P , and aircraft location distributions, $f(x,y)$, needed for the Aircraft Crash Hit Analysis. This information is presented by category of aviation in the following sections: 3.2 Air Carriers, 3.3 Air Taxis, 3.4 General Aviation, 3.5 Military Aviation, and 3.6 References.

3.2 AIR CARRIERS

Commercial aviation is the broad categorization of aviation activities which are performed for commercial purposes. Such activities include passengers flights performed by scheduled airlines, cargo flights by freight airlines, charter flights by nonscheduled airlines, etc. Because of the evolutionary development of aviation, and the related evolutionary development of the Federal aviation regulations, several classification schemes are currently in existence for classifying commercial aviation activities.

The NTSB has been granted the authority in 49 CFR 831.2 to investigate all aviation accidents that occur in the United States except for those involving military aircraft only and for certain public-use aircraft only [Ref. 3.4]. In addition, the NTSB investigates other accidents as requested, e.g. U.S. air carrier accidents in foreign airspace, foreign air carriers in foreign airspace involving U.S. built aircraft and involving special circumstances, etc. [Ref. 3.4]. The NTSB tabulates accident data annually for U.S. Air Carriers according to the regulations or part under which the flight was conducted, i.e. 14 CFR 121 [Ref. 3.5], and 14 CFR 135 [Ref. 3.6]. Flights conducted under 14 CFR 121 involve aircraft capable of carrying 30 or more passengers or a maximum payload of 7,500 pounds or more.

The Federal Aviation Administration (FAA) tabulates operations data for U.S. Air Carriers according to the economic classification under which the operator of the aircraft is classified. Under this classification arrangement, U.S. Air Carriers includes Certificated Air Carriers, Supplemental Air Carriers, Commercial Operators of Large Aircraft, and Air Taxis (including commuters) [Ref. 3.5]. This classification arrangement can usually be correlated with the flights conducted under 14 CFR 121 [Ref. 3.5], and 14 CFR 135 [Ref. 3.6], respectively.

Air Traffic Controllers use another classification scheme in tabulating their data on airport operations. As discussed in Ref. 3.7 and from discussions with the FAA staff which compiles the data on airport traffic activity, air carriers are defined as aircraft in general commercial service capable of carrying 70 or more passengers, regardless of whether that particular flight is being flown under 14 CFR 121 or 14 CFR 91 rules [Ref. 3.8]. All other aircraft in general commercial service that carry less than 70 passengers are classified as air taxis. However, since many air taxis operate small single-engine aircraft, air controllers often count these flights as General Aviation flights unless the flight is identified by a flight plan or a commercial livery is carried by the aircraft.

3.2.1 Air Carrier Crash Rates

Tables 3.1 to 3.3 taken from the NTSB Annual Review of Aircraft Accident Data, U.S. Air Carrier Operations [Ref. 3.9 to 3.30] and the NTSB News Annual Press Release on U.S. Airline Accidents [Ref. 3.31 and 3.32] presents the following information for the years 1973 to 1996:

1. The number of fatal accidents,
2. The total number of accidents,
3. The number of passenger fatalities aboard the aircraft flying under that part,
4. The number of crew fatalities aboard the aircraft flying under that part,
5. Other fatalities associated with the accident including ground fatalities and fatalities aboard aircraft involved in the accident but not flying under that part, i.e. collisions,
6. The total number of fatalities,
7. The number of aircraft flying under that part involved in the accidents that were destroyed,
8. The number of aircraft flying under that part involved in the accidents that were substantially (major) damaged,
9. The number of aircraft flying under that part involved in the accidents that suffered minor or no damage,

10. The total number of aircraft flying under that part involved in the accidents,
11. The number of aircraft hours flown by aircraft flying under that part,
12. The number of aircraft miles by thousands flown by aircraft flying under that part,
13. The number of aircraft departures performed by aircraft flying under that part,
14. The average speed of aircraft flying under that part, calculated by dividing the number of aircraft miles flown by the number of aircraft hours flown,
15. The average number of aircraft miles flown by aircraft flying under that part per flight or departure, calculated by dividing the number of aircraft miles flown by the number of departures,
16. The average amount of time flown by aircraft flying under that part per flight or departure, calculated by dividing the number of aircraft hours flown by the number of departures,
17. The fatal accident rate per aircraft hour, aircraft mile, and departure, determined by dividing the number of fatal accidents by the number of aircraft hours, aircraft miles, and departures, respectively,
18. The total accident rate per aircraft hour, aircraft mile, and departure, determined by dividing the total number of accidents by the number of aircraft hours, aircraft miles, and departures, respectively.
19. The crash rate per aircraft hour, aircraft mile, and departure, determined by dividing the number of crashes (defined as aircraft flying under that part involved in the accident that were destroyed or substantially damaged) by the number of aircraft hours, aircraft miles, and departures, respectively.

The total, average, and standard deviation for each of the above categories of information were calculated for those years in which information was available, except for the calculated average speed, distance and time per departure (14. to 16.) and calculated fatal accident, total accident and crash rates (17. to 19.) which had only the average and standard deviation calculated. Table 3.1 presents data for the scheduled U.S. air carriers operating under 14 CFR 121. Table 3.2 presents data for the nonscheduled or charter U.S. air carriers operating under 14 CFR 121. Table 3.3 presents data for total U.S. air carriers operating under 14 CFR 121 and is the sum of Tables 3.1 and 3.2.

While Tables 3.1 to 3.3 were taken from NTSB documents [Refs. 3.9 to 2.32], only the accident data and the aircraft damage data were compiled by the NTSB. All operations data are tabulated by the F.A.A. It should be emphasized that all of the accidents, aircrafts involvement, and operations given in Tables 3.1 to 3.3 were tabulated on the basis of the part or regulation under which the flight was conducted and that the accident and crash rates are calculated on a consistent basis.

Because the data of Tables 3.1 to 3.3 were tabulated on the basis of the part or regulation under which the flight was conducted, certain caveats should be associated with these tables when used in Aircraft Crash Hit Analysis. As the final result desired by the Aircraft Crash Hit Analysis is the aircraft crash hit frequency into the facility, the analysis should be based on the total number of aircraft operations, N, near the facility, regardless of the part or regulations under which the flight is conducted. This is exactly how air traffic controllers tabulate aircraft operations near airports and is consistent with the requirements of the Aircraft Crash Hit Analysis. However, the crash rate needed by the crash frequency analysis is determined by the part under which the flight is conducted which is inconsistent with the requirements of the Aircraft Crash Hit Analysis. The result of using crash rate based solely on the part or regulation under which the flight is conducted is that other flights such as repositioning flights and training flights, flown by the same aircraft are conducted under Part 91 rules and are not counted in the NTSB tables. The resultant error introduced by this inconsistency is probably not large, but it is there nevertheless.

Another caveat associated with Tables 3.1 to 3.3 is that accidents by foreign air carriers in U.S. airspace are not included. This is because foreign air carriers conduct their flights in U.S. airspace under 14 CFR Part 129 rules [Ref. 3.33]. As the foreign air carrier operations in U.S. airspace are also not

counted in Tables 3.1 to 3.3, no error is introduced. However, for the Aircraft Crash Hit Analysis, an aircraft crash is equally damaging to a facility whether by a U.S. air carrier or foreign air carrier. This factor is compensated to some degree by the fact that accidents by U.S. air carriers in foreign airspace are counted by the NTSB and the operations by U.S. air carriers in foreign airspace are included. Again, this is because these flights are conducted under Part 121 rules even while in foreign airspace. Whether these two factors are comparable and therefore one can consider them to cancel each other out is unknown at this time.

The solution to this dilemma posed by these caveats would be to determine the crash rate regardless of the part or regulation under which that the flight is conducted. This would required determining the number of U.S. and foreign air carrier accidents and operations which occurred in U.S. airspace only, under all flight rules. It would be possible to develop this information but this would require additional research.

Accident data compiled by the NTSB and operations data compiled by the FAA prior to 1980 were gathered on the basis of the economic classification of the air carrier, i.e. certificated route air carriers, supplemental air carriers, commercial operators of large aircraft, and all cargo air service. Flights performed by these air carriers were further broken down into scheduled and nonscheduled service, domestic and international service, passenger and other operations. The change in the way the NTSB and the FAA compiled their accident and operation data was due to the deregulation of the U.S. airline industry in 1978. One of the results of the deregulation of the U.S. airline industry in 1978 was that many of the economic classifications were now obsolete and that classification of operations and accidents under the previous classification system was no longer desired. This is the main reason for the changeover in 1980 by the NTSB and FAA to gather accident and operations data on the basis of the economic classification of the air carriers to flight rules under which the flight was conducted. The result of this changeover is that accident and operations data compiled prior to 1980 may be inconsistent with accident and operations data compiled after 1980. Certain assumptions must be made regarding accident and operations data compiled before 1980 if this data is included with accident and operations data compiled after 1980. One of these assumptions is that the operations of U.S. Air Carriers operating on scheduled certificated route operations are comparable to the Scheduled U.S. Air Carriers operated under 14 CFR 121 for the 1973-1979 time period. Another assumption is that the operations of U.S. Air Carriers operating on nonscheduled certificated route operations are comparable to the Nonscheduled U.S. Air Carriers operated under 14 CFR 121 for the 1973-1979 time period.

In order to calculate an accident and crash rate that is reasonably conservative and yet incorporates recent data, it is necessary to include data over a reasonably long period of time that is complete and current. For U.S. air carriers operating under 14 CFR 121, the years 1973 to 1994 were selected. This enabled the accident and crash rates for 121 air carriers to be determined for a 22 year periods.

The accident and crash rates given by Tables 3.1 to 3.3 for 14 CFR 121 air carriers represent the accident and crash rates over the entire flight. As experience and numerous past studies on commercial aviation safety has shown, accidents do not occur with equal probability during the course of the flight. Certain flight phases, e.g. landing and takeoff, experience significantly higher number of accidents and crashes. To determine accident and crash rates by flight phase, it is necessary to determine the number of accidents and crashes that occur in each flight phase.

Table 3.4 presents the total number of aircraft flying under 14 CFR 121 regulations involved in accidents by flight phase for the 1973-1994 time period. From the number of 14 CFR 121 aircraft involved in accidents given by Table 3.4, and assuming 1.4 hour average flight duration, 570 miles average distance flown per flight, and 407 miles/hour average velocity for each flight, for the 139,934,558 departures (flights) flown by all U.S. Air Carriers (scheduled and nonscheduled) for 1973 to 1994, the accident rates by flight phases are determined in Table 3.5. The adjusted number of accidents by flight phase in Table 3.5 (the 4th column from the left) are the number of accidents minus the accidents which occurred in the taxi, ground accident, and unknown flight phases. The adjusted percentage by flight phase in

Table 3.5 (the 5th column from the left is the adjusted number of accidents for that flight phase divided by the total adjusted number of accidents.

Table 3.6 presents the number of aircraft flying under 14 CFR 121 regulations involved in crashes (accidents resulting in destruction or major damage to the airframe) by flight phase for the 1973-1994 time period. The crash rates of Table 3.7 are calculated from the number of crashes determined in Table 3.6 by the procedure used in Table 3.5. Similar operations assumptions are also used in the calculation.

Table 3.8 presents the number of aircraft flying under 14 CFR 121 regulations involved in crashes which resulted in destruction or such major damage to the airframe that the aircraft is written off (major-w.o.) by flight phase for the 1973-1994 time period. The crash rates of Table 3.9 are calculated from the number of crashes determined in Table 3.8 by the procedure used in Table 3.5. Similar operations assumptions are also used in the calculation.

3.2.2 Air Carrier Crash Location Distribution, $f(x,y)$

Tables 3.10 and 3.11, derived from Ref. 3.3, presents a grid of impact location probabilities for Air Carrier takeoff and landing crashes, respectively. The origin of the grid system is the center of the airport runway with the direction of flight from the left to the right. The number in each square in Tables 3.10 and 3.11 represents the conditional probability, given that a takeoff or landing crash occurs, respectively, that the impact will take place within that particular one square mile area.

3.3 AIR TAXIS

Air Taxis are defined as a classification of Air Carriers which transports in accordance with 14 CFR 135 [Ref. 3.6], persons, property, and mail using small aircraft (under 30 seats or a maximum payload capacity of less than 7,500 pounds). Commuter Air Carriers or Scheduled 14 CFR 135 Air Carriers are Air Taxi operators which perform at least five round trips per week between two or more points and publish flight schedules which specify the times, days of the week, and points between which such flights are performed. Nonscheduled 14 CFR 135 Air Carriers are Air Taxi operators which perform less than five round trips per week between two or more points. Commuter Air Carriers, especially the larger operators which have agreements between a major air carrier (e.g. American Airlines, Delta Airlines, United Airlines), and a code sharing commuter air carrier (e.g. American Eagle, Delta Connection, United Express) tend to operate larger aircraft and their operations tend to resemble 14 CFR 121 operations. The nonscheduled 14 CFR 135 Air Carriers or Air Taxi operators are "for-hire" operators which tend to operate smaller aircraft and whose operation tends to resemble General Aviation operation.

3.3.1 Air Taxi Crash Rates

Tables 3.12 to 3.14 taken from the NTSB Annual Review of Aircraft Accident Data, U.S. Air Carrier Operations [Ref. 3.9 to 3.30] and the NTSB News Annual Press Release on U.S. Airline Accidents [Ref. 3.31 and 3.32] presents the following information on Air Taxi accidents for the years 1975 to 1996:

1. The number of fatal accidents,
2. The total number of accidents,
3. The number of passenger fatalities aboard the aircraft flying under that part,
4. The number of crew fatalities aboard the aircraft flying under that part,
5. Other fatalities associated with the accident including ground fatalities and fatalities aboard aircraft involved in the accident but not flying under that part, i.e. collisions,
6. The total number of fatalities,
7. The number of aircraft flying under that part involved in the accidents that were destroyed,
8. The number of aircraft flying under that part involved in the accidents that were substantially (major) damaged,
9. The number of aircraft flying under that part involved in the accidents that suffered minor or no damage,
10. The total number of aircraft flying under that part involved in the accidents,
11. The number of aircraft hours flown by aircraft flying under that part,
12. The number of aircraft miles by thousands flown by aircraft flying under that part,
13. The number of aircraft departures performed by aircraft flying under that part,
14. The average speed of aircraft flying under that part, calculated by dividing the number of aircraft miles flown by the number of aircraft hours flown,
15. The average number of aircraft miles flown by aircraft flying under that part per flight or departure, calculated by dividing the number of aircraft miles flown by the number of departures,
16. The average amount of time flown by aircraft flying under that part per flight or departure, calculated by dividing the number of aircraft hours flown by the number of departures,
17. The fatal accident rate per aircraft hour, aircraft mile, and departure, determined by dividing the number of fatal accidents by the number of aircraft hours, aircraft miles, and departures, respectively,
18. The total accident rate per aircraft hour, aircraft mile, and departure, determined by dividing the total number of accidents by the number of aircraft hours, aircraft miles, and departures, respectively.

19. The crash rate per aircraft hour, aircraft mile, and departure, determined by dividing the number of crashes (defined as aircraft flying under that part involved in the accident that were destroyed or substantially damaged) by the number of aircraft hours, aircraft miles, and departures, respectively.

The total, average, and standard deviation for each of the above categories of information were calculated for those years in which information was available, except for the calculated average speed, distance and time per departure (14. to 16.) and calculated fatal accident, total accident and crash rates (17. to 19.) which had only the average and standard deviation calculated. Table 3.12 presents data for the scheduled or commuter U.S. air carriers operating under 14 CFR 135. Table 3.13 presents data for the nonscheduled or air taxi U.S. air carriers operating under 14 CFR 135. Table 3.14 presents for total U.S. air carriers operating under 14 CFR 135 and is the sum of Tables 3.12 and 3.13.

While Tables 3.12 to 3.14 were taken from NTSB documents [Refs. 3.9 to 3.32], only the accident data and the aircraft damage data were compiled by the NTSB. All operations data are tabulated by the F.A.A. It should be emphasized that all of the accidents, aircraft involvement, and operations given in Tables 3.12 to 3.14 were tabulated on the basis of the part or regulation under which the flight was conducted and that the accident and crash rates are calculated on a consistent basis.

The caveats stated for 14 CFR 121 Air Carriers in Section 3.2 generally apply to the 14 CFR 135 Air Carriers (Air Taxis), i.e., repositioning or ferry flights, and training flights are not counted as part of the operations, and operations by foreign air carriers in U.S. airspace are not counted. The errors introduced by these restrictions on the data are not known but are assumed to be small. The number of air taxi flights by foreign air carriers in U.S. airspace are expected to be particularly small because of the distances involved and the range limitation of air taxi aircraft types.

In order to calculate an accident and crash rate that is reasonably conservative and yet incorporates recent data, it is necessary to include data over a reasonably long period of time that is complete and current. For U.S. air carriers operating under 14 CFR 135, the years 1980 to 1994 were selected. This enabled the accident and crash rates for 14 CFR 135 air carriers to be determined for a 15 year period.

The accident and crash rates given by Tables 3.12 to 3.14 for 14 CFR 135 air carriers represent the accident and crash rates over the entire flight. As experience and numerous past studies on commercial aviation safety has shown, accidents do not occur with equal probability during the course of the flight. Certain flight phases, e.g. landing and takeoff, experience significantly higher number of accidents and crashes. To determine accident and crash rates by flight phase, it is necessary to determine the number of accidents and crashes that occur in each flight phase.

Table 3.15 presents the total number of accidents involving aircraft flying under scheduled 14 CFR 135 regulations by flight phase and by aircraft damage state for the 1980 to 1993 time period except for 1981 [Refs. 3.16 to 3.29]. From the number of accidents involving Scheduled 14 CFR 135 aircraft given by Table 3.15, and assuming 0.71 hour average flight duration, 132.1 miles average distance flown per flight, and 186.3 miles/hour average velocity for each flight, for the 41,089,306 departures (flights) flown by Scheduled 14 CFR 135 Air Carriers for 1980 to 1993, the accident and crash rates by flight phases are determined in Table 3.16.

Table 3.16 has a column (2nd from the left) which lists the calculated number of accidents. This was determined by taking the flight phase percentages determined in Table 3.15 and applying the percentages to the total number of Scheduled 14 CFR 135 accidents for the 1980-1993 time period determined from Table 3.12. This was done because the number for Scheduled 14 CFR 135 accidents by flight phase for 1981 was not available at the time Table 3.15 was prepared. It is hoped that this data can be obtained and that these tables can be revised to present the actual 1981 data in the calculations.

3.3.2 Air Taxi Crash Location Distribution, $f(x,y)$

For scheduled 14 CFR 135 Air Carrier operators, whose operations tend to resemble 14 CFR 121 Air Carrier operations, the Aircraft Crash Location Distribution described in Section 3.2.2 for Air Carriers should be used. For nonscheduled 14 CFR 135 Air Carrier operations, whose operations tend to resemble General Aviation operations, the Aircraft Crash Location Distribution described in Section 3.4.2 should be used. Aircraft Crash Location Distributions are used in the Aircraft Crash Hit Analysis in the Near Airport Flight Environment. As the Livermore Municipal Airport, discussed in Section 2.2, is the only airport under consideration in this analysis, air taxi flights at the Livermore Airport are almost all nonscheduled 14 CFR 135 flights and thus tend to resemble General Aviation operations. Therefore, the Aircraft Crash Location Distribution for General Aviation given in Section 3.4.2 will be used for Air Taxis.

3.4 GENERAL AVIATION

General Aviation is the broad categorization of all aviation activities which do not fall under the categories of commercial aviation and Military Aviation. It includes diverse and dissimilar aviation activities such as personal flying, business flying, corporate/executive flights, aerial (spray) application, and instructional or training flights. As the first step in compiling the data necessary to determine the risk to facilities from General Aviation aircraft crashes, the term General Aviation must be more formally and precisely defined. This definition will determine which aircraft accidents and operations (flights, departures, landings, aircraft hours, aircraft miles, etc.) will be tabulated to determine the aircraft crash rate relevant to the risk analysis.

The Federal Aviation Administration (FAA) in their General Aviation Activity Survey [Refs. 3.34 to 3.42], defines General Aviation as all aircraft in the U.S. civil air fleet except those operated under 14 CFR 121 [Ref. 3.5] and 14 CFR 127 [Ref. 3.43]. Thus, under the FAA definition, General Aviation includes all aircraft of the U.S. civil air fleet operated under 14 CFR 91 [Ref. 3.8], 103 [Ref. 3.44], 105 [Ref. 3.45], 125 [Ref. 3.46], 133 [Ref. 3.47], 135 [Ref. 3.6], and 137 [Ref. 3.48]. Note that this definition excludes all foreign owned and foreign operated aircraft. Those foreign aircraft which operate as air carriers in U.S. airspace and foreign operators of U.S. registered aircraft engaged in common carriage operate under 14 CFR 129 [Ref. 3.33].

As defined by the National Transportation Safety Board (NTSB) in their compilation of accident data [Refs. 3.49 to 3.57], General Aviation is considered as all accidents involving U.S. registered aircraft that were not conducting air carrier revenue operations under 14 CFR 121, 125, 127 or 135. So, under the NTSB definition, General Aviation includes aircraft operated under 14 CFR 91, 103, 105, 133, and 137. Note that the difference between the FAA's definition and the NTSB's definition of General Aviation is the inclusion or exclusion of aircraft operating under 14 CFR 125 and 135.

For this Aircraft Crash Hit Analysis, General Aviation will be as defined by the NTSB in their compilation of General Aviation accident data, that is all accidents involving U.S. registered aircraft that were not conducting air carrier revenue operations under 14 CFR 121, 125, 127, or 135. The reason for adopting the NTSB for General Aviation is because of the method by which the FAA uses to tabulate their estimate of the General Aviation operations. In conversations with the FAA staff which prepares the General Aviation Activity Survey [Refs. 3.34 to 3.42] and reviewing the operational data in those documents, it was discovered that contrary to their definition given in their introductory section, no 14 CFR 125 operators, and those operators that were known to be scheduled 14 CFR 135 operators were not included in the survey. Nevertheless, despite a conscious effort to exclude these operators, some scheduled 14 CFR 135 operators (commuter air carriers) were included in the survey along with nonscheduled 14 CFR 135 operators (air taxis).

If the FAA definition was used for General Aviation, it would be necessary to determine the accidents of those particular scheduled 14 CFR 135 operators along with all of the nonscheduled 14 CFR 135 operators which were included in the General Aviation Activity Survey [Refs. 3.34 to 3.42]. This would require the identification of those scheduled 14 CFR 135 operators and the nonscheduled 14 CFR 135 operators which were included in the General Aviation Activity Survey, and determining the accidents that occurred to the particular aircraft operated by these operators while performing 14 CFR 135 flights. These accidents would then have to be added to the accidents compiled by the NTSB for General Aviation. Then an accident rate could be determined using the combined accidents of the NTSB for General Aviation and the particular scheduled 14 CFR 135 operators and all of the nonscheduled 14 CFR 135 operators included in the General Aviation Activity Survey, divided by the total number of operations (landings, aircraft hours, aircraft miles, etc.) as estimated by the General Aviation Activity Survey. Two crucial pieces of information are missing to perform this calculation. First, the identities of the particular 14 CFR 135 operators included in the General Aviation Activity Survey are not available. Second, the number of accidents suffered by those particular 14 CFR 135 operators included in the General Aviation Activity Survey are not available.

By using the NTSB definition for General Aviation, the above situation is avoided. Instead, the operations of the particular scheduled 14 CFR 135 operators and all of the nonscheduled 14 CFR 135 included in the General Aviation Activity Survey is subtracted from the total number of General Aviation operations estimated. It is then possible to determine the General Aviation accident rate by dividing the total General Aviation accidents tabulated by the NTSB by General Aviation operations (total-scheduled 135 and nonscheduled 135 operators) calculated from the General Aviation Activity Survey. This method was judged to be easier to accomplish.

The major category of General Aviation has been divided further into seven subcategories. This was done because the General Aviation covers a wide array of dissimilar aircraft types, accident and operational data was available for the subcategories, and by determining the General Aviation accident rates by subcategory would enable certain subcategories of General Aviation aircraft to be screened from further analysis due to facility structural considerations, i.e. the facility is built such that it could withstand the direct impact with the smaller General Aviation aircraft subcategories. For General Aviation, seven subcategories are defined: 1) single-engine piston, fixed wing, 2) multiple-engine piston, fixed wing, 3) turboprop, fixed wing, 4) turbojet, fixed wing, 5) piston, rotary wing, 6) turbine, rotary wing, and 7) other. The seventh subcategory, other, developed only for the purpose of completing the accident and operations table such that it could be screened from further consideration. Aircraft included in the "other" subcategory include hanggliders, gliders, balloons, and any other aircraft which did not fit the previous six subcategories.

3.4.1 General Aviation Crash Rates

Tables 3.17 to 3.31 taken from the NTSB Annual Review of Aircraft Accident Data, U.S. General Aviation [Ref. 3.49 to 3.57] presents the following information by years for the years 1986 to 1994:

1. The number of fatal accidents by phase of operation for each year,
2. The number of injury accidents by phase of operation for each year,
3. The number of property damage accidents by phase of operation for each year, and
4. The total number of accidents by phase of operation for each year.

The tables listed below gives the General Aviation subcategories for which the General Aviation accidents by phase of flight operation table were created.

Table 3.17	Single-engine reciprocating (piston), fixed wing
Table 3.18	Multiple-engine reciprocating (piston), fixed wing
Table 3.19	Turboprop, fixed wing
Table 3.20	Turbojet, fixed wing
Table 3.21	Total, fixed wing (summation of Tables 3.17 to 3.20)
Table 3.22	Reciprocating (piston), rotary wing (helicopters)
Table 3.23	Turbine, rotary wing (helicopters)
Table 3.24	Total, rotary wing (helicopters) (summation of Tables 3.22 and 3.23)
Table 3.25	Total powered aircraft (summation of Tables 3.17 to 3.20, 3.22 and 3.23)
Table 3.26	Gliders
Table 3.27	Balloons
Table 3.28	Other aircraft
Table 3.29	Total aircraft (summation of Tables 3.17 to 3.20, 3.22 to 3.23, 3.26 to 3.28)

The years 1986 to 1994 were chosen as the period of interest because it is the most current and complete. General Aviation accident data compiled by the NTSB prior to 1985 were tabulated on the bases of aircraft destruction, aircraft substantial damage, or minor or no aircraft damage. It would be possible to tabulate NTSB General Aviation accident data prior to 1985 and to combine it with the current tables.

However, the utility of that exercise would be limited due to limitations on the operations data compiled by the FAA prior to 1985.

Because of the large number of phases of operation used by the NTSB in their General Aviation accident summary documents [Ref. 3.49 to 3.57], it was judged necessary to combine the phases of operation into a smaller set of flight phases that could be more easily manipulated. The phases of operation called standing, stand-preflight, standing-standing engine(s), standing-engine(s) operating, standing-engine(s) not operating, and standing-idling rotors were combined into the standing flight phase. The phases of operation called taxi, taxi-to takeoff, take-from landing, and taxi-aerial were combined into the taxi flight phase. The phases of operation called takeoff, takeoff-aborted, and takeoff-ground run were combined into the takeoff flight phase. The phase of operation called takeoff-initial climb was retained as the initial climb flight phase. The climb and climb-to-cruise phases of operation were combined into the climb (to cruise) flight phase. The phases of operation called cruise, cruise-normal, and cruise-holding (IFR) were combined into the cruise (enroute) flight phase. The phases of operation called descent, descent-normal, descent-emergency, and descent-uncontrolled were combined into the descent (from cruise) flight phase. The flight phases called approach, approach-VFR pattern-downwind, approach-VFR pattern-base turn, approach-VFR pattern-base to final, approach-VFR pattern-final approach, approach-go around (VFR), approach-IAF to FAR/outer marker (IFR), approach-FAR/outer marker to threshold, approach-circling (IFR), and approach-missed approach (IFR) were combined in the landing approach flight phase. The phases of operation called landing-aborted, landing, landing-flare/touchdown, and landing/roll were combined in the landing flight phase. The phases of operation called maneuvering, maneuvering-aerial application, maneuvering-turn to reverse direction, maneuvering-turn to landing area (emer.), and hover were combined into the maneuvering flight phase. The other, unknown, and not reported phases of operation were combined into the other/??/NR flight phase. The maneuvering and other/??/NR flight phases were created for the sole purpose of tabulating the accidents to assure that the numbers in Tables 3.17 to 3.29 were consistent with Refs. 3.49 to 3.57. These flight phases were not included in determining the accident percentages by flight phase.

One additional feature of Table 3.29 is the inclusion of aircraft damage for each year. The NTSB did not tabulate accident data according to aircraft damage by flight phase after 1986 but did include totals on aircraft damage. These data are included at the bottom of Table 3.29. A noteworthy feature is that of the 20,423 General Aviation accidents tabulated by the NTSB for 1986 to 1994, only 264 accidents or 1.29% of the total resulted in minor or no damage to the aircraft. From this, it was determined that for General Aviation, different definitions for aircraft accidents and aircraft crashes were not necessary since virtually all General Aviation accidents resulted in destruction or substantial damage to the aircraft. Therefore, for General Aviation only, the terms aircraft accidents and aircraft crashes are used synonymously.

Table 3.30 summarizes the General Aviation accidents by phase of flight operation and by aircraft subcategories as presented by Tables 3.17 to 3.29. Table 3.31 presents the same information as Table 3.30 (General Aviation accidents by phase of flight operation and by aircraft subcategories) except that accidents during the standing, and taxi flight phases and accidents classified as either other, unknown, or not recorded flight phases have been excluded.

General Aviation operations are tabulated by the FAA Office of Aviation Policy, Plans, and Management Analysis in their publication General Aviation Activity and Avionics Survey published annually by calendar year. According to the introduction of this survey, all facets of civil (nonmilitary) aviation are included in this survey except for flights conducted by air carriers under 14 CFR 121 [Ref. 3.5] and 14 CFR 127 [Ref. 3.43]. However, in comparing the operations data for commuter carrier with the data published by the NTSB for scheduled 135 air carriers and in conversations with the FAA staff which prepares the General Aviation Activity and Avionics Survey, it was discovered that no 14 CFR 125 operators and those operators that were known to be scheduled 14 CFR 135 operators were not included in the survey. Despite a conscious effort to exclude these operators, some scheduled 14

CFR 135 operators (commuter air carriers) were included in the survey along with all nonscheduled 14 CFR 135 operators (air taxis).

To determine the General Aviation operations consistent with the NTSB definition for General Aviation, it is necessary to subtract the scheduled 14 CFR 135 operations (commuter carriers) and the nonscheduled 14 CFR 135 operations (air taxis) from the total operations given by the General Aviation Activity and Avionics Survey. This can be accomplished very readily for hours flown and nautical miles flown since the General Aviation Activity and Avionics Survey lists these numbers separately under total, commuter and air taxi. Determining the number of flights (or landings) for strictly General Aviation is another matter. The General Aviation Activity and Avionics Survey gives numbers only on the total number of landings. No breakdown by commuter or air taxi or any other primary use is provided. An estimate of the number of commuter and air taxi flights must be made in order to continue the development of the General Aviation accident rate by flight phase.

The number of commuter and air taxi flights can be estimated by two methods. One is to base the estimated number of flights on the number of primary use hours flown divided by the average trip time for that particular subcategory of aircraft. The other method is to base the estimated number of flights on the number of primary use nautical miles flown divided by the average trip length for that particular subcategory of aircraft. Both methods were used and two estimates in the number of commuter and air taxi flights were calculated. The reason for the difference in two estimates is due to rounding in the various factors used to estimate the number of flights.

Tables 3.32 to 3.42 taken from the FAA General Aviation Activity and Avionics Survey [Ref. 3.34 to 3.42] presents the following information by years for the years 1986 to 1994:

1. Population (from Ref. Table 2.1),
2. Number active (from Ref. Table 2.1),
3. Total hours flown (from Ref. Table 2.1),
- 3a. Commuter hours flown (scheduled 14 CFR 135) hours flown (from Ref. Table 3.2),
- 3b. Air taxi hours flown (nonscheduled 14 CFR 135) hours flown (from Ref. Table 3.2),
- 3c. Total day hours flown (from Ref. Table 4.1),
- 3d. Total night hours flown (from Ref. Table 4.1),
- 3e. Visual Meteorological Conditions (VMC) day hours flown (from Ref. Table 4.2),
- 3f. Visual Meteorological Conditions (VMC) night hours flown (from Ref. Table 4.2),
- 3g. Total Visual Meteorological Conditions (VMC) hours flown (from Ref. Table 4.2),
- 3h. Instrument Meteorological Conditions (IMC) day hours flown (from Ref. Table 4.3),
- 3i. Instrument Meteorological Conditions (IMC) night hours flown (from Ref. Table 4.3),
- 3j. Total Instrument Meteorological Conditions (IMC) hours flown (from Ref. Table 4.3),
4. General Aviation hours flown = 3. total hours-3a. commuter hours-3b. air taxi hours
5. Total landings (from Ref. Table 2.5)
- 5a. Local landings (from Ref. Table 2.6),
- 5b. Cross country landings (from Ref. Table 2.7),
6. Estimated flights (based on primary use hours/average trip time),
- 6a. Commuter flights (determined from 3a. commuter hours flown/13. average trip time),
- 6b. Air taxi flights (determined from 3b. air taxi hours flown/13. average trip time),
7. Estimated flights (based on primary use nautical miles/average trip length)
- 7a. Commuter flights (determined from 9a. commuter nautical miles flown/12. average trip length),
- 7b. Air taxi flights (determined from 9b. air taxi nautical miles flown/12. average trip length),
8. General Aviation flights,

- 8a. Based on hours/average trip time (determined from 5. total landings-6a. commuter flights-6b. air taxi flights),
- 8b. Based on nautical miles/average trip length (determined from 5. total landings -7a commuter flights-7b. air taxi flights),
- 9. Total nautical miles flown (from Ref. Table 3.3),
- 9a. Commuter nautical miles flown (from Ref. Table 3.3),
- 9b. Air taxi nautical miles flown (from Ref. Table 3.3),
- 10. General Aviation nautical miles flown = 9. total nmiles-9a. commuter nmiles-9b. air taxi nmiles,
- 11. Average speed (nmiles/hour) (determined from 9. total nmiles flown/5. total landings),
- 12. Average trip length (nmiles/hour) (determined from 9. total nmiles flown/3. total hours flown),
- 13. Average trip time (hours/landing) (determined from 3. total hours flown/5. total landings),
- 14. Average commuter speed (nmiles/hour) (determined from 9a. commuter nautical miles flown/3a. commuter hours flown),
- 15. Average air taxi speed (nmiles/hour) (determined from 9b. air taxi nautical miles flown/3b. air taxi hours flown),
- 16. General Aviation average speed (nmiles/hour) (determined from 10. General Aviation nautical miles flown/4. General Aviation hours flown).

The tables listed below gives the General Aviation subcategories for which the General Aviation operations table were created:

Table 3.32	Single-engine reciprocating (piston), fixed wing,
Table 3.33	Multiple-engine reciprocating (piston), fixed wing,
Table 3.34	Turboprop, fixed wing,
Table 3.35	Turbojet, fixed wing,
Table 3.36	Total fixed wing (summation of Tables 3.32 to 3.35),
Table 3.37	Reciprocating engine (piston), rotary wing,
Table 3.38	Turbine engine, rotary wing,
Table 3.39	Total rotary wing (summation of Tables 3.37 and 3.38),
Table 3.40	Total powered aircraft (summation of Tables 3.32 to 3.35, and 3.37 to 3.38),
Table 3.41	Other aircraft (includes gliders and balloons),
Table 3.42	Total aircraft (summation of Tables 3.32 to 3.35, 3.37 to 3.38, and 3.41),

For consistency with the General Aviation accident data, General Aviation operations data were added and summarized for the 1986 to 1994 time period. General Aviation operations data tabulated by the FAA prior to 1986 are not as complete as operations data tabulated from 1986 onwards. Important information such as the estimated number of total landings were not tabulated prior to 1985. Prior to 1983, the estimated number of General Aviation nautical miles flown were not tabulated. General Aviation operations data were found only as far back as 1977 and could be added to Tables 3.32 to 3.42 if it becomes necessary to extend these tables backwards in time further. However, the utility of this exercise would be limited because of the incompleteness of the data.

Table 3.43 summarizes the General Aviation operations by aircraft subcategories for 1986-1994 and is based on the information developed in Tables 3.32 through 3.42.

Table 3.44 presents the General Aviation accident (or crash) rates by aircraft subcategories. All accident data are taken from Table 3.31. All operations data are taken from Table 3.43.

Tables 3.45 to 3.53 presents the following information by flight phases for each subcategory of General Aviation:

1. Number of accidents,
2. Percent of total subcategory accidents,
3. Average percent of subcategory flight time,
4. Average flight time per flight phase,
5. Assumed subcategory average flight phase speed in miles/hour,
6. Assumed subcategory average flight phase speed in nmiles (knots)/hour,
7. Calculated subcategory average flight phase distance flown in miles,
8. Calculated subcategory average flight phase distance in nmiles (knots),
9. Calculated crash rate by flight phase, expressed in
 - 9a. Crashes/landing,
 - 9b. Crashes/aircraft hour flown,
 - 9c. Crashes/mile flown,
 - 9d. Crashes/nmile (knot) flown,

The tables listed below gives the General Aviation subcategories for which the General Aviation crash rate by flight phase table were created:

Table 3.45	Single-engine reciprocating (piston), fixed wing,
Table 3.46	Multiple-engine reciprocating (piston), fixed wing,
Table 3.47	Turboprop, fixed wing,
Table 3.48	Turbojet, fixed wing,
Table 3.49	Total fixed wing (summation of Tables 3.45 to 3.48)
Table 3.50	Reciprocating (piston) engine, rotary wing (helicopters)
Table 3.51	Turbine engine, rotary wing (helicopters)
Table 3.52	Total rotary wing (summation of Tables 3.50 and 3.51)
Table 3.53	Total powered aircraft (summation of Tables 3.45 to 3.48, 3.50 and 3.51)

The number of accidents for each flight phase by General Aviation subcategory were taken from Table 3.31. The hours average flight duration, nmiles average flight distance, and the number of landings were taken from Table 3.43. The number of estimated flights were taken to be equal to the estimated number of General Aviation landings for that subcategory and is the average of the two methods used to estimate this number. The first method is to base the estimated number of flights on the number of primary use hours flown divided by the average trip time for that particular subcategory of General Aviation. The other method is to base the estimated number of flights on the number of primary use nautical miles flown divided by the average trip length for that particular subcategory of General Aviation. Flight times for each flight phase were assigned based on conversations with licensed pilots and instructors and engineering judgment and experience. A more formalized process for assigning flight times to the flight phases would be to solicit opinions from qualified pilots and instructors and to adjust the flight times for the flight phases appropriately. A process similar to the NRC expert opinion solicitation process could be followed if a more formalized, accepted procedure was desired. This was not done because of the time and resource constraints. Average flight phase velocities for the subcategory were then adjusted until the average flight distance was approximately equal to the average flight distance of Table 3.43.

3.4.2 General Aviation Crash Location Distribution. $f(x,y)$

Tables 3.54 and 3.55, derived from Ref. 3.3, presents a grid of impact location probabilities for General Aviation takeoff and landing crashes, respectively. The origin of the grid system is the center of the airport runway with the direction of flight from the left to the right. The number in each square in Tables 3.54 and 3.55 represents the conditional probability, given that a takeoff or landing crash occurs, respectively, that the impact will take place within that particular one square mile area. Separate Aircraft Crash Location Distribution grids for General Aviation subcategories were not developed due to the scarcity of records for certain General Aviation subcategories.

3.5 MILITARY AVIATION

Military Aviation is defined as the broad categorization of aviation activities performed by military personnel in fulfillment of their official duties. Such activities include passenger and cargo transport, in-flight refueling, flight training, etc.

Military Aviation has three subcategories of aircraft defined, large aircraft, small aircraft, helicopters. Examples of large military aircraft include bombers and transport (cargo) aircraft such as the B-1 Lancer, B-2 Spirit, B-52 Stratofortress, C-5 Galaxy, C-9 Nightingale, KC-10 Extender, C-21 Learjet, C-130 Hercules, KC-135 Stratotanker, and the C-141 Starlifter. Examples of small military include attack aircraft, fighters, and trainers such as the A-7 Corsair II, A-10 Thunderbolt II, A-37 Dragonfly, F-4 Phantom II, F-5 Freedom Fighter/Tiger II, F-15 Eagle, F-16 Falcon, F-106 Delta Dart, F-111, F-117 Night Hawk, T-33 Shooting Star, T-37 Tweet, T-38 Talon, T-39 Sabreliner, and T-41 Mescalero. Examples of helicopters include the UH-1 Iroquois, HH-3 Jolly Green Giant, HH-53 Pave Low, and UH-60 Black Hawk.

3.5.1 Military Aviation Crash Rates

The United States Air Force (USAF) classification of mishaps is based on the economic costs of damage to the aircraft and personnel costs and are defined as follows:

Flight Mishap - A mishap involving an Air Force aircraft when intent for flight exists.

Class A - A mishap in which the resulting total cost of property damage, injury and illness is \$1,000,000 or greater; or an Air Force aircraft is destroyed; or a fatality occurs.

Class B - A mishap in which the resulting total cost of property damage, injury and illness is \$200,000 or more, but less than \$1,000,000.

Class C - A mishap in which the resulting total cost of property damage is \$10,000 or more, but less than \$200,000 or injury or occupational illness resulted in a lost workday case involving days away from work.

Destroyed - Destroyed means uneconomical to repair, defined by the number of man-hours estimated as needed to repair the aircraft. Repair time varies depending on the type of aircraft.

Mishap Rates - Rates are computed on basis of the number of mishaps per 100,000 flying hours.

Flight Related - When there is a mishap with little or no damage to the aircraft, the incident does not affect the mishap rate.

Table 3.56 presents summary information for U.S. Air Force mishaps taken from the Minuteman III Weapon System Safety Assessment derived from 1240 impact mishaps. The mishaps were partitioned by aircraft "size" (large, small and helicopter) and by flight phase (takeoff, landing and inflight). Takeoff and landing were further partitioned into "on runway" and "off runway" mishaps. In-flight mishaps were partitioned into "normal" and "special", i.e., low altitude and maneuvering operation mishaps. Takeoff includes takeoff roll, abort/discontinue, and initial climb portions of a flight; landing includes the pattern, final approach, flare and rollout portions; normal in-flight includes climb to cruise, cruise between an originating airfield and an operations area, if applicable, and cruise descent portions; and special in-flight includes low level and maneuvering operations in restricted airspace. The number of impacting mishaps for each subcategory of aircraft and flight phase, appropriate flight information and the resulting estimates of crash frequencies are summarized in Table 3.56. Crash

frequencies for takeoffs and landings are per takeoff/landing. Crash frequencies for "normal" inflight operation, are "per mile."

As the Livermore Municipal Airport, the principal airport in this Aircraft Crash Hit Analysis, is a General Aviation airport with no military aircraft support facilities, few large Military Aviation aircraft would fly into the Livermore Airport. The few military aircraft which would fly into the Livermore Airport would tend to be small aircraft.

From Table 3.56, the crash rate for small military aircraft during landing was found to be 3.28 E-6/landing for off runway mishaps only. The crash rate for small aircraft during takeoff was found to be 1.83 E-6/takeoff for off runway mishaps only and assuming each landing results from a takeoff.

The crash rate for small military aircraft operations at the Livermore Municipal Airport was taken from Table 3.53, General Aviation Total Powered Aircraft Crash Rates by Flight Phase. The reason for using General Aviation crash rates for small Military Aviation aircraft operations is that the length of the longest runway (7Left/25Right, 5255 ft.) and the lack of suitable ground facilities at the Livermore Municipal Airport precludes operation of small high performance military aircraft except under special circumstances. Small military aircraft which would use the Livermore Municipal Airport would tend to be similar to General Aviation aircraft. A crash rate of 1.92 E-5/landing is used for small military aircraft during landings. A crash rate during takeoffs of 1.10 E-5/takeoff is used for small military aircraft during takeoffs.

The crash rates for Military Aviation approaching or departing a San Francisco Bay area airport (other than the Livermore Municipal Airport) under Bay TRACON control were calculated from data taken from Table 3.56 for Class A and B mishaps, off runway events only, landing and runway approach flight phases combined for TRACON approach operations, takeoff and initial climb flight phases combined for TRACON departure operations, and 20 statute miles assumed for the distance travel on approaches and departures. Each sortie was assumed to result in one departure (takeoff) and one approach (landing). Small C-type military aircraft (i.e. C-12 King Air) and all T-type military aircraft except for the T-37 Tweet, and T-38 Talon were classified as small low performance military aircraft. All A-type and F-type military aircraft and the T-37 Tweet, and the T-38 Talon were classified as small high performance military aircraft. All B-type military aircraft and all C-type military aircraft except for small C-types were classified as large military aircraft.

	<u>Subcategory</u>	<u>No. of off RW Crashes</u>	<u>Sorties (Flights)</u>	<u>Crash Rate (/mile)</u>
Small Low Performance Military Aircraft				
Landing	small Cs	1	1,628,000	
	other Ts	8	2,896,000	
	Subtotal	9	4,524,000	9.95 E-8
Takeoff	small Cs	0	1,628,000	
	other Ts	3	2,896,000	
	Subtotal	3	4,524,000	3.32 E-8
Small High Performance Military Aircraft				
Landing	All As, Fs	120	14,761,000	
	T-37s	6	14,147,000	
	T-38s	20	15,118,000	
	Subtotal	146	44,026,000	1.66 E-7
Takeoff	All As, Fs	70	14,761,000	
	T-37s	4	14,147,000	
	T-38s	9	15,118,000	
	Subtotal	83	44,026,000	9.43 E-8

Large Military Aircraft				
Landing	All Bs	6	1,072,000	
	All Cs	22	16,413,000	
	-small Cs	-1	-1,628,000	
	Subtotal	27	15,857,000	8.51 E-8
Takeoff	All Bs	2	1,072,000	
	All Cs	8	16,413,000	
	-small Cs	0	-1,628,000	
	Subtotal	10	15,857,000	3.15 E-8
Military Helicopters				
Landing		10	3,507,000	1.43 E-7
Takeoff		3	3,507,000	4.28 E-8

The crash rates for Military Aviation during high altitude flights under an ARTCC control were calculated from Ref. 5.5 and Table 3.56. The crash rate for small military aircraft was 4.36 E-6/aircraft handled based on 105 accidents and 24,102,000 sorties for the 1976-93 time period. The crash rate for large military aircraft was 1.23 E-6/aircraft handled based on 9 accidents and 7,289,000 sorties for the 1976-93 time period. The crash rates for military aircraft in ARTCC airspace are expected to be conservatively high because all military aircraft accidents during the 1976-93 time period were included, not just those accidents which occurred while in ARTCC airspace.

3.5.2 Military Aviation Crash Location Distribution, $f(x,y)$

Tables 3.57 and 3.58, derived from Ref. 3.3, presents a grid of impact location probabilities for small military aircraft takeoff and landing crashes, respectively. The origin of the grid system is the center of the airport runway with the direction of flight from the left to the right. The number in each square in Tables 3.57 and 3.58 represents the conditional probability, given that a takeoff or landing crash occurs, respectively, that the impact will take place within that particular one square mile area.

The crash location probability for General Aviation is used for Military Aviation because of the similarity of Military Aviation aircraft operations and General Aviation aircraft operations at the Livermore Municipal Airport. Only limited number of high performance small Military Aviation aircraft would land and takeoff at the Livermore Municipal Airport due to the short length of the main runway (5255 feet) and the lack of ground facilities. In addition, all aircraft operations would tend to resemble General Aviation because General Aviation traffic predominates at the Livermore Municipal Airport and all forms of air traffic would have to conform to the prevailing traffic.

Table 3.1
Scheduled U.S. Air Carriers Operating Under 14 CFR 121
[References 3.9 to 3.32]

Year	Fatal Acc.	Fatalities				Total Acc.	121 Aircraft Damage				121 Aircraft Hours Flown	121 Aircraft Miles (000)	121 Aircraft Departures	Average Speed (miles/hr.)	Average AC Miles/ Departure	Average AC Hours/ Departure	Fatal Accident Rate			Total Accident Rate			Crash (Dest. + Major Dam.) Rate		
		121 Pass.	121 Crew	Other	Total		Dest.	Major	Minor/ None/ Unkn.	Total							(/AC hour)	(/AC mile)	(/Departure)	(/AC hour)	(/AC mile)	(/Departure)	(/AC hour)	(/AC mile)	(/Departure)
1972																									
1973	8	198	23	1	222	35	7	10	18	35	5,898,575	2,448,114	5,133,816	415.03	476.86	1.15	1.36E-06	3.27E-09	1.56E-06	5.93E-06	1.43E-08	6.82E-06	2.88E-06	6.94E-09	3.31E-06
1974	6	418	39	0	457	39	6	4	30	40	5,474,495	2,258,136	4,725,783	412.48	477.83	1.16	1.10E-06	2.66E-09	1.27E-06	7.12E-06	1.73E-08	8.25E-06	1.83E-06	4.43E-09	2.12E-06
1975	2	116	9	0	125	31	6	10	15	31	5,422,665	2,240,505	4,704,052	413.17	476.29	1.15	3.69E-07	8.93E-10	4.25E-07	5.72E-06	1.38E-08	6.59E-06	2.95E-06	7.14E-09	3.40E-06
1976	2	36	2	0	38	22	4	6	12	22	5,587,601	2,319,967	4,835,138	415.20	479.81	1.16	3.58E-07	8.62E-10	4.14E-07	3.94E-06	9.48E-09	4.55E-06	1.79E-06	4.31E-09	2.07E-06
1977	3	65	5	9	79	19	2	8	12	22	5,800,843	2,418,652	4,934,094	416.95	490.19	1.18	5.17E-07	1.24E-09	6.08E-07	3.28E-06	7.86E-09	3.85E-06	1.72E-06	4.13E-09	2.03E-06
1978	5	141	11	14	166	20	6	2	12	20	6,031,743	2,520,165	5,015,939	417.82	502.43	1.20	8.29E-07	1.98E-09	9.97E-07	3.32E-06	7.94E-09	3.99E-06	1.33E-06	3.17E-09	1.59E-06
1979	4	323	25	3	351	23	4	11	9	24	6,713,094	2,791,120	5,399,652	415.77	516.91	1.24	5.96E-07	1.43E-09	7.41E-07	3.43E-06	8.24E-09	4.26E-06	2.23E-06	5.37E-09	2.78E-06
1980	0	0	0	0	0	15	4	4	7	15	7,069,000	2,929,000	5,567,000	414.34	526.14	1.27	0.00E+00	0.00E+00	0.00E+00	2.12E-06	5.12E-09	2.69E-06	1.13E-06	2.73E-09	1.44E-06
1981	4	1	1	2	4	25	1	11	13	25	6,834,000	2,811,000	5,420,000	411.33	518.63	1.26	5.85E-07	1.42E-09	7.38E-07	3.66E-06	8.89E-09	4.61E-06	1.76E-06	4.27E-09	2.21E-06
1982	4	211	11	12	234	16	3	7	6	16	6,697,770	2,806,885	5,162,346	419.08	543.72	1.30	5.97E-07	1.43E-09	7.75E-07	2.39E-06	5.70E-09	3.10E-06	1.49E-06	3.56E-09	1.94E-06
1983	4	8	6	1	15	22	4	10	8	22	6,914,969	2,920,909	5,235,262	422.40	557.93	1.32	5.78E-07	1.37E-09	7.64E-07	3.18E-06	7.53E-09	4.20E-06	2.02E-06	4.79E-09	2.67E-06
1984	1	1	3	0	4	13	2	4	7	13	7,736,037	3,258,910	5,666,076	421.26	575.16	1.37	1.29E-07	3.07E-10	1.76E-07	1.68E-06	3.99E-09	2.29E-06	7.76E-07	1.84E-09	1.06E-06
1985	4	174	22	1	197	17	6	6	5	17	8,265,332	3,452,753	6,068,893	417.74	568.93	1.36	4.84E-07	1.16E-09	6.59E-07	2.06E-06	4.92E-09	2.80E-06	1.45E-06	3.48E-09	1.98E-06
1986	2	4	0	1	5	21	2	7	12	21	9,495,158	3,829,129	6,928,103	403.27	552.70	1.37	2.11E-07	5.22E-10	2.89E-07	2.21E-06	5.48E-09	3.03E-06	9.48E-07	2.35E-09	1.30E-06
1987	4	212	17	2	231	32	5	15	15	35	10,115,407	4,125,874	7,293,025	407.88	565.73	1.39	3.95E-07	9.69E-10	5.48E-07	3.16E-06	7.76E-09	4.39E-06	1.98E-06	4.85E-09	2.74E-06
1988	3	256	18	11	285	28	7	8	13	28	10,521,052	4,260,785	7,347,575	404.98	579.89	1.43	2.85E-07	7.04E-10	4.08E-07	2.66E-06	6.57E-09	3.81E-06	1.43E-06	3.52E-09	2.04E-06
1989	8	122	8	1	131	24	7	8	9	24	10,597,922	4,337,234	7,267,341	409.25	596.81	1.46	7.55E-07	1.84E-09	1.10E-06	2.26E-06	5.53E-09	3.30E-06	1.42E-06	3.46E-09	2.06E-06
1990	6	8	4	27	39	22	4	6	13	23	11,524,726	4,689,287	7,795,761	406.89	601.52	1.48	5.21E-07	1.28E-09	7.70E-07	1.91E-06	4.69E-09	2.82E-06	8.68E-07	2.13E-09	1.28E-06
1991	4	40	9	13	62	25	5	9	12	26	11,139,166	4,558,537	7,503,873	409.24	607.49	1.48	3.59E-07	8.77E-10	5.33E-07	2.24E-06	5.48E-09	3.33E-06	1.26E-06	3.07E-09	1.87E-06
1992	4	26	5	2	33	16	4	0	13	17	11,732,026	4,782,825	7,515,373	407.67	636.41	1.56	3.41E-07	8.36E-10	5.32E-07	1.36E-06	3.35E-09	2.13E-06	3.41E-07	8.36E-10	5.32E-07
1993	1	0	0	1	1	22	1	8	13	22	11,981,347	4,936,067	7,721,975	411.98	639.22	1.55	8.35E-08	2.03E-10	1.30E-07	1.84E-06	4.46E-09	2.85E-06	7.51E-07	1.82E-09	1.17E-06
1994	4	228	9	2	239	19	3	5	10	18	12,292,356	5,112,633	7,824,802	415.92	653.39	1.57	3.25E-07	7.82E-10	5.11E-07	1.55E-06	3.72E-09	2.43E-06	6.51E-07	1.56E-09	1.02E-06
1995P	2	152	8	6	166	34	N.A.	N.A.	N.A.	N.A.	12,770,405	5,326,266	8,102,491	417.08	657.36	1.58	1.57E-07	3.75E-10	2.47E-07	2.66E-06	6.38E-09	4.20E-06	N.A.	N.A.	N.A.
1996P	3	319	23	0	342	32	N.A.	N.A.	N.A.	N.A.	12,900,000	5,419,380	8,185,000	420.11	662.11	1.58	2.33E-07	5.54E-10	3.67E-07	2.48E-06	5.90E-09	3.91E-06	N.A.	N.A.	N.A.
Total	88	3059	258	109	3426	572	93	159	264	516	209,515,689	86,554,133	151,353,370	413.12	571.87	1.38	4.20E-07	1.02E-09	5.81E-07	2.73E-06	6.61E-09	3.78E-06	N.A.	N.A.	N.A.
Avg.	3.67	127.46	10.75	4.54	142.75	23.83	4.23	7.23	12.00	23.45	8,729,820	3,606,422	6,306,390	413.62	560.98	1.36	4.65E-07	1.12E-09	6.07E-07	3.01E-06	7.27E-09	3.93E-06	1.50E-06	3.63E-09	1.94E-06
Std.	1.99	122.77	9.90	6.63	131.35	6.95	1.90	3.37	5.15	6.91	2,663,299	1,089,614	1,264,512	5.21	61.54	0.15	3.14E-07	7.57E-10	3.65E-07	1.45E-06	3.49E-09	1.49E-06	6.71E-07	1.61E-09	7.39E-07

P = Preliminary Data

N.A. = Information not available when table prepared.

1973-1979 Scheduled U.S. Air Carriers operated under 14 CFR 121 assumed equal to U.S. Air Carriers operating on Scheduled Certificated Route Operations.

For 1973-1994																									
Total	83	2588	227	103	2918	506	93	159	264	516	183,845,284	75,808,487	135,065,879	412.35	561.27	1.36	4.51E-07	1.09E-09	6.15E-07	2.75E-06	6.67E-09	3.75E-06	1.37E-06	3.32E-09	1.87E-06
Avg.	3.77	117.64	10.32	4.68	132.64	23.00	4.23	7.23	12.00	23.45	8,356,604	3,445,840	6,139,358	413.17	552.00	1.34	4.90E-07	1.18E-09	6.34E-07	3.05E-06	7.37E-09	3.91E-06	1.50E-06	3.63E-09	1.94E-06
Std.	2.05	120.96	9.99	6.86	129.90	6.64	1.90	3.37	5.15	6.91	2,453,002	987,902	1,183,374	5.19	55.99	0.14	3.17E-07	7.63E-10	3.69E-07	1.51E-06	3.64E-09	1.56E-06	6.71E-07	1.61E-09	7.39E-07

Table 3.2
Nonscheduled U.S. Air Carriers Operating Under 14 CFR 121
[References 3.9 to 3.32]

Year	Fatal Acc.	Fatalities				Total Acc.	121 Aircraft Damage				121 Aircraft Hours Flown	121 Aircraft Miles (000)	121 Aircraft Departures	Average Speed (miles/hr.)	Average AC Miles/Departure	Average AC Hours/Departure	Fatal Accident Rate			Total Accident Rate			Crash (Dest. + Major Dam.) Rate		
		Pass.	Crew	Other	Total		Dest.	Minor/None/Unkn.	Total	(/AC hour)							(/AC mile)	/Departure	(/AC hour)	(/AC mile)	/Departure	(/AC hour)	(/AC mile)	/Departure	
1972																									
1973	1	3	3	0	6	3	1	1	1	3	231,890	107,618	84,161	464.09	1278.72	2.76	4.31E-06	9.29E-09	1.19E-05	1.29E-05	2.79E-08	3.56E-05	8.62E-06	1.86E-08	2.38E-05
1974	1	1	3	0	4	2	1	0	1	2	202,842	92,670	76,063	456.86	1218.33	2.67	4.93E-06	1.08E-08	1.31E-05	9.86E-06	2.16E-08	2.63E-05	4.93E-06	1.08E-08	1.31E-05
1975	1	0	3	0	3	8	4	2	2	8	184,794	84,126	72,132	455.24	1166.28	2.56	5.41E-06	1.19E-08	1.39E-05	4.33E-05	9.51E-08	1.11E-04	3.25E-05	7.13E-08	8.32E-05
1976	0	0	0	0	0	2	2	0	0	2	218,126	99,192	87,363	454.75	1135.40	2.50	0.00E+00	0.00E+00	0.00E+00	9.17E-06	2.02E-08	2.29E-05	9.17E-06	2.02E-08	2.29E-05
1977	2	560	26	0	586	5	3	1	2	6	240,849	106,451	108,446	441.98	981.60	2.22	8.30E-06	1.88E-08	1.84E-05	2.08E-05	4.70E-08	4.61E-05	1.66E-05	3.76E-08	3.69E-05
1978	0	0	0	0	0	2	0	2	0	2	202,883	88,197	96,351	434.72	915.37	2.11	0.00E+00	0.00E+00	0.00E+00	9.86E-06	2.27E-08	2.08E-05	9.86E-06	2.27E-08	2.08E-05
1979	1	0	3	0	3	6	3	3	0	6	165,817	68,018	86,311	410.20	788.06	1.92	6.03E-06	1.47E-08	1.16E-05	3.62E-05	8.82E-08	6.95E-05	3.62E-05	8.82E-08	6.95E-05
1980	1	0	0	1	1	4	0	3	1	4	310,000	115,000	162,000	370.97	709.88	1.91	3.23E-06	8.70E-09	6.17E-06	1.29E-05	3.48E-08	2.47E-05	9.68E-06	2.61E-08	1.85E-05
1981	0	0	0	0	0	1	0	1	0	1	292,000	109,000	155,000	373.29	703.23	1.88	0.00E+00	0.00E+00	0.00E+00	3.42E-06	9.17E-09	6.45E-06	3.42E-06	9.17E-09	6.45E-06
1982	1	0	1	0	1	2	0	3	1	4	342,555	131,628	188,787	384.25	697.23	1.81	2.92E-06	7.60E-09	5.30E-06	5.84E-06	1.52E-08	1.06E-05	8.76E-06	2.28E-08	1.59E-05
1983	0	0	0	0	0	1	0	1	1	2	383,830	148,409	209,112	386.65	709.71	1.84	0.00E+00	0.00E+00	0.00E+00	2.61E-06	6.74E-09	4.78E-06	2.61E-06	6.74E-09	4.78E-06
1984	0	0	0	0	0	3	1	3	0	4	429,087	169,153	232,776	394.22	726.68	1.84	0.00E+00	0.00E+00	0.00E+00	6.99E-06	1.77E-08	1.29E-05	9.32E-06	2.36E-08	1.72E-05
1985	3	312	17	0	329	4	5	0	0	5	444,562	178,264	237,866	400.99	749.43	1.87	6.75E-06	1.68E-08	1.26E-05	9.00E-06	2.24E-08	1.68E-05	1.12E-05	2.80E-08	2.10E-05
1986	1	0	3	0	3	3	1	0	2	3	480,946	188,497	273,924	391.93	688.14	1.76	2.08E-06	5.31E-09	3.65E-06	6.24E-06	1.59E-08	1.10E-05	2.08E-06	5.31E-09	3.65E-06
1987	1	1	0	0	1	2	1	2	1	4	529,785	234,647	308,348	442.91	760.98	1.72	1.89E-06	4.26E-09	3.24E-06	3.78E-06	8.52E-09	6.49E-06	5.66E-06	1.28E-08	9.73E-06
1988	0	0	0	0	0	1	0	0	1	1	619,496	242,641	368,486	391.67	658.48	1.68	0.00E+00	0.00E+00	0.00E+00	1.61E-06	4.12E-09	2.71E-06	0.00E+00	0.00E+00	0.00E+00
1989	3	137	9	1	147	4	2	1	1	4	676,621	267,849	378,153	395.86	708.31	1.79	4.43E-06	1.12E-08	7.93E-06	5.91E-06	1.49E-08	1.06E-05	4.43E-06	1.12E-08	7.93E-06
1990	0	0	0	0	0	2	1	0	1	2	625,390	258,545	296,545	413.41	871.86	2.11	0.00E+00	0.00E+00	0.00E+00	3.20E-06	7.74E-09	6.74E-06	1.60E-06	3.87E-09	3.37E-06
1991	0	0	0	0	0	1	0	1	0	1	641,444	266,287	311,002	415.14	856.22	2.06	0.00E+00	0.00E+00	0.00E+00	1.56E-06	3.76E-09	3.22E-06	1.56E-06	3.76E-09	3.22E-06
1992	0	0	0	0	0	2	0	2	0	2	627,689	272,091	365,334	433.48	744.77	1.72	0.00E+00	0.00E+00	0.00E+00	3.19E-06	7.35E-09	5.47E-06	3.19E-06	7.35E-09	5.47E-06
1993	0	0	0	0	0	1	0	0	0	0	724,859	313,402	352,418	432.36	889.29	2.06	0.00E+00	0.00E+00	0.00E+00	1.38E-06	3.19E-09	2.84E-06	0.00E+00	0.00E+00	0.00E+00
1994	0	0	0	0	0	4	0	2	2	4	829,865	365,485	418,101	440.42	874.15	1.98	0.00E+00	0.00E+00	0.00E+00	4.82E-06	1.09E-08	9.57E-06	2.41E-06	5.47E-09	4.78E-06
1995P	1	0	2	0	2	2	N.A.	N.A.	N.A.	N.A.	742,814	322,246	349,115	433.82	923.04	2.13	1.35E-06	3.10E-09	2.86E-06	2.69E-06	6.21E-09	5.73E-06	N.A.	N.A.	N.A.
1996P	2	0	8	30	38	6	N.A.	N.A.	N.A.	N.A.	783,000	342,555	369,000	437.49	928.33	2.12	2.55E-06	5.84E-09	5.42E-06	7.66E-06	1.75E-08	1.63E-05	N.A.	N.A.	N.A.
Total	19	1014	78	32	1124	71	25	28	17	70	10,931,144	4,571,971	5,586,794	418.25	818.35	1.96	1.74E-06	4.16E-09	3.40E-06	6.50E-06	1.55E-08	1.27E-05	N.A.	N.A.	N.A.
Avg.	0.79	42.25	3.25	1.33	46.83	2.96	1.14	1.27	0.77	3.18	455,464	190,499	232,783	419.03	861.81	2.04	2.26E-06	5.35E-09	4.84E-06	9.37E-06	2.20E-08	2.04E-05	8.35E-06	1.98E-08	1.78E-05
Std.	0.93	129.70	6.28	6.11	135.48	1.85	1.46	1.12	0.75	1.94	216,839	93,413	117,614	28.39	180.41	0.31	2.60E-06	6.11E-09	5.78E-06	1.04E-05	2.39E-08	2.49E-05	9.42E-06	2.20E-08	2.12E-05

P = Preliminary Data

N.A. = Information not available when table prepared.

1973-1979 Nonscheduled U.S. Air Carriers operated under 14 CFR 121 assumed equal to U.S. Air Carriers operating on Nonscheduled Certificated Route Operations.

For 1973-1994																									
Total	16	1014	68	2	1084	63	25	28	17	70	9,405,330	3,907,170	4,868,679	415.42	802.51	1.93	1.70E-06	4.10E-09	3.29E-06	6.70E-06	1.61E-08	1.29E-05	5.64E-06	1.36E-08	1.09E-05
Avg.	0.73	46.09	3.09	0.09	49.27	2.86	1.14	1.27	0.77	3.18	427,515	177,599	221,304	417.52	856.01	2.03	2.29E-06	5.42E-09	4.90E-06	9.75E-06	2.30E-08	2.12E-05	8.35E-06	1.98E-08	1.78E-05
Std.	0.94	135.05	6.48	0.29	141.41	1.81	1.46	1.12	0.75	1.94	204,054	86,343	116,123	29.22	187.68	0.32	2.71E-06	6.38E-09	6.03E-06	1.08E-05	2.47E-08	2.58E-05	9.42E-06	2.20E-08	2.12E-05

Table 3.3
Total (Scheduled and Nonscheduled) U.S. Air Carriers Operating Under 14 CFR 121
[References 3.9 to 3.32]

Year	Fatal Acc.	Fatalities				Total Acc.	121 Aircraft Damage Minor/ None/ Unkn.				121 Aircraft Hours Flown	121 Aircraft Miles (000)	121 Aircraft Departures	Average Speed (miles/hr.)	Average AC Miles/ Departure	Average AC Hours/ Departure	Fatal Accident Rate			Total Accident Rate			Crash (Dest. + Major Dam.) Rate				
		121 Pass.	121 Crew	Other	Total		Dest.	Major	Unkn.	Total							(/AC hour)	(/AC mile)	/Departure	(/AC hour)	(/AC mile)	/Departure	(/AC hour)	(/AC mile)	/Departure		
1972																											
1973	9	201	26	1	228	38	8	11	19	38	6,130,465	2,555,732	5,217,977	416.89	489.79	1.17	1.47E-06	3.52E-09	1.72E-06	6.20E-06	1.49E-08	7.28E-06	3.10E-06	7.43E-09	3.64E-06		
1974	7	419	42	0	461	41	7	4	31	42	5,677,337	2,350,806	4,801,846	414.07	489.56	1.18	1.23E-06	2.98E-09	1.46E-06	7.22E-06	1.74E-08	8.54E-06	1.94E-06	4.68E-09	2.29E-06		
1975	3	116	12	0	128	39	10	12	17	39	5,607,459	2,324,631	4,776,184	414.56	486.71	1.17	5.35E-07	1.29E-09	6.28E-07	6.96E-06	1.68E-08	8.17E-06	3.92E-06	9.46E-09	4.61E-06		
1976	2	36	2	0	38	24	6	6	12	24	5,805,727	2,419,159	4,922,501	416.68	491.45	1.18	3.44E-07	8.27E-10	4.06E-07	4.13E-06	9.92E-09	4.88E-06	2.07E-06	4.96E-09	2.44E-06		
1977	5	625	31	9	665	24	5	9	14	28	6,041,692	2,525,103	5,042,540	417.95	500.76	1.20	8.28E-07	1.98E-09	9.92E-07	3.97E-06	9.50E-09	4.76E-06	2.32E-06	5.54E-09	2.78E-06		
1978	5	141	11	14	166	22	6	4	12	22	6,234,626	2,608,362	5,112,290	418.37	510.21	1.22	8.02E-07	1.92E-09	9.78E-07	3.53E-06	8.43E-09	4.30E-06	1.60E-06	3.83E-09	1.96E-06		
1979	5	323	28	3	354	29	7	14	9	30	6,878,911	2,859,138	5,485,963	415.64	521.17	1.25	7.27E-07	1.75E-09	9.11E-07	4.22E-06	1.01E-08	5.29E-06	3.05E-06	7.34E-09	3.83E-06		
1980	1	0	0	1	1	19	4	7	8	19	7,379,000	3,044,000	5,729,000	412.52	531.33	1.29	1.36E-07	3.29E-10	1.75E-07	2.57E-06	6.24E-09	3.32E-06	1.49E-06	3.61E-09	1.92E-06		
1981	4	1	1	2	4	26	1	12	13	26	7,126,000	2,920,000	5,575,000	409.77	523.77	1.28	5.61E-07	1.37E-09	7.17E-07	3.65E-06	8.90E-09	4.66E-06	1.82E-06	4.45E-09	2.33E-06		
1982	5	211	12	12	235	18	3	10	7	20	7,040,325	2,938,513	5,351,133	417.38	549.14	1.32	7.10E-07	1.70E-09	9.34E-07	2.56E-06	6.13E-09	3.36E-06	1.85E-06	4.42E-09	2.43E-06		
1983	4	8	6	1	15	23	4	11	9	24	7,298,799	3,069,318	5,444,374	420.52	563.76	1.34	5.48E-07	1.30E-09	7.35E-07	3.15E-06	7.49E-09	4.22E-06	2.06E-06	4.89E-09	2.76E-06		
1984	1	1	3	0	4	16	3	7	7	17	8,165,124	3,428,063	5,898,852	419.84	581.14	1.38	1.22E-07	2.92E-10	1.70E-07	1.96E-06	4.67E-09	2.71E-06	1.22E-06	2.92E-09	1.70E-06		
1985	7	486	39	1	526	21	11	6	5	22	8,709,894	3,631,017	6,306,759	416.88	575.73	1.38	8.04E-07	1.93E-09	1.11E-06	2.41E-06	5.78E-09	3.33E-06	1.95E-06	4.68E-09	2.70E-06		
1986	3	4	3	1	8	24	3	7	14	24	9,976,104	4,017,626	7,202,027	402.72	557.85	1.39	3.01E-07	7.47E-10	4.17E-07	2.41E-06	5.97E-09	3.33E-06	1.00E-06	2.49E-09	1.39E-06		
1987	5	213	17	2	232	34	6	17	16	39	10,645,192	4,360,521	7,601,373	409.62	573.65	1.40	4.70E-07	1.15E-09	6.58E-07	3.19E-06	7.80E-09	4.47E-06	2.16E-06	5.27E-09	3.03E-06		
1988	3	256	18	11	285	29	7	8	14	29	11,140,540	4,503,426	7,716,061	404.24	583.64	1.44	2.69E-07	6.66E-10	3.89E-07	2.60E-06	6.44E-09	3.76E-06	1.35E-06	3.33E-09	1.94E-06		
1989	11	259	17	2	278	28	9	9	10	28	11,274,543	4,605,083	7,645,494	408.45	602.33	1.47	9.76E-07	2.39E-09	1.44E-06	2.48E-06	6.08E-09	3.66E-06	1.60E-06	3.91E-09	2.35E-06		
1990	6	8	4	27	39	24	5	6	14	25	12,150,116	4,947,832	8,092,306	407.23	611.42	1.50	4.94E-07	1.21E-09	7.41E-07	1.98E-06	4.85E-09	2.97E-06	9.05E-07	2.22E-09	1.36E-06		
1991	4	40	9	13	62	26	5	10	12	27	11,780,610	4,824,824	7,814,875	409.56	617.39	1.51	3.40E-07	8.29E-10	5.12E-07	2.21E-06	5.39E-09	3.33E-06	1.27E-06	3.11E-09	1.92E-06		
1992	4	26	5	2	33	18	4	2	13	19	12,359,715	5,054,916	7,880,707	408.98	641.43	1.57	3.24E-07	7.91E-10	5.08E-07	1.46E-06	3.56E-09	2.28E-06	4.85E-07	1.19E-09	7.61E-07		
1993	1	0	0	1	1	23	1	8	13	22	12,706,206	5,249,469	8,074,393	413.14	650.14	1.57	7.87E-08	1.90E-10	1.24E-07	1.81E-06	4.38E-09	2.85E-06	7.08E-07	1.71E-09	1.11E-06		
1994	4	228	9	2	239	23	3	7	12	22	13,122,221	5,478,118	8,242,903	417.47	664.59	1.59	3.05E-07	7.30E-10	4.85E-07	1.75E-06	4.20E-09	2.79E-06	7.62E-07	1.83E-09	1.21E-06		
1995P	3	152	10	6	168	36	N.A.	N.A.	N.A.	N.A.	13,513,219	5,648,512	8,451,606	418.00	668.34	1.60	2.22E-07	5.31E-10	3.55E-07	2.66E-06	6.37E-09	4.26E-06	N.A.	N.A.	N.A.		
1996P	5	319	31	30	380	38	N.A.	N.A.	N.A.	N.A.	13,683,000	5,761,935	8,554,000	421.10	673.60	1.60	3.65E-07	8.68E-10	5.85E-07	2.78E-06	6.60E-09	4.44E-06	N.A.	N.A.	N.A.		
Total	107	4073	336	141	4550	643	118	187	281	586	220,446,833	91,126,104	156,940,164	413.37	580.64	1.40	4.85E-07	1.17E-09	6.82E-07	2.92E-06	7.06E-09	4.10E-06	N.A.	N.A.	N.A.		
Avg.	4.46	169.71	14.00	5.88	189.58	26.79	5.36	8.50	12.77	26.64	9,185,285	3,796,921	6,539,174	413.82	569.12	1.38	5.40E-07	1.30E-09	7.15E-07	3.24E-06	7.83E-09	4.29E-06	1.76E-06	4.24E-09	2.29E-06		
Std.	2.40	173.49	12.57	8.30	185.99	7.27	2.66	3.49	5.32	7.09	2,874,945	1,181,035	1,375,616	5.16	61.59	0.15	3.50E-07	8.41E-10	4.18E-07	1.57E-06	3.76E-09	1.64E-06	8.37E-07	2.01E-09	9.30E-07		

P = Preliminary Data

N.A. = Information not available when table prepared.

For 1973-1994																									
Total	99	3602	295	105	4002	569	118	187	281	586	193,250,614	79,715,657	139,934,558	412.50	569.66	1.38	5.12E-07	1.24E-09	7.07E-07	2.94E-06	7.14E-09	4.07E-06	1.58E-06	3.83E-09	2.18E-06
Avg.	4.50	163.73	13.41	4.77	181.91	25.86	5.36	8.50	12.77	26.64	8,784,119	3,623,439	6,360,662	413.29	559.86	1.36	5.62E-07	1.36E-09	7.37E-07	3.29E-06	7.95E-09	4.28E-06	1.76E-06	4.24E-09	2.29E-06
Std.	2.48	178.47	12.58	6.81	189.93	6.85	2.66	3.49	5.32	7.09	2,651,155	1,071,927	1,292,937	5.05	55.46	0.14	3.57E-07	8.57E-10	4.28E-07	1.63E-06	3.92E-09	1.71E-06	8.37E-07	2.01E-09	9.30E-07

Table 3.4
TOTAL 14 CFR 121 AIRCRAFT INVOLVED IN ACCIDENTS BY FLIGHT PHASE
[References 3.9 to 3.30]

FLIGHT PHASES	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	Total	Pct.
Taxi	3	3	3	4	6	1	2	4	5	2	1	2	0	2	8	5	4	4	8	7	2	3	79	13.5%
Takeoff (TO)	3	3	3	2	3	2	1	1	2	2	2	1	2	1	4	2	1	5	3	2	0	2	47	8.0%
Initial Climb (IC)	2	1	4	0	2	2	3	0	0	2	2	2	6	1	5	1	2	1	1	0	0	1	38	6.5%
Climb to Cruise (CC)	2	4	0	1	1	2	3	1	1	1	4	0	1	3	2	2	2	1	0	1	3	4	39	6.7%
Cruise/En Route (ER)	15	10	10	5	7	6	4	3	5	3	1	5	4	5	9	10	4	4	7	1	4	4	126	21.6%
Initial Descent (ID)	3	8	4	3	3	0	1	3	3	1	1	2	1	3	3	3	2	4	0	3	2	2	55	9.4%
Airport Approach (AA)	1	3	0	0	2	1	1	0	0	0	1	0	2	0	0	0	3	0	1	0	1	1	17	2.9%
Runway Approach (RA)	4	3	7	1	0	2	1	1	1	3	4	1	3	0	1	0	1	1	2	1	2	0	39	6.7%
Landing (L)	4	2	6	6	1	2	10	6	3	3	6	3	3	5	7	4	5	2	3	1	6	3	91	15.6%
Grd. Accident (G)	1	5	2	2	3	4	3	0	6	1	2	0	0	3	0	2	4	2	2	1	2	2	47	8.0%
Unknown (?)	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	1	0	2	0	0	6	1.0%
Total:	38	42	39	24	28	22	30	19	26	19	24	17	22	23	39	29	28	25	27	19	22	22	584	100.0%

Table 3.5
Total (Scheduled and Nonscheduled) 14 CFR 121 Aircraft Involved In Accident Rate by Flight Phase

Flight Phases	No. of		Adjusted		Average Pct. Flt. Time	Average Flt. Time (hours)	Assumed Average Velocity		Calculated Average Distance		Accident Rate by Flight Phases				Accident Rate by Combined Flight Phases			
	Accidents	Pct.	No. of Accidents	Adjusted Pct.			Miles	Knots	Miles	Knots	Accidents /Departure	Accidents /AC Hour	Accidents /Mile	Accidents /Knot	Accidents /Departure	Accidents /AC Hour	Accidents /Mile	Accidents /Knot
Taxi	79	13.53%																
Takeoff (TO)	47	8.05%	47	10.40%	1.00%	0.014	100.00	86.90	1.40	1.22	3.359E-07	2.399E-05	2.399E-07	2.761E-07	6.074E-07	2.169E-05	1.314E-07	1.512E-07
Initial Climb (IC)	38	6.51%	38	8.41%	1.00%	0.014	230.16	200.00	3.22	2.80	2.716E-07	1.940E-05	8.428E-08	9.698E-08				
Climb to Cruise (CC)	39	6.68%	39	8.63%	13.00%	0.182	356.74	310.00	64.93	56.42	2.787E-07	1.531E-06	4.293E-09	4.940E-09				
Cruise/ Enroute (ER)	126	21.58%	126	27.88%	60.00%	0.840	477.57	415.00	401.16	348.60	9.004E-07	1.072E-06	2.245E-09	2.583E-09	1.694E-06	1.301E-06	3.076E-09	3.539E-09
Initial Descent (ID)	55	9.42%	55	12.17%	10.00%	0.140	356.74	310.00	49.94	43.40	3.930E-07	2.807E-06	7.870E-09	9.056E-09				
Airport Approach (AA)	17	2.91%	17	3.76%	10.00%	0.140	247.42	215.00	34.64	30.10	1.215E-07	8.678E-07	3.507E-09	4.036E-09				
Runway Approach (RA)	39	6.68%	39	8.63%	4.00%	0.056	247.42	215.00	13.86	12.04	2.787E-07	4.977E-06	2.012E-08	2.315E-08				
Landing (L)	91	15.58%	91	20.13%	1.00%	0.014	100.00	86.90	1.40	1.22	6.503E-07	4.645E-05	4.645E-07	5.345E-07	9.290E-07	1.327E-05	6.090E-08	7.008E-08
Ground Accident (G)	47	8.05%																
Unknown (?)	6	1.03%																
TOTAL:	584	100.00%	452	100.00%	100.00%	1.400	407.53	354.14	570.55	495.79	3.230E-06	2.307E-06	5.661E-09	6.515E-09	3.230E-06	2.307E-06	5.661E-09	6.515E-09

Bases for Total 14 CFR 121 Accident Rates by Flight Phase, 1973-1994 Totals:

1.4 Hours Average Flight Duration
570 Miles Average Flight Distance
407.14 Miles/Hour Average Flight Velocity
139,934,558 Departures

Table 3.6
14 CFR 121 CRASHES (ACCIDENTS WITH DESTROYED OR MAJOR DAMAGE TO AIRFRAME)
BY FLIGHT PHASE
[References 3.9 to 3.30]

FLIGHT PHASES	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	Total	Pct.
Taxi	2	1	2	3	6	0	0	3	4	2	1	2	0	2	7	4	1	1	6	0	2	1	50	16.4%
Takeoff (TO)	2	0	3	1	2	1	1	1	2	1	2	1	2	1	2	1	1	3	3	2	0	2	34	11.2%
Initial Climb (IC)	2	0	3	0	2	1	3	0	0	2	2	2	6	1	2	1	2	1	1	0	0	1	32	10.5%
Climb to Cruise (CC)	1	1	0	0	0	0	3	0	1	0	2	0	1	0	1	1	1	1	0	0	1	0	14	4.6%
Cruise/En Route (ER)	3	2	0	1	1	1	1	1	1	0	0	2	0	0	3	4	2	0	0	1	0	0	23	7.6%
Initial Descent (ID)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0.3%
Airport Approach (AA)	1	2	0	0	1	1	1	0	0	0	1	0	2	0	0	0	3	0	1	0	0	0	13	4.3%
Runway Approach (RA)	4	2	7	1	0	2	1	1	1	3	2	1	3	0	1	0	1	1	2	1	1	1	36	11.8%
Landing (L)	4	2	6	6	1	2	9	5	3	3	5	2	3	5	7	4	5	2	2	1	5	3	85	28.0%
Grd. Accident (G)	0	1	1	0	1	2	1	0	1	1	0	0	0	0	0	0	2	1	0	0	0	1	12	3.9%
Unknown (?)	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	4	1.3%
Total:	19	11	22	12	14	10	21	11	13	13	15	10	17	9	23	15	18	11	15	6	9	10	304	100.0%

Table 3.7
14 CFR 121 Crash (Accidents with Destroyed or Major Damage to Airframe) Rates by Flight Phase

Flight Phases	No. of Crashes		Adjusted No. of Crashes		Average Pct. Flt. Time	Average Flt. Time (hours)	Assumed Average Velocity		Calculated Average Distance		Crash Rate by Flight Phases				Accident Rate by Combined Flight Phases			
	Crashes	Pct.	Crashes	Pct.			Miles	Knots	Miles	Knots	Crashes /Departure	Crashes /AC Hour	Crashes /Mile	Crashes /Knot	Accidents /Departure	Accidents /AC Hour	Accidents /Mile	Accidents /Knot
Taxi	50	16.45%																
Takeoff (TO)	34	11.18%	34	14.29%	1.00%	0.014	100.00	86.90	1.40	1.22	2.430E-07	1.736E-05	1.736E-07	1.997E-07	4.716E-07	1.684E-05	1.020E-07	1.174E-07
Initial Climb (IC)	32	10.53%	32	13.45%	1.00%	0.014	230.16	200.00	3.22	2.80	2.287E-07	1.633E-05	7.097E-08	8.167E-08				
Climb to Cruise (CC)	14	4.61%	14	5.88%	13.00%	0.182	356.74	310.00	64.93	56.42	1.000E-07	5.497E-07	1.541E-09	1.773E-09				
Cruise/ Enroute (ER)	23	7.57%	23	9.66%	60.00%	0.840	477.57	415.00	401.16	348.60	1.644E-07	1.957E-07	4.097E-10	4.715E-10	3.645E-07	2.799E-07	6.618E-10	7.616E-10
Initial Descent (ID)	1	0.33%	1	0.42%	10.00%	0.140	356.74	310.00	49.94	43.40	7.146E-09	5.104E-08	1.431E-10	1.647E-10				
Airport Approach (AA)	13	4.28%	13	5.46%	10.00%	0.140	247.42	215.00	34.64	30.10	9.290E-08	6.636E-07	2.682E-09	3.086E-09				
Runway Approach (RA)	36	11.84%	36	15.13%	4.00%	0.056	247.42	215.00	13.86	12.04	2.573E-07	4.594E-06	1.857E-08	2.137E-08				
Landing (L)	85	27.96%	85	35.71%	1.00%	0.014	100.00	86.90	1.40	1.22	6.074E-07	4.339E-05	4.339E-07	4.993E-07	8.647E-07	1.235E-05	5.668E-08	6.523E-08
Ground Accident (G)	12	3.95%																
Unknown (?)	4	1.32%																
TOTAL:	304	100.00%	238	100.00%	100.00%	1.400	407.53	354.14	570.55	495.79	1.701E-06	1.215E-06	2.981E-09	3.430E-09	1.701E-06	1.215E-06	2.981E-09	3.430E-09

Bases for Total 14 CFR 121 Crash Rates by Flight Phase, 1973-1994 Totals:

1.4 Hours Average Flight Duration
570 Miles Average Flight Distance
407.14 Miles/Hour Average Flight Velocity
139,934,558 Departures

Table 3.8
14 CFR 121 CRASHES WITH DESTROYED/MAJOR-W.O. AIRFRAMES
BY FLIGHT PHASE
[References 3.9 to 3.30]

FLIGHT PHASES	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	Total	Pct.	
Taxi	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	1.7%	
Takeoff (TO)	1	0	1	1	1	1	0	0	0	0	0	0	1	0	1	1	1	1	2	2	0	0	14	11.6%	
Initial Climb (IC)	2	0	2	0	1	1	3	0	0	2	1	1	6	1	1	1	1	1	1	0	0	1	26	21.5%	
Climb to Cruise (CC)	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	5	4.1%	
Cruise/En Route (ER)	0	2	0	0	1	0	0	0	0	0	0	2	0	0	2	2	2	0	0	0	0	0	11	9.1%	
Initial Descent (ID)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0.8%	
Airport Approach (AA)	0	2	0	0	1	1	0	0	0	0	1	0	1	0	0	0	3	0	0	0	0	1	10	8.3%	
Runway Approach (RA)	4	2	4	1	0	2	1	1	0	0	1	0	2	0	1	0	1	1	1	1	0	0	23	19.0%	
Landing (L)	3	1	3	4	0	1	1	3	1	1	1	0	1	2	1	2	0	0	1	1	1	0	28	23.1%	
Grd. Accident (G)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0.8%	
Unknown (?)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
Total:	10	7	10	6	5	6	7	4	1	3	4	3	11	3	6	7	10	5	5	4	1	3	121	100.0%	

Table 3.9
14 CFR 121 Crashes with Destroyed/Major-W.O. Airframe Rates by Flight Phase

Flight Phases	No. of		Adjusted		Average Pct.	Average Flt. Time (hours)	Assumed Average Velocity		Calculated Average Distance		Crash Rate by Flight Phases				Accident Rate by Combined Flight Phases			
	Crashes	Pct.	No. of Crashes	Adjusted Pct.			Miles	Knots	Miles	Knots	Crashes /Departure	Crashes /AC Hour	Crashes /Mile	Crashes /Knot	Accidents /Departure	Accidents /AC Hour	Accidents /Mile	Accidents /Knot
Taxi	2	1.65%																
Takeoff (TO)	14	11.57%	14	11.86%	1.00%	0.014	100.00	86.90	1.40	1.22	1.000E-07	7.146E-06	7.146E-08	8.224E-08	2.858E-07	1.021E-05	6.184E-08	7.117E-08
Initial Climb (IC)	26	21.49%	26	22.03%	1.00%	0.014	230.16	200.00	3.22	2.80	1.858E-07	1.327E-05	5.766E-08	6.636E-08				
Climb to Cruise (CC)	5	4.13%	5	4.24%	13.00%	0.182	356.74	310.00	64.93	56.42	3.573E-08	1.963E-07	5.503E-10	6.333E-10				
Cruise/ Enroute (ER)	11	9.09%	11	9.32%	60.00%	0.840	477.57	415.00	401.16	348.60	7.861E-08	9.358E-08	1.960E-10	2.255E-10	1.929E-07	1.482E-07	3.504E-10	4.032E-10
Initial Descent (ID)	1	0.83%	1	0.85%	10.00%	0.140	356.74	310.00	49.94	43.40	7.146E-09	5.104E-08	1.431E-10	1.647E-10				
Airport Approach (AA)	10	8.26%	10	8.47%	10.00%	0.140	247.42	215.00	34.64	30.10	7.146E-08	5.104E-07	2.063E-09	2.374E-09				
Runway Approach (RA)	23	19.01%	23	19.49%	4.00%	0.056	247.42	215.00	13.86	12.04	1.644E-07	2.935E-06	1.186E-08	1.365E-08				
Landing (L)	28	23.14%	28	23.73%	1.00%	0.014	100.00	86.90	1.40	1.22	2.001E-07	1.429E-05	1.429E-07	1.645E-07	3.645E-07	5.207E-06	2.389E-08	2.749E-08
Ground Accident (G)	1	0.83%																
Unknown (?)	0	0.00%																
TOTAL:	121	100.00%	118	100.00%	100.00%	1.400	407.53	354.14	570.55	495.79	8.433E-07	6.023E-07	1.478E-09	1.701E-09	8.433E-07	6.023E-07	1.478E-09	1.701E-09

Bases for Total 14 CFR 121 Crash Rates by Flight Phase, 1973-1994 Totals:

1.4 Hours Average Flight Duration
570 Miles Average Flight Distance
407.14 Miles/Hour Average Flight Velocity
139,934,558 Departures

Table 3.10
Conditional Probabilities of Air Carrier Crash Location (/sq. mile), Given a Crash on Takeoff
[Reference 3.3]

y/x	[-1,0]	[0,1]	[1,2]	[2,3]	[3,4]	[4,5]	[5,6]	[6,7]	[7,8]	[8,9]	[9,10]	[10,11]	[11,12]	[12,13]	[13,14]	[14,15]	[15,16]	[16,17]	[17,18]	[18,19]
[19,20]	3.68E-14	5.91E-11	4.77E-09	8.59E-08	5.69E-07	1.84E-06	3.48E-06	4.44E-06	4.23E-06	3.25E-06	2.13E-06	1.25E-06	6.74E-07	3.44E-07	1.69E-07	8.11E-08	3.83E-08	1.79E-08	8.39E-09	3.93E-09
[18,19]	7.98E-14	1.08E-10	7.62E-09	1.24E-07	7.58E-07	2.30E-06	4.15E-06	5.11E-06	4.73E-06	3.56E-06	2.30E-06	1.33E-06	7.11E-07	3.60E-07	1.76E-07	8.41E-08	3.96E-08	1.85E-08	8.64E-09	4.04E-09
[17,18]	1.77E-13	2.00E-10	1.24E-08	1.81E-07	1.02E-06	2.90E-06	4.98E-06	5.91E-06	5.32E-06	3.91E-06	2.48E-06	1.42E-06	7.51E-07	3.78E-07	1.84E-07	8.74E-08	4.10E-08	1.91E-08	8.91E-09	4.16E-09
[16,17]	4.00E-13	3.79E-10	2.03E-08	2.67E-07	1.38E-06	3.68E-06	6.02E-06	6.86E-06	5.99E-06	4.31E-06	2.69E-06	1.52E-06	7.96E-07	3.98E-07	1.92E-07	9.09E-08	4.25E-08	1.98E-08	9.21E-09	4.29E-09
[15,16]	9.29E-13	7.31E-10	3.39E-08	3.98E-07	1.89E-06	4.71E-06	7.31E-06	8.01E-06	6.79E-06	4.77E-06	2.92E-06	1.63E-06	8.45E-07	4.19E-07	2.01E-07	9.49E-08	4.42E-08	2.05E-08	9.53E-09	4.44E-09
[14,15]	2.22E-12	1.44E-09	5.77E-08	6.04E-07	2.62E-06	6.08E-06	8.94E-06	9.40E-06	7.72E-06	5.30E-06	3.19E-06	1.75E-06	9.00E-07	4.43E-07	2.11E-07	9.92E-08	4.61E-08	2.13E-08	9.89E-09	4.60E-09
[13,14]	5.45E-12	2.91E-09	1.00E-07	9.29E-07	3.67E-06	7.93E-06	1.10E-05	1.11E-05	8.84E-06	5.91E-06	3.49E-06	1.89E-06	9.61E-07	4.69E-07	2.23E-07	1.04E-07	4.82E-08	2.22E-08	1.03E-08	4.78E-09
[12,13]	1.39E-11	6.05E-09	1.78E-07	1.45E-06	5.22E-06	1.05E-05	1.37E-05	1.32E-05	1.02E-05	6.63E-06	3.84E-06	2.05E-06	1.03E-06	4.99E-07	2.35E-07	1.09E-07	5.05E-08	2.32E-08	1.07E-08	4.97E-09
[11,12]	3.66E-11	1.30E-08	3.23E-07	2.32E-06	7.54E-06	1.40E-05	1.73E-05	1.59E-05	1.18E-05	7.49E-06	4.25E-06	2.23E-06	1.11E-06	5.32E-07	2.49E-07	1.15E-07	5.30E-08	2.44E-08	1.12E-08	5.19E-09
[10,11]	1.01E-10	2.88E-08	6.03E-07	3.80E-06	1.11E-05	1.89E-05	2.20E-05	1.93E-05	1.38E-05	8.51E-06	4.73E-06	2.45E-06	1.20E-06	5.71E-07	2.66E-07	1.22E-07	5.60E-08	2.56E-08	1.18E-08	5.44E-09
[9,10]	2.92E-10	6.65E-08	1.17E-06	6.37E-06	1.66E-05	2.61E-05	2.83E-05	2.36E-05	1.63E-05	9.75E-06	5.31E-06	2.70E-06	1.31E-06	6.16E-07	2.84E-07	1.30E-07	5.94E-08	2.71E-08	1.24E-08	5.73E-09
[8,9]	8.95E-10	1.61E-07	2.34E-06	1.10E-05	2.56E-05	3.66E-05	3.71E-05	2.93E-05	1.94E-05	1.13E-05	6.00E-06	3.00E-06	1.43E-06	6.68E-07	3.07E-07	1.39E-07	6.33E-08	2.89E-08	1.32E-08	6.07E-09
[7,8]	2.94E-09	4.14E-07	4.92E-06	1.97E-05	4.04E-05	5.26E-05	4.95E-05	3.70E-05	2.35E-05	1.32E-05	6.86E-06	3.36E-06	1.59E-06	7.31E-07	3.33E-07	1.51E-07	6.81E-08	3.09E-08	1.41E-08	6.47E-09
[6,7]	1.05E-08	1.14E-06	1.09E-05	3.69E-05	6.63E-05	7.78E-05	6.77E-05	4.77E-05	2.89E-05	1.57E-05	7.94E-06	3.81E-06	1.77E-06	8.09E-07	3.65E-07	1.64E-07	7.38E-08	3.33E-08	1.52E-08	6.96E-09
[5,6]	4.17E-08	3.41E-06	2.60E-05	7.32E-05	1.14E-04	1.19E-04	9.55E-05	6.30E-05	3.63E-05	1.90E-05	9.35E-06	4.40E-06	2.01E-06	9.07E-07	4.06E-07	1.81E-07	8.10E-08	3.65E-08	1.65E-08	7.57E-09
[4,5]	1.90E-07	1.15E-05	6.80E-05	1.56E-04	2.07E-04	1.92E-04	1.40E-04	8.61E-05	4.70E-05	2.37E-05	1.13E-05	5.18E-06	2.33E-06	1.04E-06	4.59E-07	2.03E-07	9.05E-08	4.05E-08	1.83E-08	8.37E-09
[3,4]	1.05E-06	4.53E-05	2.02E-04	3.68E-04	4.09E-04	3.31E-04	2.17E-04	1.24E-04	6.36E-05	3.06E-05	1.41E-05	6.31E-06	2.78E-06	1.22E-06	5.34E-07	2.34E-07	1.04E-07	4.62E-08	2.08E-08	9.48E-09
[2,3]	7.77E-06	2.29E-04	7.32E-04	1.02E-03	9.19E-04	6.35E-04	3.70E-04	1.92E-04	9.20E-05	4.20E-05	1.86E-05	8.09E-06	3.49E-06	1.50E-06	6.49E-07	2.83E-07	1.24E-07	5.50E-08	2.47E-08	1.12E-08
[1,2]	1.01E-04	1.86E-03	3.85E-03	3.82E-03	2.64E-03	1.50E-03	7.48E-04	3.46E-04	1.53E-04	6.53E-05	2.75E-05	1.15E-05	4.84E-06	2.04E-06	8.70E-07	3.74E-07	1.63E-07	7.17E-08	3.20E-08	1.45E-08
[0,1]	2.63E-02	1.80E-01	1.52E-01	7.14E-02	2.83E-02	1.07E-02	3.95E-03	1.46E-03	5.48E-04	2.08E-04	7.99E-05	3.13E-05	1.25E-05	5.07E-06	2.10E-06	8.83E-07	3.78E-07	1.65E-07	7.28E-08	3.27E-08
[-1,0]	2.63E-02	1.80E-01	1.52E-01	7.14E-02	2.83E-02	1.07E-02	3.95E-03	1.46E-03	5.48E-04	2.08E-04	7.99E-05	3.13E-05	1.25E-05	5.07E-06	2.10E-06	8.83E-07	3.78E-07	1.65E-07	7.28E-08	3.27E-08
[-2,-1]	1.01E-04	1.86E-03	3.85E-03	3.82E-03	2.64E-03	1.50E-03	7.48E-04	3.46E-04	1.53E-04	6.53E-05	2.75E-05	1.15E-05	4.84E-06	2.04E-06	8.70E-07	3.74E-07	1.63E-07	7.17E-08	3.20E-08	1.45E-08
[-3,-2]	7.77E-06	2.29E-04	7.32E-04	1.02E-03	9.19E-04	6.35E-04	3.70E-04	1.92E-04	9.20E-05	4.20E-05	1.86E-05	8.09E-06	3.49E-06	1.50E-06	6.49E-07	2.83E-07	1.24E-07	5.50E-08	2.47E-08	1.12E-08
[-4,-3]	1.05E-06	4.53E-05	2.02E-04	3.68E-04	4.09E-04	3.31E-04	2.17E-04	1.24E-04	6.36E-05	3.06E-05	1.41E-05	6.31E-06	2.78E-06	1.22E-06	5.34E-07	2.34E-07	1.04E-07	4.62E-08	2.08E-08	9.48E-09
[-5,-4]	1.90E-07	1.15E-05	6.80E-05	1.56E-04	2.07E-04	1.92E-04	1.40E-04	8.61E-05	4.70E-05	2.37E-05	1.13E-05	5.18E-06	2.33E-06	1.04E-06	4.59E-07	2.03E-07	9.05E-08	4.05E-08	1.83E-08	8.37E-09
[-6,-5]	4.17E-08	3.41E-06	2.60E-05	7.32E-05	1.14E-04	1.19E-04	9.55E-05	6.30E-05	3.63E-05	1.90E-05	9.35E-06	4.40E-06	2.01E-06	9.07E-07	4.06E-07	1.81E-07	8.10E-08	3.65E-08	1.65E-08	7.57E-09
[-7,-6]	1.05E-08	1.14E-06	1.09E-05	3.69E-05	6.63E-05	7.78E-05	6.77E-05	4.77E-05	2.89E-05	1.57E-05	7.94E-06	3.81E-06	1.77E-06	8.09E-07	3.65E-07	1.64E-07	7.38E-08	3.33E-08	1.52E-08	6.96E-09
[-8,-7]	2.94E-09	4.14E-07	4.92E-06	1.97E-05	4.04E-05	5.26E-05	4.95E-05	3.70E-05	2.35E-05	1.32E-05	6.86E-06	3.36E-06	1.59E-06	7.31E-07	3.33E-07	1.51E-07	6.81E-08	3.09E-08	1.41E-08	6.47E-09
[-9,-8]	8.95E-10	1.61E-07	2.34E-06	1.10E-05	2.56E-05	3.66E-05	3.71E-05	2.93E-05	1.94E-05	1.13E-05	6.00E-06	3.00E-06	1.43E-06	6.68E-07	3.07E-07	1.39E-07	6.33E-08	2.89E-08	1.32E-08	6.07E-09
[-10,-9]	2.92E-10	6.65E-08	1.17E-06	6.37E-06	1.66E-05	2.61E-05	2.83E-05	2.36E-05	1.63E-05	9.75E-06	5.31E-06	2.70E-06	1.31E-06	6.16E-07	2.84E-07	1.30E-07	5.94E-08	2.71E-08	1.24E-08	5.73E-09
[-11,-10]	1.01E-10	2.88E-08	6.03E-07	3.80E-06	1.11E-05	1.89E-05	2.20E-05	1.93E-05	1.38E-05	8.51E-06	4.73E-06	2.45E-06	1.20E-06	5.71E-07	2.66E-07	1.22E-07	5.60E-08	2.56E-08	1.18E-08	5.44E-09
[-12,-11]	3.66E-11	1.30E-08	3.23E-07	2.32E-06	7.54E-06	1.40E-05	1.73E-05	1.59E-05	1.18E-05	7.49E-06	4.25E-06	2.23E-06	1.11E-06	5.32E-07	2.49E-07	1.15E-07	5.30E-08	2.44E-08	1.12E-08	5.19E-09
[-13,-12]	1.39E-11	6.05E-09	1.78E-07	1.45E-06	5.22E-06	1.05E-05	1.37E-05	1.32E-05	1.02E-05	6.63E-06	3.84E-06	2.05E-06	1.03E-06	4.99E-07	2.35E-07	1.09E-07	5.05E-08	2.32E-08	1.07E-08	4.97E-09
[-14,-13]	5.45E-12	2.91E-09	1.00E-07	9.29E-07	3.67E-06	7.93E-06	1.10E-05	1.11E-05	8.84E-06	5.91E-06	3.49E-06	1.89E-06	9.61E-07	4.69E-07	2.23E-07	1.04E-07	4.82E-08	2.22E-08	1.03E-08	4.78E-09
[-15,-14]	2.22E-12	1.44E-09	5.77E-08	6.04E-07	2.62E-06	6.08E-06	8.94E-06	9.40E-06	7.72E-06	5.30E-06	3.19E-06	1.75E-06	9.00E-07	4.43E-07	2.11E-07	9.92E-08	4.61E-08	2.13E-08	9.89E-09	4.60E-09
[-16,-15]	9.29E-13	7.31E-10	3.39E-08	3.98E-07	1.89E-06	4.71E-06	7.31E-06	8.01E-06	6.79E-06	4.77E-06	2.92E-06	1.63E-06	8.45E-07	4.19E-07	2.01E-07	9.49E-08	4.42E-08	2.05E-08	9.53E-09	4.44E-09
[-17,-16]	4.00E-13	3.79E-10	2.03E-08	2.67E-07	1.38E-06	3.68E-06	6.02E-06	6.86E-06	5.99E-06	4.31E-06	2.69E-06	1.52E-06	7.96E-07	3.98E-07	1.92E-07	9.09E-08	4.25E-08	1.98E-08	9.21E-09	4.29E-09
[-18,-17]	1.77E-13	2.00E-10	1.24E-08	1.81E-07	1.02E-06	2.90E-06	4.98E-06	5.91E-06	5.32E-06	3.91E-06	2.48E-06	1.42E-06	7.51E-07	3.78E-07	1.84E-07	8.74E-08	4.10E-08	1.91E-08	8.91E-09	4.16E-09
[-19,-18]	7.98E-14	1.08E-10	7.62E-09	1.24E-07	7.58E-07	2.30E-06	4.15E-06	5.11E-06	4.73E-06	3.56E-06	2.30E-06	1.33E-06	7.11E-07	3.60E-07	1.76E-07	8.41E-08	3.96E-08	1.85E-08	8.64E-09	4.04E-09
[-20,-19]	3.68E-14	5.91E-11	4.77E-09	8.59E-08	5.69E-07	1.84E-06	3.48E-06	4.44E-06	4.23E-06	3.25E-06	2.13E-06	1.25E-06	6.74E-07	3.44E-07	1.69E-07	8.11E-08	3.83E-08	1.79E-08	8.39E-09	3.93E-09

intended direction of travel is left to right
origin is center of runway
units are miles

Table 3.11
Conditional Probabilities of Air Carrier Crash Location (/sq. mile), Given a Crash on Landing
[Reference 3.3]

y/x	[-19,-18]	[-18,-17]	[-17,-16]	[-16,-15]	[-15,-14]	[-14,-13]	[-13,-12]	[-12,-11]	[-11,-10]	[-10,-9]	[-9,-8]	[-8,-7]	[-7,-6]	[-6,-5]	[-5,-4]	[-4,-3]	[-3,-2]	[-2,-1]	[-1,0]	[0,1]
[19,20]	2.13E-07	2.83E-07	3.40E-07	3.59E-07	3.21E-07	2.31E-07	1.26E-07	4.87E-08	1.21E-08	1.71E-09	1.20E-10	3.44E-12	3.19E-14	6.97E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
[18,19]	2.29E-07	3.10E-07	3.81E-07	4.13E-07	3.82E-07	2.88E-07	1.67E-07	6.91E-08	1.87E-08	2.97E-09	2.40E-10	8.23E-12	9.56E-14	2.79E-16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
[17,18]	2.47E-07	3.40E-07	4.27E-07	4.76E-07	4.57E-07	3.60E-07	2.21E-07	9.84E-08	2.92E-08	5.20E-09	4.84E-10	1.99E-11	2.90E-13	1.13E-15	8.62E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
[16,17]	2.66E-07	3.73E-07	4.79E-07	5.50E-07	5.47E-07	4.51E-07	2.94E-07	1.41E-07	4.58E-08	9.15E-09	9.85E-10	4.86E-11	8.95E-13	4.69E-15	4.99E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
[15,16]	2.87E-07	4.10E-07	5.38E-07	6.37E-07	6.57E-07	5.68E-07	3.92E-07	2.02E-07	7.24E-08	1.62E-08	2.03E-09	1.20E-10	2.80E-12	1.98E-14	3.01E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
[14,15]	3.11E-07	4.51E-07	6.07E-07	7.39E-07	7.91E-07	7.17E-07	5.25E-07	2.92E-07	1.15E-07	2.91E-08	4.22E-09	3.02E-10	8.91E-12	8.50E-14	1.92E-16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
[13,14]	3.36E-07	4.97E-07	6.85E-07	8.60E-07	9.56E-07	9.09E-07	7.07E-07	4.25E-07	1.84E-07	5.26E-08	8.87E-09	7.70E-10	2.89E-11	3.73E-13	1.24E-15	5.31E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00
[12,13]	3.65E-07	5.50E-07	7.75E-07	1.00E-06	1.16E-06	1.16E-06	9.57E-07	6.22E-07	2.97E-07	9.60E-08	1.89E-08	1.99E-09	9.55E-11	1.68E-12	8.30E-15	8.35E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00
[11,12]	3.97E-07	6.09E-07	8.80E-07	1.17E-06	1.41E-06	1.48E-06	1.30E-06	9.17E-07	4.84E-07	1.77E-07	4.09E-08	5.26E-09	3.23E-10	7.79E-12	5.73E-14	9.24E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00
[10,11]	4.32E-07	6.77E-07	1.00E-06	1.38E-06	1.72E-06	1.90E-06	1.79E-06	1.36E-06	7.96E-07	3.31E-07	8.98E-08	1.41E-08	1.12E-09	3.72E-11	4.11E-13	1.10E-15	0.00E+00	0.00E+00	0.00E+00	0.00E+00
[9,10]	4.73E-07	7.54E-07	1.15E-06	1.63E-06	2.12E-06	2.46E-06	2.46E-06	2.04E-06	1.32E-06	6.28E-07	2.01E-07	3.88E-08	3.99E-09	1.84E-10	3.07E-12	1.40E-14	1.20E-17	0.00E+00	0.00E+00	0.00E+00
[8,9]	5.18E-07	8.44E-07	1.31E-06	1.93E-06	2.62E-06	3.20E-06	3.43E-06	3.09E-06	2.23E-06	1.21E-06	4.58E-07	1.09E-07	1.47E-08	9.46E-10	2.41E-11	1.88E-13	3.17E-16	0.00E+00	0.00E+00	0.00E+00
[7,8]	5.71E-07	9.48E-07	1.52E-06	2.30E-06	3.25E-06	4.20E-06	4.81E-06	4.73E-06	3.80E-06	2.37E-06	1.07E-06	3.17E-07	5.60E-08	5.09E-09	2.00E-10	2.71E-12	9.21E-15	4.60E-18	0.00E+00	0.00E+00
[6,7]	6.31E-07	1.07E-06	1.76E-06	2.76E-06	4.08E-06	5.56E-06	6.84E-06	7.34E-06	6.61E-06	4.75E-06	2.55E-06	9.52E-07	2.23E-07	2.89E-08	1.78E-09	4.24E-11	2.96E-13	4.03E-16	0.00E+00	0.00E+00
[5,6]	7.03E-07	1.22E-06	2.06E-06	3.34E-06	5.16E-06	7.46E-06	9.85E-06	1.16E-05	1.17E-05	9.74E-06	6.31E-06	2.97E-06	9.33E-07	1.75E-07	1.72E-08	7.33E-10	1.07E-11	3.76E-14	1.72E-17	0.00E+00
[4,5]	7.90E-07	1.40E-06	2.43E-06	4.10E-06	6.62E-06	1.01E-05	1.44E-05	1.87E-05	2.13E-05	2.06E-05	1.62E-05	9.75E-06	4.16E-06	1.15E-06	1.83E-07	1.44E-08	4.55E-10	4.23E-12	7.15E-15	3.32E-19
[3,4]	8.98E-07	1.63E-06	2.91E-06	5.10E-06	8.65E-06	1.41E-05	2.17E-05	3.10E-05	4.01E-05	4.56E-05	4.39E-05	3.41E-05	2.02E-05	8.38E-06	2.23E-06	3.34E-07	2.38E-08	6.14E-10	3.78E-12	9.75E-16
[2,3]	1.04E-06	1.94E-06	3.57E-06	6.51E-06	1.16E-05	2.02E-05	3.37E-05	5.35E-05	7.92E-05	1.07E-04	1.28E-04	1.31E-04	1.09E-04	7.06E-05	3.27E-05	9.85E-06	1.68E-06	1.29E-07	3.11E-09	4.35E-12
[1,2]	1.26E-06	2.40E-06	4.58E-06	8.71E-06	1.64E-05	3.06E-05	5.60E-05	9.96E-05	1.71E-04	2.77E-04	4.20E-04	5.81E-04	7.15E-04	7.53E-04	6.48E-04	4.27E-04	1.94E-04	5.05E-05	5.44E-06	4.56E-08
[0,1]	1.83E-06	3.61E-06	7.18E-06	1.44E-05	2.90E-05	5.89E-05	1.20E-04	2.46E-04	5.04E-04	1.03E-03	2.11E-03	4.29E-03	8.64E-03	1.72E-02	3.37E-02	6.33E-02	1.09E-01	1.48E-01	9.90E-02	6.93E-03
[-1,0]	1.83E-06	3.61E-06	7.18E-06	1.44E-05	2.90E-05	5.89E-05	1.20E-04	2.46E-04	5.04E-04	1.03E-03	2.11E-03	4.29E-03	8.64E-03	1.72E-02	3.37E-02	6.33E-02	1.09E-01	1.48E-01	9.90E-02	6.93E-03
[-2,-1]	1.26E-06	2.40E-06	4.58E-06	8.71E-06	1.64E-05	3.06E-05	5.60E-05	9.96E-05	1.71E-04	2.77E-04	4.20E-04	5.81E-04	7.15E-04	7.53E-04	6.48E-04	4.27E-04	1.94E-04	5.05E-05	5.44E-06	4.56E-08
[-3,-2]	1.04E-06	1.94E-06	3.57E-06	6.51E-06	1.16E-05	2.02E-05	3.37E-05	5.35E-05	7.92E-05	1.07E-04	1.28E-04	1.31E-04	1.09E-04	7.06E-05	3.27E-05	9.85E-06	1.68E-06	1.29E-07	3.11E-09	4.35E-12
[-4,-3]	8.98E-07	1.63E-06	2.91E-06	5.10E-06	8.65E-06	1.41E-05	2.17E-05	3.10E-05	4.01E-05	4.56E-05	4.39E-05	3.41E-05	2.02E-05	8.38E-06	2.23E-06	3.34E-07	2.38E-08	6.14E-10	3.78E-12	9.75E-16
[-5,-4]	7.90E-07	1.40E-06	2.43E-06	4.10E-06	6.62E-06	1.01E-05	1.44E-05	1.87E-05	2.13E-05	2.06E-05	1.62E-05	9.75E-06	4.16E-06	1.15E-06	1.83E-07	1.44E-08	4.55E-10	4.23E-12	7.15E-15	3.32E-19
[-6,-5]	7.03E-07	1.22E-06	2.06E-06	3.34E-06	5.16E-06	7.46E-06	9.85E-06	1.16E-05	1.17E-05	9.74E-06	6.31E-06	2.97E-06	9.33E-07	1.75E-07	1.72E-08	7.33E-10	1.07E-11	3.76E-14	1.72E-17	0.00E+00
[-7,-6]	6.31E-07	1.07E-06	1.76E-06	2.76E-06	4.08E-06	5.56E-06	6.84E-06	7.34E-06	6.61E-06	4.75E-06	2.55E-06	9.52E-07	2.23E-07	2.89E-08	1.78E-09	4.24E-11	2.96E-13	4.03E-16	0.00E+00	0.00E+00
[-8,-7]	5.71E-07	9.48E-07	1.52E-06	2.30E-06	3.25E-06	4.20E-06	4.81E-06	4.73E-06	3.80E-06	2.37E-06	1.07E-06	3.17E-07	5.60E-08	5.09E-09	2.00E-10	2.71E-12	9.21E-15	4.60E-18	0.00E+00	0.00E+00
[-9,-8]	5.18E-07	8.44E-07	1.31E-06	1.93E-06	2.62E-06	3.20E-06	3.43E-06	3.09E-06	2.23E-06	1.21E-06	4.58E-07	1.09E-07	1.47E-08	9.46E-10	2.41E-11	1.88E-13	3.17E-16	0.00E+00	0.00E+00	0.00E+00
[-10,-9]	4.73E-07	7.54E-07	1.15E-06	1.63E-06	2.12E-06	2.46E-06	2.46E-06	2.04E-06	1.32E-06	6.28E-07	2.01E-07	3.88E-08	3.99E-09	1.84E-10	3.07E-12	1.40E-14	1.20E-17	0.00E+00	0.00E+00	0.00E+00
[-11,-10]	4.32E-07	6.77E-07	1.00E-06	1.38E-06	1.72E-06	1.90E-06	1.79E-06	1.36E-06	7.96E-07	3.31E-07	8.98E-08	1.41E-08	1.12E-09	3.72E-11	4.11E-13	1.10E-15	0.00E+00	0.00E+00	0.00E+00	0.00E+00
[-12,-11]	3.97E-07	6.09E-07	8.80E-07	1.17E-06	1.41E-06	1.48E-06	1.30E-06	9.17E-07	4.84E-07	1.77E-07	4.09E-08	5.26E-09	3.23E-10	7.79E-12	5.73E-14	9.24E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00
[-13,-12]	3.65E-07	5.50E-07	7.75E-07	1.00E-06	1.16E-06	1.16E-06	9.57E-07	6.22E-07	2.97E-07	9.60E-08	1.89E-08	1.99E-09	9.55E-11	1.68E-12	8.30E-15	8.35E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00
[-14,-13]	3.36E-07	4.97E-07	6.85E-07	8.60E-07	9.56E-07	9.09E-07	7.07E-07	4.25E-07	1.84E-07	5.26E-08	8.87E-09	7.70E-10	2.89E-11	3.73E-13	1.24E-15	5.31E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00
[-15,-14]	3.11E-07	4.51E-07	6.07E-07	7.39E-07	7.91E-07	7.17E-07	5.25E-07	2.92E-07	1.15E-07	2.91E-08	4.22E-09	3.02E-10	8.91E-12	8.50E-14	1.92E-16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
[-16,-15]	2.87E-07	4.10E-07	5.38E-07	6.37E-07	6.57E-07	5.68E-07	3.92E-07	2.02E-07	7.24E-08	1.62E-08	2.03E-09	1.20E-10	2.80E-12	1.98E-14	3.01E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
[-17,-16]	2.66E-07	3.73E-07	4.79E-07	5.50E-07	5.47E-07	4.51E-07	2.94E-07	1.41E-07	4.58E-08	9.15E-09	9.85E-10	4.86E-11	8.95E-13	4.69E-15	4.99E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
[-18,-17]	2.47E-07	3.40E-07	4.27E-07	4.76E-07	4.57E-07	3.60E-07	2.21E-07	9.84E-08	2.92E-08	5.20E-09	4.84E-10	1.99E-11	2.90E-13	1.13E-15	8.62E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
[-19,-18]	2.29E-07	3.10E-07	3.81E-07	4.13E-07	3.82E-07	2.88E-07	1.67E-07	6.91E-08	1.87E-08	2.97E-09	2.40E-10	8.23E-12	9.56E-14	2.79E-16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
[-20,-19]	2.13E-07	2.83E-07	3.40E-07	3.59E-07	3.21E-07	2.31E-07	1.26E-07	4.87E-08	1.21E-08	1.71E-09	1.20E-10	3.44E-12	3.19E-14	6.97E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

intended direction of travel is left to right
origin is center of runway
units are miles

Table 3.12
Scheduled U.S. Air Carriers Operating Under 14 CFR 135 (Commuters)
[References 3.11 to 3.32]

Year	Fatal Acc.	Fatalities				Total Acc.	135 Aircraft Damage				135 Aircraft Hours Flown	135 Aircraft Miles (000)	135 Aircraft Departures	Average Speed (miles/hr.)	Average AC Miles/ Departure	Average AC Hours/ Departure	Fatal Accident Rate			Total Accident Rate			Crash (Dest. + Major Dam.) Rate		
		135 Pass.	135 Crew	Other	Total		Dest.	Minor/ None/ Unkn.	Total	(/AC hour)							(/AC mile)	(/Departure)	(/AC hour)	(/AC mile)	(/Departure)	(/AC hour)	(/AC mile)	(/Departure)	
1974																									
1975	12	N.A.	N.A.	N.A.	28	48	N.A.	N.A.	N.A.	N.A.	936,312	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	1.28E-05	N.A.	N.A.	5.13E-05	N.A.	N.A.	N.A.	N.A.
1976	9	N.A.	N.A.	N.A.	27	35	N.A.	N.A.	N.A.	N.A.	965,296	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	9.32E-06	N.A.	N.A.	3.63E-05	N.A.	N.A.	N.A.	N.A.
1977	9	N.A.	N.A.	N.A.	32	44	N.A.	N.A.	N.A.	N.A.	1,150,250	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	7.82E-06	N.A.	N.A.	3.83E-05	N.A.	N.A.	N.A.	N.A.
1978	14	34	14	0	48	61	20	41	0	61	1,302,136	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	1.08E-05	N.A.	N.A.	4.68E-05	N.A.	N.A.	4.68E-05	N.A.
1979	15	50	16	0	66	52	20	32	0	52	1,169,921	192,493	1,883,705	164.54	102.19	0.62	1.28E-05	7.79E-08	7.96E-06	4.44E-05	2.70E-07	2.76E-05	4.44E-05	2.70E-07	2.76E-05
1980	8	27	10	0	37	38	9	27	3	39	1,175,588	192,200	1,776,999	163.49	108.16	0.66	6.81E-06	4.16E-08	4.50E-06	3.23E-05	1.98E-07	2.14E-05	3.06E-05	1.87E-07	2.03E-05
1981	9	21	11	2	34	31	10	20	1	31	1,240,764	193,001	1,835,144	155.55	105.17	0.68	7.25E-06	4.66E-08	4.90E-06	2.50E-05	1.61E-07	1.69E-05	2.42E-05	1.55E-07	1.63E-05
1982	5	8	6	0	14	26	8	17	2	27	1,299,748	222,355	2,026,691	171.08	109.71	0.64	3.85E-06	2.25E-08	2.47E-06	2.00E-05	1.17E-07	1.28E-05	1.92E-05	1.12E-07	1.23E-05
1983	2	9	1	1	11	17	6	9	2	17	1,510,908	253,572	2,328,430	167.83	108.90	0.65	1.32E-06	7.89E-09	8.59E-07	1.13E-05	6.70E-08	7.30E-06	9.93E-06	5.92E-08	6.44E-06
1984	7	38	8	2	48	22	7	15	0	22	1,745,762	291,460	2,676,590	166.95	108.89	0.65	4.01E-06	2.40E-08	2.62E-06	1.26E-05	7.55E-08	8.22E-06	1.26E-05	7.55E-08	8.22E-06
1985	7	28	8	1	37	21	9	12	0	21	1,737,106	300,817	2,561,463	173.17	117.44	0.68	4.03E-06	2.33E-08	2.73E-06	1.21E-05	6.98E-08	8.20E-06	1.21E-05	6.98E-08	8.20E-06
1986	2	3	1	0	4	15	1	13	2	16	1,724,586	307,393	2,798,811	178.24	109.83	0.62	1.16E-06	6.51E-09	7.15E-07	8.70E-06	4.88E-08	5.36E-06	8.12E-06	4.55E-08	5.00E-06
1987	10	42	15	2	59	33	11	18	3	32	1,946,349	350,879	2,809,918	180.28	124.87	0.69	5.14E-06	2.85E-08	3.56E-06	1.70E-05	9.40E-08	1.17E-05	1.49E-05	8.26E-08	1.03E-05
1988	2	17	4	0	21	19	3	15	1	19	2,092,689	380,237	2,909,005	181.70	130.71	0.72	9.56E-07	5.26E-09	6.88E-07	9.08E-06	5.00E-08	6.53E-06	8.60E-06	4.73E-08	6.19E-06
1989	5	25	6	0	31	19	5	13	1	19	2,240,555	393,619	2,818,520	175.68	139.65	0.79	2.23E-06	1.27E-08	1.77E-06	8.48E-06	4.83E-08	6.74E-06	8.03E-06	4.57E-08	6.39E-06
1990	4	3	1	2	6	16	2	12	1	15	2,341,760	450,133	3,160,089	192.22	142.44	0.74	1.71E-06	8.89E-09	1.27E-06	6.83E-06	3.55E-08	5.06E-06	5.98E-06	3.11E-08	4.43E-06
1991	8	64	13	22	99	22	9	13	0	22	2,291,693	433,900	2,820,440	189.34	153.84	0.81	3.49E-06	1.84E-08	2.84E-06	9.60E-06	5.07E-08	7.80E-06	9.60E-06	5.07E-08	7.80E-06
1992	7	13	8	0	21	23	7	16	0	23	2,363,745	508,242	3,114,932	215.02	163.16	0.76	2.96E-06	1.38E-08	2.25E-06	9.73E-06	4.53E-08	7.38E-06	9.73E-06	4.53E-08	7.38E-06
1993	4	19	4	1	24	16	4	10	2	16	2,641,268	554,963	3,601,902	210.11	154.07	0.73	1.51E-06	7.21E-09	1.11E-06	6.06E-06	2.88E-08	4.44E-06	5.30E-06	2.52E-08	3.89E-06
1994	3	20	5	0	25	10	3	6	1	10	2,787,904	594,716	3,850,372	213.32	154.46	0.72	1.08E-06	5.04E-09	7.79E-07	3.59E-06	1.68E-08	2.60E-06	3.23E-06	1.51E-08	2.34E-06
1995P	2	7	2	0	9	11	N.A.	N.A.	N.A.	N.A.	2,478,872	565,577	3,216,900	228.16	175.81	0.77	8.07E-07	3.54E-09	6.22E-07	4.44E-06	1.94E-08	3.42E-06	N.A.	N.A.	N.A.
1996P	1	10	2	2	14	11	N.A.	N.A.	N.A.	N.A.	2,474,000	608,814	3,171,000	246.08	191.99	0.78	4.04E-07	1.64E-09	3.15E-07	4.45E-06	1.81E-08	3.47E-06	N.A.	N.A.	N.A.
Total	145	438	135	35	695	590	134	289	19	442	39,617,212	6,794,371	49,360,911												
Avg.	6.59	23.05	7.11	1.84	31.59	26.82	7.88	17.00	1.12	26.00	1,800,782	377,465	2,742,273	187.37	133.41	0.71	4.65E-06	1.97E-08	2.33E-06	1.90E-05	7.85E-08	9.28E-06	1.61E-05	8.24E-08	9.57E-06
Std.	4.00	16.62	4.94	4.96	22.27	14.25	5.42	8.85	1.05	13.59	590,070	144,367	591,557	25.17	27.21	0.06	3.94E-06	1.94E-08	1.95E-06	1.54E-05	6.83E-08	6.66E-06	1.31E-05	6.83E-08	6.68E-06

P = Preliminary Data

N.A. = Information not available when table prepared.

For 1980-1994																									
Total	83	337	101	33	471	328	94	216	19	329	29,140,425	5,427,487	41,089,306	186.25	132.09	0.71	2.85E-06	1.53E-08	2.02E-06	1.13E-05	6.04E-08	7.98E-06	1.06E-05	5.71E-08	7.54E-06
Avg.	5.53	22.47	6.73	2.20	31.40	21.87	6.27	14.40	1.27	21.93	1,942,695	361,832	2,739,287	182.26	128.75	0.70	3.17E-06	1.81E-08	2.20E-06	1.28E-05	7.37E-08	8.83E-06	1.21E-05	6.99E-08	8.37E-06
Std.	2.67	16.24	4.30	5.54	24.06	7.48	3.13	5.00	1.03	7.58	505,792	127,482	585,700	18.40	20.80	0.06	2.04E-06	1.30E-08	1.36E-06	7.73E-06	5.01E-08	4.98E-06	7.42E-06	4.81E-08	4.79E-06

Table 3.13
Nonscheduled U.S. Air Carriers Operating Under 14 CFR 135 (Air Taxis)
[References 3.11 to 3.32]

Year	Fatal Acc.	Fatalities				Total Acc.	135 Aircraft Damage				135 Aircraft Hours Flown	135 Aircraft Miles (000)	135 Aircraft Departures	Average Speed (miles/hr.)	Average AC Miles/ Departure	Average AC Hours/ Departure	Fatal Accident Rate			Total Accident Rate			Crash (Dest. + Major Dam.) Rate		
		135 Pass.	135 Crew	Other	Total		Dest.	Major	Minor/ None/ Unkn.	Total							(/AC hour)	(/AC mile)	(/Departure)	(/AC hour)	(/AC mile)	(/Departure)	(/AC hour)	(/AC mile)	(/Departure)
1974																									
1975	24	N.A.	N.A.	N.A.	69	152	N.A.	N.A.	N.A.	N.A.	2,526,271	N.A.	N.A.	N.A.	N.A.	N.A.	9.50E-06	N.A.	N.A.	6.02E-05	N.A.	N.A.	N.A.	N.A.	N.A.
1976	31	N.A.	N.A.	N.A.	100	137	N.A.	N.A.	N.A.	N.A.	2,703,203	N.A.	N.A.	N.A.	N.A.	N.A.	1.15E-05	N.A.	N.A.	5.07E-05	N.A.	N.A.	N.A.	N.A.	N.A.
1977	31	N.A.	N.A.	N.A.	118	158	N.A.	N.A.	N.A.	N.A.	3,304,220	N.A.	N.A.	N.A.	N.A.	N.A.	9.38E-06	N.A.	N.A.	4.78E-05	N.A.	N.A.	N.A.	N.A.	N.A.
1978	54	99	53	3	155	198	74	125	1	200	3,545,753	N.A.	N.A.	N.A.	N.A.	N.A.	1.52E-05	N.A.	N.A.	5.58E-05	N.A.	N.A.	5.61E-05	N.A.	N.A.
1979	30	39	34	4	77	160	40	118	3	161	3,684,321	N.A.	N.A.	N.A.	N.A.	N.A.	8.14E-06	N.A.	N.A.	4.34E-05	N.A.	N.A.	4.29E-05	N.A.	N.A.
1980	46	62	41	2	105	171	52	118	2	172	3,617,724	N.A.	N.A.	N.A.	N.A.	N.A.	1.27E-05	N.A.	N.A.	4.73E-05	N.A.	N.A.	4.70E-05	N.A.	N.A.
1981	40	57	35	2	94	157	54	102	2	158	2,895,827	N.A.	N.A.	N.A.	N.A.	N.A.	1.38E-05	N.A.	N.A.	5.42E-05	N.A.	N.A.	5.39E-05	N.A.	N.A.
1982	31	45	27	0	72	132	47	83	4	134	3,008,000	N.A.	N.A.	N.A.	N.A.	N.A.	1.03E-05	N.A.	N.A.	4.39E-05	N.A.	N.A.	4.32E-05	N.A.	N.A.
1983	27	27	30	5	62	141	33	106	4	143	2,378,000	N.A.	N.A.	N.A.	N.A.	N.A.	1.14E-05	N.A.	N.A.	5.93E-05	N.A.	N.A.	5.85E-05	N.A.	N.A.
1984	23	22	30	0	52	146	40	104	3	147	2,843,000	N.A.	N.A.	N.A.	N.A.	N.A.	8.09E-06	N.A.	N.A.	5.14E-05	N.A.	N.A.	5.07E-05	N.A.	N.A.
1985	35	39	36	1	76	154	50	104	3	157	2,570,000	N.A.	N.A.	N.A.	N.A.	N.A.	1.36E-05	N.A.	N.A.	5.99E-05	N.A.	N.A.	5.99E-05	N.A.	N.A.
1986	31	26	35	4	65	117	38	77	3	118	2,690,000	N.A.	N.A.	N.A.	N.A.	N.A.	1.15E-05	N.A.	N.A.	4.35E-05	N.A.	N.A.	4.28E-05	N.A.	N.A.
1987	30	31	32	2	65	96	34	62	4	100	2,657,000	N.A.	N.A.	N.A.	N.A.	N.A.	1.13E-05	N.A.	N.A.	3.61E-05	N.A.	N.A.	3.61E-05	N.A.	N.A.
1988	28	22	33	4	59	101	37	62	2	101	2,632,000	N.A.	N.A.	N.A.	N.A.	N.A.	1.06E-05	N.A.	N.A.	3.84E-05	N.A.	N.A.	3.76E-05	N.A.	N.A.
1989	25	46	35	2	83	110	32	80	0	112	3,020,000	N.A.	N.A.	N.A.	N.A.	N.A.	8.28E-06	N.A.	N.A.	3.64E-05	N.A.	N.A.	3.71E-05	N.A.	N.A.
1990	28	20	28	2	50	106	38	68	2	108	2,249,000	N.A.	N.A.	N.A.	N.A.	N.A.	1.24E-05	N.A.	N.A.	4.71E-05	N.A.	N.A.	4.71E-05	N.A.	N.A.
1991	27	35	31	4	70	87	31	53	4	88	2,241,000	N.A.	N.A.	N.A.	N.A.	N.A.	1.20E-05	N.A.	N.A.	3.88E-05	N.A.	N.A.	3.75E-05	N.A.	N.A.
1992	24	43	22	3	68	76	26	49	1	76	2,009,000	N.A.	N.A.	N.A.	N.A.	N.A.	1.19E-05	N.A.	N.A.	3.78E-05	N.A.	N.A.	3.73E-05	N.A.	N.A.
1993	19	20	22	0	42	69	26	44	0	70	1,809,000	N.A.	N.A.	N.A.	N.A.	N.A.	1.05E-05	N.A.	N.A.	3.81E-05	N.A.	N.A.	3.87E-05	N.A.	N.A.
1994	26	40	22	1	63	85	24	60	2	86	1,993,000	N.A.	N.A.	N.A.	N.A.	N.A.	1.30E-05	N.A.	N.A.	4.26E-05	N.A.	N.A.	4.21E-05	N.A.	N.A.
1995P	24	N.A.	N.A.	0	52	75	N.A.	N.A.	N.A.	N.A.	1,910,000	N.A.	N.A.	N.A.	N.A.	N.A.	1.26E-05	N.A.	N.A.	3.93E-05	N.A.	N.A.	N.A.	N.A.	N.A.
1996P	27	N.A.	N.A.	0	59	87	N.A.	N.A.	N.A.	N.A.	1,902,000	N.A.	N.A.	N.A.	N.A.	N.A.	1.42E-05	N.A.	N.A.	4.57E-05	N.A.	N.A.	N.A.	N.A.	N.A.
Total	661	673	546	39	1656	2715	676	1415	40	2131	58,188,319	N.A.	N.A.	N.A.	N.A.	N.A.	1.14E-05	N.A.	N.A.	4.67E-05	N.A.	N.A.	N.A.	N.A.	N.A.
Avg.	30.05	39.59	32.12	2.05	75.27	123.4	39.76	83.24	2.35	125.4	2,644,924	N.A.	N.A.	N.A.	N.A.	N.A.	1.15E-05	N.A.	N.A.	4.63E-05	N.A.	N.A.	4.52E-05	N.A.	N.A.
Std.	7.91	19.75	7.58	1.65	25.93	36.37	12.60	26.51	1.32	37.21	564,183	N.A.	N.A.	N.A.	N.A.	N.A.	1.98E-06	N.A.	N.A.	7.84E-06	N.A.	N.A.	7.97E-06	N.A.	N.A.

P = Preliminary Data

N.A. = Information not available when table prepared.

For 1980-1994

Total	440	535	459	32	1026	1748	562	1172	36	1770	38,612,551	N.A.	N.A.	N.A.	N.A.	N.A.	1.14E-05	N.A.	N.A.	4.53E-05	N.A.	N.A.	4.49E-05	N.A.	N.A.
Avg.	29.33	35.67	30.60	2.13	68.40	116.5	37.47	78.13	2.40	118.0	2,574,170	N.A.	N.A.	N.A.	N.A.	N.A.	1.14E-05	N.A.	N.A.	4.50E-05	N.A.	N.A.	4.46E-05	N.A.	N.A.
Std.	6.81	13.31	5.64	1.60	16.40	31.96	9.59	23.75	1.35	32.18	476,088	N.A.	N.A.	N.A.	N.A.	N.A.	1.70E-06	N.A.	N.A.	8.03E-06	N.A.	N.A.	7.96E-06	N.A.	N.A.

Table 3.14
Total (Scheduled and Nonscheduled) U.S. Air Carriers Operating Under 14 CFR 135
[References 3.11 to 3.32]

Year	Fatal Acc.	Fatalities				Total Acc.	135 Aircraft Damage				135 Aircraft Hours Flown	135 Aircraft Miles (000)	135 Aircraft Departures	Average Speed (miles/hr.)	Average AC Miles/ Departure	Average AC Hours/ Departure	Fatal Accident Rate			Total Accident Rate			Crash (Dest. + Major Dam.) Rate		
		135 Pass.	135 Crew	Other	Total		Dest.	Major	Minor/ None/ Unkn.	Total							(/AC hour)	(/AC mile)	/Departure	(/AC hour)	(/AC mile)	/Departure	(/AC hour)	(/AC mile)	/Departure
1974																									
1975	36	N.A.	N.A.	N.A.	97	200	N.A.	N.A.	N.A.	N.A.	3,462,583	N.A.	N.A.	N.A.	N.A.	N.A.	1.04E-05	N.A.	N.A.	5.78E-05	N.A.	N.A.	N.A.	N.A.	N.A.
1976	40	N.A.	N.A.	N.A.	127	172	N.A.	N.A.	N.A.	N.A.	3,668,499	N.A.	N.A.	N.A.	N.A.	N.A.	1.09E-05	N.A.	N.A.	4.69E-05	N.A.	N.A.	N.A.	N.A.	N.A.
1977	40	N.A.	N.A.	N.A.	150	202	N.A.	N.A.	N.A.	N.A.	4,454,470	N.A.	N.A.	N.A.	N.A.	N.A.	8.98E-06	N.A.	N.A.	4.53E-05	N.A.	N.A.	N.A.	N.A.	N.A.
1978	68	133	67	3	203	259	94	166	1	261	4,847,889	N.A.	N.A.	N.A.	N.A.	N.A.	1.40E-05	N.A.	N.A.	5.34E-05	N.A.	N.A.	5.36E-05	N.A.	N.A.
1979	45	89	50	4	143	212	60	150	3	213	4,854,242	N.A.	N.A.	N.A.	N.A.	N.A.	9.27E-06	N.A.	N.A.	4.37E-05	N.A.	N.A.	4.33E-05	N.A.	N.A.
1980	54	89	51	2	142	209	61	145	5	211	4,793,312	N.A.	N.A.	N.A.	N.A.	N.A.	1.13E-05	N.A.	N.A.	4.36E-05	N.A.	N.A.	4.30E-05	N.A.	N.A.
1981	49	78	46	4	128	188	64	122	3	189	4,136,591	N.A.	N.A.	N.A.	N.A.	N.A.	1.18E-05	N.A.	N.A.	4.54E-05	N.A.	N.A.	4.50E-05	N.A.	N.A.
1982	36	53	33	0	86	158	55	100	6	161	4,307,748	N.A.	N.A.	N.A.	N.A.	N.A.	8.36E-06	N.A.	N.A.	3.67E-05	N.A.	N.A.	3.60E-05	N.A.	N.A.
1983	29	36	31	6	73	158	39	115	6	160	3,888,908	N.A.	N.A.	N.A.	N.A.	N.A.	7.46E-06	N.A.	N.A.	4.06E-05	N.A.	N.A.	3.96E-05	N.A.	N.A.
1984	30	60	38	2	100	168	47	119	3	169	4,588,762	N.A.	N.A.	N.A.	N.A.	N.A.	6.54E-06	N.A.	N.A.	3.66E-05	N.A.	N.A.	3.62E-05	N.A.	N.A.
1985	42	67	44	2	113	175	59	116	3	178	4,307,106	N.A.	N.A.	N.A.	N.A.	N.A.	9.75E-06	N.A.	N.A.	4.06E-05	N.A.	N.A.	4.06E-05	N.A.	N.A.
1986	33	29	36	4	69	132	39	90	5	134	4,414,586	N.A.	N.A.	N.A.	N.A.	N.A.	7.48E-06	N.A.	N.A.	2.99E-05	N.A.	N.A.	2.92E-05	N.A.	N.A.
1987	40	73	47	4	124	129	45	80	7	132	4,603,349	N.A.	N.A.	N.A.	N.A.	N.A.	8.69E-06	N.A.	N.A.	2.80E-05	N.A.	N.A.	2.72E-05	N.A.	N.A.
1988	30	39	37	4	80	120	40	77	3	120	4,724,689	N.A.	N.A.	N.A.	N.A.	N.A.	6.35E-06	N.A.	N.A.	2.54E-05	N.A.	N.A.	2.48E-05	N.A.	N.A.
1989	30	71	41	2	114	129	37	93	1	131	5,260,535	N.A.	N.A.	N.A.	N.A.	N.A.	5.70E-06	N.A.	N.A.	2.45E-05	N.A.	N.A.	2.47E-05	N.A.	N.A.
1990	32	23	29	4	56	122	40	80	3	123	4,590,760	N.A.	N.A.	N.A.	N.A.	N.A.	6.97E-06	N.A.	N.A.	2.66E-05	N.A.	N.A.	2.61E-05	N.A.	N.A.
1991	35	99	44	26	169	109	40	66	4	110	4,532,693	N.A.	N.A.	N.A.	N.A.	N.A.	7.72E-06	N.A.	N.A.	2.40E-05	N.A.	N.A.	2.34E-05	N.A.	N.A.
1992	31	56	30	3	89	99	33	65	1	99	4,372,745	N.A.	N.A.	N.A.	N.A.	N.A.	7.09E-06	N.A.	N.A.	2.26E-05	N.A.	N.A.	2.24E-05	N.A.	N.A.
1993	23	39	26	1	66	85	30	54	2	86	4,450,268	N.A.	N.A.	N.A.	N.A.	N.A.	5.17E-06	N.A.	N.A.	1.91E-05	N.A.	N.A.	1.89E-05	N.A.	N.A.
1994	29	60	27	1	88	95	27	66	3	96	4,780,904	N.A.	N.A.	N.A.	N.A.	N.A.	6.07E-06	N.A.	N.A.	1.99E-05	N.A.	N.A.	N.A.	N.A.	N.A.
1995P	26	N.A.	N.A.	N.A.	61	86	N.A.	N.A.	N.A.	N.A.	4,388,872	N.A.	N.A.	N.A.	N.A.	N.A.	5.92E-06	N.A.	N.A.	1.96E-05	N.A.	N.A.	N.A.	N.A.	N.A.
1996P	28	N.A.	N.A.	N.A.	73	98	N.A.	N.A.	N.A.	N.A.	4,376,000	N.A.	N.A.	N.A.	N.A.	N.A.	6.40E-06	N.A.	N.A.	2.24E-05	N.A.	N.A.	N.A.	N.A.	N.A.
Total	806	1094	677	72	2351	3305	810	1704	59	2573	97,805,531	N.A.	N.A.	N.A.	N.A.	N.A.	8.24E-06	N.A.	N.A.	3.38E-05	N.A.	N.A.	N.A.	N.A.	N.A.
Avg.	36.64	64.35	39.82	4.24	106.86	150.2	47.65	100.2	3.47	151.4	4,445,706	N.A.	N.A.	N.A.	N.A.	N.A.	8.29E-06	N.A.	N.A.	3.42E-05	N.A.	N.A.	3.34E-05	N.A.	N.A.
Std.	10.38	28.20	10.64	5.80	38.30	48.12	16.45	32.92	1.81	47.86	402,756	N.A.	N.A.	N.A.	N.A.	N.A.	2.31E-06	N.A.	N.A.	1.18E-05	N.A.	N.A.	1.01E-05	N.A.	N.A.

P = Preliminary Data

N.A. = Information not available when table prepared.

For 1980-1994

Total	523	872	560	65	1497	2076	656	1388	55	2099	67,752,976	N.A.	N.A.	N.A.	N.A.	N.A.	7.72E-06	N.A.	N.A.	3.06E-05	N.A.	N.A.	3.02E-05	N.A.	N.A.
Avg.	34.87	58.13	37.33	4.33	99.80	138.4	43.73	92.53	3.67	139.9	4,516,865	N.A.	N.A.	N.A.	N.A.	N.A.	7.76E-06	N.A.	N.A.	3.09E-05	N.A.	N.A.	3.12E-05	N.A.	N.A.
Std.	8.25	22.08	7.92	6.20	31.50	36.26	11.33	26.25	1.80	36.71	318,826	N.A.	N.A.	N.A.	N.A.	N.A.	1.94E-06	N.A.	N.A.	8.88E-06	N.A.	N.A.	8.57E-06	N.A.	N.A.

Table 3.15
Scheduled 14 CFR 135 Aircraft Accidents by Damage and Flight Phase [References 3.16-3.30]

Flight Phases	1980				1981				1982				1983				1984				1985				1986				1987			
	Dest.	Major	Minor/None	Total	Dest.	Major	Minor/None	Total	Dest.	Major	Minor/None	Total	Dest.	Major	Minor/None	Total	Dest.	Major	Minor/None	Total	Dest.	Major	Minor/None	Total	Dest.	Major	Minor/None	Total	Dest.	Major	Minor/None	Total
Taxi	0	8	0	8	N.A.	N.A.	N.A.	N.A.	0	3	0	3	0	2	0	2	0	4	0	4	0	1	0	1	0	1	1	2	0	2	0	2
Takeoff (TO)	0	2	0	2	N.A.	N.A.	N.A.	N.A.	0	4	0	4	0	2	0	2	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0
Initial Climb (IC)	3	5	0	8	N.A.	N.A.	N.A.	N.A.	1	3	0	4	1	1	0	2	1	1	0	2	1	2	0	3	0	1	0	1	3	0	0	3
Climb to Cruise (CC)	0	0	0	0	N.A.	N.A.	N.A.	N.A.	0	1	0	1	0	0	0	0	2	1	0	3	0	0	0	0	0	2	0	2	0	0	1	1
Cruise/Enroute (ER)	1	2	0	3	N.A.	N.A.	N.A.	N.A.	2	2	0	4	3	1	0	4	0	0	0	0	0	1	0	1	0	1	1	2	1	0	0	1
Initial Descent (ID)	1	0	1	2	N.A.	N.A.	N.A.	N.A.	1	0	0	1	0	1	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	4	0	4
Landing Approach (LA)	3	1	1	5	N.A.	N.A.	N.A.	N.A.	3	2	0	5	1	2	0	3	3	4	0	7	6	4	0	10	1	2	0	3	5	3	0	8
Landing (L)	0	7	0	7	N.A.	N.A.	N.A.	N.A.	0	2	0	2	0	1	0	1	0	5	0	5	0	4	0	4	0	3	0	3	0	6	0	6
Ground (G)	0	2	1	3	N.A.	N.A.	N.A.	N.A.	0	1	1	2	1	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2
Other/Unkn./Not Reported	1	0	0	1	N.A.	N.A.	N.A.	N.A.	1	0	0	1	0	0	0	0	1	0	0	1	1	0	0	1	0	1	0	1	2	2	1	5
Total	9	27	3	39	N.A.	N.A.	N.A.	N.A.	8	18	1	27	6	10	2	18	7	15	0	22	9	12	0	21	1	13	2	16	11	18	3	32

Flight Phases	1988				1989				1990				1991				1992				1993				1994				1995				1980, 1982-1994 Total				Adjstd. Pct.	
	Dest.	Major	Minor/None	Total	Dest.	Major	Minor/None	Total	Dest.	Major	Minor/None	Total	Dest.	Major	Minor/None	Total	Dest.	Major	Minor/None	Total	Dest.	Major	Minor/None	Total	Dest.	Major	Minor/None	Total	Dest.	Major	Minor/None	Total	Pct.					
Taxi	0	5	0	5	0	7	0	7	0	2	0	2	0	0	0	0	0	3	0	3	0	1	0	1	0	1	0	1	N.A.	N.A.	N.A.	N.A.	0	40	1	41	13.62%	
Takeoff (TO)	0	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	3	0	0	0	0	N.A.	N.A.	N.A.	N.A.	0	15	0	15	4.98%	6.8%
Initial Climb (IC)	2	0	0	2	0	0	0	0	0	1	0	1	0	1	0	1	1	3	0	4	2	1	0	3	0	1	0	1	N.A.	N.A.	N.A.	N.A.	15	20	0	35	11.63%	16.0%
Climb to Cruise (CC)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	1	N.A.	N.A.	N.A.	N.A.	2	6	1	9	2.99%	4.1%	
Cruise/Enroute (ER)	0	2	1	3	3	0	0	3	2	1	0	3	2	1	0	3	1	2	0	3	1	0	0	1	1	0	0	1	N.A.	N.A.	N.A.	N.A.	17	13	2	32	10.63%	14.6%
Initial Descent (ID)	0	1	0	1	0	1	0	1	0	1	0	1	2	0	0	2	1	1	0	2	0	1	0	1	0	0	0	0	N.A.	N.A.	N.A.	N.A.	6	10	1	17	5.65%	7.8%
Landing Approach (LA)	1	0	0	1	1	1	0	2	0	2	0	2	2	0	0	2	4	4	0	8	1	1	0	2	2	1	0	3	N.A.	N.A.	N.A.	N.A.	33	27	1	61	20.27%	27.9%
Landing (L)	0	4	0	4	0	1	0	1	0	5	0	5	0	5	0	5	0	2	0	2	0	2	0	2	0	2	1	3	N.A.	N.A.	N.A.	N.A.	0	49	1	50	16.61%	22.8%
Ground (G)	0	1	0	1	0	2	1	3	0	0	1	1	1	1	1	3	0	1	0	1	0	0	2	2	0	0	0	0	N.A.	N.A.	N.A.	N.A.	2	9	10	21	6.98%	
Other/Unkn./Not Reported	0	1	0	1	1	0	0	1	1	0	0	1	2	5	0	7	0	0	0	0	0	0	0	0	0	0	0	0	N.A.	N.A.	N.A.	N.A.	10	9	1	20	6.64%	
Total	3	15	1	19	5	13	1	19	3	12	1	16	9	13	1	23	7	16	0	23	4	10	2	16	3	6	1	10	N.A.	N.A.	N.A.	N.A.	85	198	18	301	100.00%	100.0%

N.A. = Information not available at time of table preparation.

Table 3.16
Scheduled 14 CFR 135 Crash Rates by Flight Phase

	Calc.		Calc.		Average		Assumed		Calculated		Crash Rate by Flight Phases				Accident Rate by Combined Flight Phases			
Flight Phases	No. of		No. of	Adjusted	Pct.	Flt. Time	Average	Average	Average	Distance	Crashes	Crashes	Crashes	Crashes	Accidents	Accidents	Accidents	Accidents
	Accs.	Pct.	Accs.	Pct.		(hours)	Miles	Knots	Miles	Knots	/Departure	/AC Hour	/Mile	/Knot	/Departure	/AC Hour	/Mile	/Knot
Taxi	45	13.62%																
Takeoff	16	4.98%	16	7.10%	1.13%	0.008	86.31	75.00	0.69	0.60	3.975E-07	4.969E-05	5.757E-07	6.626E-07	1.326E-06	5.525E-05	4.572E-07	5.262E-07
Initial Climb	38	11.63%	38	16.20%	2.25%	0.016	138.09	120.00	2.21	1.92	9.284E-07	5.802E-05	4.202E-07	4.835E-07				
Climb to Cruise	10	2.99%	10	3.80%	18.73%	0.133	169.16	147.00	22.50	19.55	2.387E-07	1.795E-06	1.061E-08	1.221E-08				
Cruise/ Enroute	35	10.63%	35	14.80%	31.41%	0.223	235.91	205.00	52.61	45.72	8.486E-07	3.805E-06	1.613E-08	1.856E-08	1.538E-06	2.828E-06	1.375E-08	1.582E-08
Descent from Cruise	19	5.65%	19	8.10%	26.48%	0.188	195.63	170.00	36.78	31.96	4.510E-07	2.399E-06	1.226E-08	1.411E-08				
Landing Approach	66	20.27%	66	27.60%	18.87%	0.134	126.59	110.00	16.96	14.74	1.618E-06	1.208E-05	9.539E-08	1.098E-07				
Landing	54	16.61%	54	22.40%	1.13%	0.008	57.54	50.00	0.46	0.40	1.326E-06	1.657E-04	2.880E-06	3.315E-06	2.944E-06	2.073E-05	1.690E-07	1.945E-07
Ground	23	6.98%																
Other/Unkn./ Not Reported	22	6.64%																
TOTAL:	328	100.00%	239	100.00%	100.00%	0.710	186.21	161.81	132.21	114.89	5.808E-06	8.180E-06	4.393E-08	5.056E-08	5.808E-06	8.180E-06	4.393E-08	5.056E-08

Bases for Scheduled 14 CFR 135 Crash Rates by Flight Phase, 1980-1994 Totals:

0.71 Hours Average Flight Duration
132.09 Miles Average Flight Distance
186.04 Miles/Hour Average Flight Velocity
41,089,306 Departures

Table 3.17
General Aviation Accidents by Phase of Flight Operation
Single Engine-Reciprocating, Fixed Wing
[References 3.49 to 3.57]

Single-Engine Reciprocating, Fixed Wing	1986				1987				1988				1989				1990				1991			
Phase of Operation	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.
Standing	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	0	1	0	1	0	0	2	2
Standing-preflight	1	0	0	1	0	1	0	1	0	0	1	1	0	0	0	0	0	0	0	0	1	1	0	2
Standing-starting engine(s)	0	5	16	21	1	2	17	20	0	3	15	18	0	0	13	13	0	1	7	8	0	2	4	6
Standing-engine(s) operating	1	0	4	5	2	2	7	11	1	1	6	8	1	4	9	14	0	1	6	7	2	1	8	11
Standing-engine(s) not operating	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Standing-idling rotors	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxi	1	0	12	13	0	0	3	3	1	0	5	6	0	0	5	5	1	0	9	10	0	1	4	5
Taxi-to takeoff	0	0	18	18	0	0	24	24	0	1	22	23	0	0	20	20	0	0	22	22	0	0	14	14
Taxi-from landing	0	1	15	16	0	0	26	26	0	0	28	28	0	0	23	23	0	0	16	16	0	2	15	17
Taxi-aerial	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Takeoff	6	5	19	30	1	6	15	22	5	5	20	30	3	3	19	25	5	7	21	33	5	4	22	31
Takeoff-aborted	0	0	0	0	0	0	0	0	0	1	15	16	0	0	0	0	0	0	0	0	0	0	0	0
Takeoff-ground run	4	6	100	110	1	7	99	107	1	2	70	73	2	1	67	70	3	3	68	74	1	5	79	85
Takeoff-initial climb	54	52	204	310	42	63	195	300	56	64	167	287	48	48	185	281	54	56	161	271	43	52	165	260
Climb	11	5	18	34	4	4	10	18	3	2	13	18	6	1	7	14	6	5	7	18	13	9	18	40
Climb-to cruise	18	5	22	45	12	6	27	45	21	4	23	48	9	2	13	24	11	5	9	25	8	4	21	33
Cruise	29	13	96	138	30	8	73	111	33	16	85	134	43	16	90	149	36	16	74	126	41	19	99	159
Cruise-normal	36	32	143	211	48	15	134	197	45	27	143	215	49	17	121	187	29	12	117	158	29	20	103	152
Cruise-holding (IFR)	0	0	0	0	0	0	0	0	0	0	2	2	0	0	1	1	0	0	0	0	0	0	1	1
Descent	9	0	9	18	3	0	3	6	8	1	7	16	8	1	5	14	4	1	8	13	3	5	6	14
Descent-normal	9	5	22	36	7	5	28	40	4	1	34	39	5	2	18	25	9	5	20	34	3	4	21	28
Descent-emergency	2	2	4	8	0	0	4	4	1	0	1	2	0	0	2	2	0	0	1	1	2	1	2	5
Descent-uncontrolled	3	1	1	5	2	0	2	4	0	1	0	1	1	0	2	3	2	0	2	4	2	0	2	4
Approach	9	5	17	31	5	6	21	32	9	5	19	33	11	7	29	47	8	2	13	23	10	1	18	29
Approach-VFR pattern-downwind	4	2	15	21	9	4	10	23	3	3	10	16	5	2	8	15	11	1	13	25	5	4	8	17
Approach-VFR pattern-base turn	4	0	5	9	1	2	3	6	2	2	5	9	3	1	4	8	4	1	9	14	3	1	3	7
Approach-VFR pattern-base to final	7	2	6	15	7	1	6	14	2	2	7	11	9	4	6	19	6	3	10	19	7	2	11	20
Approach-VFR pattern-final approach	9	28	77	114	9	15	80	104	7	20	69	96	13	15	71	99	17	8	80	105	15	8	58	81
Approach-go-around (VFR)	4	9	42	55	4	11	31	46	6	7	37	50	4	5	27	36	7	5	22	34	4	7	34	45
Approach-IAF to FAF/outer marker (IFR)	1	2	1	4	4	0	0	4	5	0	2	7	4	1	0	5	3	0	2	5	2	1	1	4
Approach-FAF/outer marker to threshold	14	3	6	23	6	3	4	13	2	3	3	8	3	0	2	5	5	1	4	10	3	2	2	7
Approach-circling (IFR)	1	0	1	2	1	0	0	1	0	1	1	2	0	0	0	0	0	0	0	0	0	1	0	1
Approach-missed approach (IFR)	1	0	3	4	3	0	0	3	3	0	2	5	1	0	0	1	3	0	0	3	1	1	0	2
Landing-aborted	0	0	0	0	0	0	0	0	3	4	18	25	0	0	0	0	0	0	0	0	0	0	0	0
Landing	3	7	38	48	3	3	30	36	0	1	36	37	2	2	33	37	1	2	18	21	1	3	11	15
Landing-flare/touchdown	3	9	188	200	1	9	195	205	2	5	153	160	3	8	146	157	2	5	141	148	0	2	146	148
Landing-roll	6	6	259	271	0	8	280	288	1	9	238	248	2	7	220	229	1	5	234	240	1	0	208	209
Maneuvering	87	28	53	168	110	20	49	179	99	21	55	175	65	23	57	145	86	12	42	140	85	27	54	166
Maneuvering-aerial application	6	8	41	55	9	10	42	61	5	14	39	58	16	7	37	60	9	5	42	56	8	9	41	58
Maneuvering-turn to reverse direction	10	2	17	29	2	8	8	18	8	2	9	19	7	2	0	9	11	4	9	24	8	2	9	19
Maneuvering-turn to landing area (emer)	0	0	2	2	1	0	0	1	0	0	7	7	0	0	1	1	2	0	0	2	1	0	1	2
Hover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	3	0	2	5	3	1	20	24	0	0	1	1	3	6	53	62	4	5	51	60	9	3	40	52
Unknown	11	2	0	13	11	1	2	14	10	1	2	13	16	0	2	18	17	0	1	18	11	0	1	12
Not reported	1	0	1	2	4	0	2	6	2	0	4	6	1	0	0	1	3	0	5	8	4	0	6	10
Total:	368	245	1477	2090	346	221	1451	2018	348	229	1375	1952	343	185	1297	1825	360	172	1245	1777	331	204	1238	1773

Table 3.17 (Continued)
General Aviation Accidents by Phase of Flight Operation
Single Engine-Reciprocating, Fixed Wing
[References 3.49 to 3.57]

Single-Engine Reciprocating, Fixed Wing Phase of Operation	1992				1993				1994				TOTAL				Flight Phase	No.	Pct.
	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.			
Standing	0	0	0	0	0	1	1	2	0	0	0	0	0	2	5	7	Standing	203	1.25%
Standing-preflight	0	1	0	1	0	0	0	0	0	0	0	0	2	3	1	6			
Standing-starting engine(s)	0	1	3	4	1	0	8	9	0	1	6	7	2	15	89	106			
Standing-engine(s) operating	2	0	1	3	3	3	2	8	3	8	4	15	15	20	47	82			
Standing-engine(s) not operating	0	0	0	0	0	0	0	0	0	1	0	1	0	1	1	2			
Standing-idling rotors	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Taxi	0	0	4	4	0	0	6	6	1	0	7	8	4	1	55	60	Taxi	397	2.44%
Taxi-to takeoff	0	2	15	17	0	1	17	18	1	0	11	12	1	4	163	168			
Taxi-from landing	0	1	13	14	0	1	14	15	0	0	13	13	0	5	163	168			
Taxi-aerial	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1			
Takeoff	4	2	11	17	4	2	13	19	6	8	29	43	39	42	169	250	Takeoff	1013	6.23%
Takeoff-aborted	0	0	0	0	0	0	0	0	0	1	19	20	0	2	34	36			
Takeoff-ground run	0	4	67	71	2	0	70	72	3	6	56	65	17	34	676	727			
Takeoff-initial climb	46	46	153	245	40	44	147	231	55	43	138	236	438	468	1515	2421			
Climb	5	1	14	20	8	3	17	28	6	8	11	25	62	38	115	215	Climb	509	3.13%
Climb-to cruise	4	3	16	23	5	5	14	24	10	4	13	27	98	38	158	294			
Cruise	39	13	73	125	39	21	97	157	28	20	103	151	318	142	790	1250	Cruise	2740	16.85%
Cruise-normal	35	11	105	151	27	10	89	126	21	11	57	89	319	155	1012	1486			
Cruise-holding (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4			
Descent	4	2	2	8	10	0	6	16	3	2	4	9	52	12	50	114			
Descent-normal	10	2	24	36	3	0	24	27	5	3	17	25	55	27	208	290	Descent	468	2.88%
Descent-emergency	1	0	2	3	1	1	3	5	2	0	1	3	9	4	20	33			
Descent-uncontrolled	1	2	2	5	0	1	2	3	2	0	0	2	13	5	13	31			
Approach	9	7	5	21	6	2	15	23	6	9	13	28	73	44	150	267	Approach	2010	12.36%
Approach-VFR pattern-downwind	2	1	14	17	2	3	4	9	3	4	10	17	44	24	92	160			
Approach-VFR pattern-base turn	2	1	6	9	3	2	3	8	0	1	1	2	22	11	39	72			
Approach-VFR pattern-base to final	6	3	6	15	5	0	10	15	1	1	10	12	50	18	72	140			
Approach-VFR pattern-final approach	12	11	61	84	10	9	63	82	8	13	52	73	100	127	611	838			
Approach-go-around (VFR)	6	3	23	32	3	6	34	43	3	5	14	22	41	58	264	363			
Approach-IAF to FAF/outer marker (IFR)	3	0	1	4	1	0	1	2	0	0	1	1	23	4	9	36			
Approach-FAF/outer marker to threshold	7	1	4	12	4	2	4	10	1	1	5	7	45	16	34	95			
Approach-circling (IFR)	0	0	0	0	2	0	0	2	3	1	0	4	7	3	2	12			
Approach-missed approach (IFR)	2	0	1	3	0	2	0	2	4	0	0	4	18	3	6	27			
Landing-aborted	0	0	0	0	0	0	0	0	1	2	17	20	4	6	35	45			
Landing	3	2	32	37	0	3	31	34	2	0	23	25	15	23	252	290			
Landing-flare/touchdown	2	7	139	148	2	3	123	128	2	5	136	143	17	53	1367	1437			
Landing-roll	3	4	209	216	1	5	209	215	1	5	208	214	16	49	2065	2130			
Maneuvering	80	18	44	142	94	25	41	160	85	13	51	149	791	187	446	1424	Maneuvering	2102	12.92%
Maneuvering-aerial application	6	8	34	48	8	7	27	42	8	8	41	57	75	76	344	495			
Maneuvering-turn to reverse direction	9	5	9	23	3	3	7	13	3	5	0	8	61	33	68	162			
Maneuvering-turn to landing area (emer)	1	1	0	2	0	0	1	1	1	0	2	3	6	1	14	21			
Hover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Other	10	5	39	54	2	3	42	47	0	0	0	0	34	23	248	305	Other/?/NR	499	3.07%
Unknown	13	0	6	19	12	2	1	15	6	0	2	8	107	6	17	130			
Not reported	4	0	7	11	4	2	5	11	4	0	5	9	27	2	35	64			
Total:	331	168	1145	1644	305	172	1151	1628	288	189	1080	1557	3020	1785	11459	16264		16264	100.00%

Table 3.18
General Aviation Accidents by Phase of Flight Operation
Multi-Engine Reciprocating, Fixed Wing
[References 3.49 to 3.57]

Multi-Engine Reciprocating, Fixed Wing Phase of Operation	1986				1987				1988				1989				1990				1991			
	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.
Standing	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Standing-preflight	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Standing-starting engine(s)	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Standing-engine(s) operating	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Standing-engine(s) not operating	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Standing-idling rotors	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxi	0	0	0	0	0	0	2	2	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Taxi-to takeoff	0	0	3	3	0	0	7	7	0	0	1	1	0	0	2	2	0	0	3	3	0	0	2	2
Taxi-from landing	0	0	3	3	0	0	0	0	1	0	2	3	0	0	3	3	0	0	2	2	0	0	1	1
Taxi-aerial	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Takeoff	2	0	5	7	1	0	3	4	0	0	0	0	0	0	1	1	1	1	1	3	6	0	3	9
Takeoff-aborted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Takeoff-ground run	0	0	5	5	1	1	8	10	0	0	7	7	0	0	7	7	0	0	3	3	0	2	2	4
Takeoff-initial climb	13	2	11	26	5	3	14	22	8	0	7	15	10	2	9	21	4	2	10	16	5	4	14	23
Climb	1	1	1	3	0	0	2	2	2	1	1	4	1	1	0	2	1	0	1	2	1	1	1	3
Climb-to cruise	2	0	2	4	2	2	2	6	3	0	2	5	2	0	1	3	1	1	4	6	4	0	1	5
Cruise	4	2	6	12	3	0	5	8	8	0	3	11	4	0	4	8	2	0	2	4	8	3	5	16
Cruise-normal	7	3	14	24	10	3	11	24	14	0	7	21	10	0	12	22	4	1	9	14	4	2	6	12
Cruise-holding (IFR)	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Descent	2	0	0	2	1	0	1	2	1	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0
Descent-normal	0	0	2	2	0	1	2	3	0	0	3	3	0	0	1	1	0	0	0	0	1	1	1	3
Descent-emergency	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Descent-uncontrolled	0	0	0	0	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Approach	2	0	2	4	1	0	0	1	2	1	2	5	3	0	4	7	5	1	2	8	2	0	3	5
Approach-VFR pattern-downwind	0	0	1	1	0	0	1	1	0	1	2	3	1	0	0	1	1	1	3	5	0	0	3	3
Approach-VFR pattern-base turn	1	0	0	1	0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0
Approach-VFR pattern-base to final	2	0	1	3	1	0	1	2	2	0	0	2	0	0	0	0	0	0	1	1	1	0	1	2
Approach-VFR pattern-final approach	3	2	5	10	1	1	6	8	1	3	2	6	0	1	8	9	1	1	5	7	0	1	4	5
Approach-go-around (VFR)	0	0	3	3	1	0	1	2	1	0	2	3	0	0	1	1	0	3	3	6	3	1	2	6
Approach-IAF to FAF/outer marker (IFR)	1	1	0	2	0	0	0	0	2	1	0	3	2	0	0	2	1	0	0	1	2	0	0	2
Approach-FAF/outer marker to threshold	2	3	2	7	1	1	1	3	3	1	1	5	0	0	2	2	2	0	2	4	2	1	3	6
Approach-circling (IFR)	1	0	1	2	1	0	0	1	3	0	1	4	0	0	1	1	1	0	0	1	1	1	0	2
Approach-missed approach (IFR)	1	2	0	3	1	0	1	2	1	0	0	1	0	0	0	0	1	0	1	2	1	0	1	2
Landing-aborted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Landing	0	0	0	0	1	0	2	3	0	0	2	2	0	0	7	7	0	0	3	3	0	0	1	1
Landing-flare/touchdown	0	0	18	18	1	0	25	26	0	0	12	12	0	0	12	12	1	1	10	12	0	0	9	9
Landing-roll	1	0	27	28	0	1	26	27	0	0	19	19	0	0	15	15	0	1	19	20	0	0	20	20
Maneuvering	7	2	2	11	6	0	0	6	4	0	1	5	4	0	3	7	2	1	1	4	4	0	0	4
Maneuvering-aerial application	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	1	0	0	0	0
Maneuvering-turn to reverse direction	0	0	1	1	2	0	0	2	2	0	0	2	0	0	0	0	0	0	0	0	0	1	0	1
Maneuvering-turn to landing area (emer)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	1	1	1	0	1	2	0	0	0	0	1	0	1	2	2	0	3	5	0	0	1	1
Unknown	2	0	1	3	1	0	1	2	1	0	0	1	1	0	0	1	1	0	1	2	0	0	0	0
Not reported	0	0	0	0	2	0	0	2	0	0	0	0	0	0	0	0	2	1	5	8	3	0	2	5
Total:	54	18	119	191	46	14	126	186	60	8	80	148	41	4	95	140	35	15	94	144	49	18	89	156

Table 3.18 (Continued)
General Aviation Accidents by Phase of Flight Operation
Multi-Engine Reciprocating, Fixed Wing
[References 3.49 to 3.57]

Multi-Engine Reciprocating, Fixed Wing	1992				1993				1994				TOTAL							
	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Flight Phase	No.	Pct.	
Phase of Operation																				
Standing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	Standing	17	1.21%
Standing-preflight	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1			
Standing-starting engine(s)	0	0	1	1	0	0	2	2	0	0	2	2	0	0	7	7				
Standing-engine(s) operating	0	0	0	0	0	0	0	0	0	0	1	1	0	0	4	4				
Standing-engine(s) not operating	0	0	0	0	0	0	1	1	1	0	0	1	1	0	2	3				
Standing-idling rotors	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
Taxi	1	0	1	2	0	0	0	0	1	0	1	2	2	0	5	7	Taxi	43	3.06%	
Taxi-to takeoff	0	0	0	0	0	0	2	2	0	1	2	3	0	1	22	23				
Taxi-from landing	0	0	1	1	0	0	0	0	0	0	0	0	1	0	12	13				
Taxi-aerial	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
Takeoff	0	0	1	1	1	0	1	2	1	2	0	3	12	3	15	30	Takeoff	80	5.69%	
Takeoff-aborted	0	0	0	0	0	0	0	0	0	0	2	2	0	0	2	2				
Takeoff-ground run	0	1	3	4	1	0	3	4	1	0	3	4	3	4	41	48				
Takeoff-initial climb	4	0	7	11	8	3	16	27	7	4	4	15	64	20	92	176				
Climb	1	0	0	1	2	0	1	3	0	0	1	1	9	4	8	21	Initial Climb	176	12.51%	
Climb-to cruise	4	0	1	5	2	0	0	2	3	0	2	5	23	3	15	41				
Cruise	4	2	6	12	6	4	8	18	7	1	2	10	46	12	41	99	Cruise	261	18.55%	
Cruise-normal	12	5	7	24	3	0	5	8	8	1	3	12	72	15	74	161				
Cruise-holding (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1				
Descent	1	0	1	2	0	0	0	0	0	0	1	1	6	0	3	9	Descent	36	2.56%	
Descent-normal	2	0	4	6	1	0	0	1	1	0	3	4	5	2	16	23				
Descent-emergency	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1				
Descent-uncontrolled	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	3				
Approach	3	0	5	8	3	0	1	4	1	0	0	1	22	2	19	43				
Approach-VFR pattern-downwind	1	0	0	1	0	0	4	4	0	0	1	1	3	2	15	20	Approach	264	18.76%	
Approach-VFR pattern-base turn	0	0	0	0	0	0	0	0	3	1	0	4	6	2	0	8				
Approach-VFR pattern-base to final	0	0	0	0	2	0	0	2	1	0	1	2	9	0	5	14				
Approach-VFR pattern-final approach	0	1	5	6	0	3	4	7	3	0	3	6	9	13	42	64				
Approach-go-around (VFR)	1	0	1	2	0	0	3	3	3	0	3	6	9	4	19	32				
Approach-IAF to FAF/outer marker (IFR)	0	0	0	0	0	1	0	1	1	0	0	1	9	3	0	12				
Approach-FAF/outer marker to threshold	1	1	1	3	0	0	3	3	3	1	0	4	14	8	15	37				
Approach-circling (IFR)	1	1	1	3	1	0	0	1	0	0	0	0	9	2	4	15				
Approach-missed approach (IFR)	2	1	1	4	1	0	1	2	3	0	0	3	11	3	5	19				
Landing-aborted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Landing	333	23.67%	
Landing	0	0	2	2	0	2	2	4	0	0	4	4	1	2	23	26				
Landing-flare/touchdown	0	0	14	14	1	0	12	13	0	1	10	11	3	2	122	127				
Landing-roll	0	0	7	7	1	0	25	26	0	3	15	18	2	5	173	180				
Maneuvering	8	0	2	10	6	0	0	6	5	0	2	7	46	3	11	60	Maneuvering	71	5.05%	
Maneuvering-aerial application	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2				
Maneuvering-turn to reverse direction	1	0	0	1	1	1	0	2	0	0	0	0	6	2	1	9				
Maneuvering-turn to landing area (emer)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
Hover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
Other	0	0	3	3	0	0	1	1	0	0	1	1	4	0	12	16	Other/?/NR	64	4.55%	
Unknown	1	0	1	2	2	1	0	3	1	0	0	1	10	1	4	15				
Not reported	1	0	4	5	4	1	5	10	1	1	1	3	13	3	17	33				
Total:	49	12	80	141	46	16	100	162	55	16	68	139	435	121	851	1407		1407	100.00%	

Table 3.19
General Aviation Accidents by Phase of Flight Operation
Turboprop, Fixed Wing
[References 3.49 to 3.57]

Turboprop, Fixed Wing Phase of Operation	1986				1987				1988				1989				1990				1991			
	Fatal Acc.	Injury Acc.	Pd. Dm Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pd. Dm Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pd. Dm Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pd. Dm Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pd. Dm Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pd. Dm Acc.	Total Acc.
Standing	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Standing-preflight	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Standing-starting engine(s)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Standing-engine(s) operating	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Standing-engine(s) not operating	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Standing-idling rotors	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxi	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	1
Taxi-to takeoff	0	0	0	0	0	0	1	1	0	0	1	1	0	0	0	0	0	1	1	0	0	0	0	0
Taxi-from landing	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
Taxi-aerial	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Takeoff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1	0	0	0	0
Takeoff-aborted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Takeoff-ground run	0	0	1	1	0	1	1	2	0	0	0	0	0	0	3	3	1	0	2	3	0	0	0	0
Takeoff-initial climb	1	0	2	3	0	1	0	1	2	0	1	3	3	1	0	4	1	2	2	5	1	1	0	2
Climb	0	0	0	0	1	0	0	1	0	0	0	0	2	0	0	2	0	0	0	0	0	0	0	0
Climb-to cruise	0	0	2	2	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Cruise	1	0	2	3	0	0	0	0	0	0	0	0	1	1	1	3	0	0	3	3	1	0	1	2
Cruise-normal	0	0	1	1	0	0	0	0	0	0	0	0	1	0	1	2	1	0	3	4	1	1	1	3
Cruise-holding (IFR)	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Descent	1	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
Descent-normal	1	1	1	3	1	0	0	1	1	0	1	2	0	0	0	0	0	0	1	1	0	0	1	1
Descent-emergency	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Descent-uncontrolled	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Approach	0	1	1	2	0	0	1	1	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	1
Approach-VFR pattern-downwind	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Approach-VFR pattern-base turn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Approach-VFR pattern-base to final	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2	0	0	0	0	0	0	1	1
Approach-VFR pattern-final approach	1	0	1	2	0	0	1	1	0	0	1	1	1	0	0	1	3	0	1	4	0	0	0	0
Approach-go-around (VFR)	0	0	1	1	1	0	0	1	1	0	0	1	0	0	1	1	0	0	1	1	0	0	0	0
Approach-IAF to FAF/outer marker (IFR)	1	0	0	1	1	0	0	1	1	0	0	1	2	0	0	2	1	1	0	2	1	0	0	1
Approach-FAF/outer marker to threshold	2	0	0	2	0	0	0	0	1	1	1	3	0	0	0	0	0	0	0	0	1	0	1	2
Approach-circling (IFR)	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Approach-missed approach (IFR)	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Landing-aborted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Landing	0	0	2	2	0	0	2	2	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0
Landing-flare/touchdown	0	0	1	1	0	0	3	3	0	0	1	1	0	0	1	1	0	0	2	2	0	0	4	4
Landing-roll	0	0	1	1	0	2	2	4	0	0	2	2	0	0	5	5	1	0	2	3	0	0	4	4
Maneuvering	1	0	0	1	1	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	1	0	1	2
Maneuvering-aerial application	2	0	1	3	0	1	3	4	1	0	3	4	1	0	2	3	1	1	0	2	3	0	5	8
Maneuvering-turn to reverse direction	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Maneuvering-turn to landing area (emer)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Unknown	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Not reported	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	1	0	1	2
Total:	12	2	21	35	9	7	15	31	9	1	13	23	14	3	16	33	13	4	21	38	12	2	22	36

Table 3.19 (Continued)
General Aviation Accidents by Phase of Flight Operation
Turboprop, Fixed Wing
[References 3.49 to 3.57]

Turboprop, Fixed Wing Phase of Operation	1992				1993				1994				TOTAL				Flight Phase	No.	Pct.
	Fatal Acc.	Injury Acc.	Pd. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.			
Standing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	Standing	7	2.03%
Standing-preflight	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Standing-starting engine(s)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Standing-engine(s) operating	0	0	1	1	0	0	2	2	0	0	0	0	0	0	5	5			
Standing-engine(s) not operating	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1			
Standing-idling rotors	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Taxi	1	0	0	1	0	0	2	2	0	0	0	0	2	0	4	6	Taxi	14	4.07%
Taxi-to takeoff	0	0	0	0	0	0	2	2	0	0	0	0	0	0	5	5			
Taxi-from landing	0	0	1	1	0	0	0	0	0	0	0	0	1	0	2	3			
Taxi-aerial	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Takeoff	0	0	1	1	0	1	0	1	0	0	1	1	1	1	3	5	Takeoff	22	6.40%
Takeoff-aborted	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1			
Takeoff-ground run	0	0	3	3	0	0	1	1	1	0	2	3	2	1	13	16			
Takeoff-initial climb	5	1	2	8	0	0	3	3	1	1	7	9	14	7	17	38	Initial Climb	38	11.05%
Climb	2	0	0	2	0	0	0	0	1	0	0	1	6	0	0	6	Climb	16	4.65%
Climb-to cruise	2	0	1	3	2	0	0	2	1	1	0	2	6	1	3	10			
Cruise	1	0	2	3	1	0	3	4	2	1	2	5	7	2	14	23	Cruise	44	12.79%
Cruise-normal	1	0	3	4	2	0	3	5	0	0	1	1	6	1	13	20			
Cruise-holding (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1			
Descent	1	0	0	1	0	0	0	0	0	0	0	0	3	1	0	4	Descent	14	4.07%
Descent-normal	0	0	0	0	0	0	1	1	0	0	0	0	3	1	5	9			
Descent-emergency	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Descent-uncontrolled	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	1			
Approach	0	0	0	0	0	0	0	0	0	0	0	0	2	1	2	5	Approach	55	15.99%
Approach-VFR pattern-downwind	0	0	0	0	1	0	0	1	0	0	0	0	2	0	0	2			
Approach-VFR pattern-base turn	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	1			
Approach-VFR pattern-base to final	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	3			
Approach-VFR pattern-final approach	1	0	2	3	0	0	1	1	1	0	2	3	7	0	9	16			
Approach-go-around (VFR)	0	0	1	1	0	0	0	0	0	0	0	0	2	0	4	6			
Approach-IAF to FAF/outer marker (IFR)	1	0	1	2	0	0	0	0	0	0	0	0	8	1	1	10			
Approach-FAF/outer marker to threshold	2	0	0	2	0	0	0	0	0	0	0	0	6	1	2	9			
Approach-circling (IFR)	0	0	0	0	0	0	1	1	0	0	0	0	1	0	1	2			
Approach-missed approach (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1			
Landing-aborted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Landing	56	16.28%
Landing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	6			
Landing-flare/touchdown	1	0	5	6	1	0	2	3	0	0	1	1	2	0	20	22			
Landing-roll	0	0	2	2	0	1	2	3	0	0	4	4	1	3	24	28			
Maneuvering	1	0	3	4	3	0	2	5	1	1	0	2	8	1	7	16	Maneuvering	68	19.77%
Maneuvering-aerial application	0	2	2	4	3	0	4	7	5	2	5	12	16	6	25	47			
Maneuvering-turn to reverse direction	0	0	0	0	0	1	0	1	0	0	0	0	2	1	1	4			
Maneuvering-turn to landing area (emer)	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1			
Hover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Other	0	0	0	0	1	0	0	1	0	0	0	0	1	0	1	2	Other / ? / NR	10	2.91%
Unknown	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2			
Not reported	1	0	0	1	1	0	0	1	0	0	0	0	5	0	1	6			
Total:	20	4	31	55	16	3	29	48	13	6	26	45	118	32	194	344		344	100.00%

Table 3.20
General Aviation Accidents by Phase of Flight Operation
Turbojet, Fixed Wing
[References 3.49 to 3.57]

Turbojet, Fixed Wing	1986				1987				1988				1989				1990				1991				
	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Total Acc.	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Total Acc.	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Total Acc.	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Total Acc.	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Total Acc.	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Total Acc.	
Phase of Operation																									
Standing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Standing-preflight	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Standing-starting engine(s)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Standing-engine(s) operating	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Standing-engine(s) not operating	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Standing-idling rotors	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Taxi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Taxi-to takeoff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Taxi-from landing	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	
Taxi-aerial	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Takeoff	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	1	1	0	0	1
Takeoff-aborted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Takeoff-ground run	0	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	
Takeoff-initial climb	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0	
Climb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	
Climb-to cruise	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	3	1	0	0	1	
Cruise	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Cruise-normal	1	0	0	1	1	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	
Cruise-holding (IFR)	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	
Descent	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Descent-normal	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Descent-emergency	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Descent-uncontrolled	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Approach	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Approach-VFR pattern-downwind	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Approach-VFR pattern-base turn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Approach-VFR pattern-base to final	0	0	0	0	1	0	0	1	1	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	
Approach-VFR pattern-final approach	0	0	1	1	1	1	0	2	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	
Approach-go-around (VFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Approach-IAF to FAF/outer marker (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Approach-FAF/outer marker to threshold	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	1	2	0	0	2	0	0	0	0	
Approach-circling (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Approach-missed approach (IFR)	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	
Landing-aborted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Landing	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Landing-flare/touchdown	0	0	3	3	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	
Landing-roll	0	0	3	3	0	0	1	1	0	0	3	3	0	0	2	2	0	0	2	2	0	0	1	1	
Maneuvering	0	0	0	0	2	0	0	2	1	0	0	1	0	0	0	0	3	0	0	3	1	0	1	2	
Maneuvering-aerial application	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1		
Maneuvering-turn to reverse direction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Maneuvering-turn to landing area (emer)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Hover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	
Unknown	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	
Not reported	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	
Total:	3	1	10	14	6	1	3	10	4	0	3	7	2	0	7	9	10	1	7	18	7	1	2	10	

Table 3.20 (Continued)
General Aviation Accidents by Phase of Flight Operation
Turbojet, Fixed Wing
[References 3.49 to 3.57]

Turbojet, Fixed Wing Phase of Operation	1992				1993				1994				TOTAL				Flight Phase	No.	Pct.
	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm. Acc.	Fatal Acc.	Injury Acc.	Pr. Acc.	Dm. Acc.	Fatal Acc.	Injury Acc.	Pr. Acc.	Dm. Acc.	Fatal Acc.	Injury Acc.	Pr. Acc.	Dm. Acc.			
Standing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Standing	0	0.00%
Standing-preflight	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Standing-starting engine(s)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Standing-engine(s) operating	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Standing-engine(s) not operating	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Standing-idling rotors	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Taxi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Taxi	2	1.92%
Taxi-to takeoff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Taxi-from landing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2			
Taxi-aerial	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Takeoff	1	0	0	1	0	0	1	1	0	0	0	0	4	0	1	5	Takeoff	12	11.54%
Takeoff-aborted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Takeoff-ground run	0	1	0	1	0	0	0	0	0	0	3	3	1	1	5	7			
Takeoff-initial climb	0	0	0	0	0	0	1	1	1	0	0	1	4	0	1	5	Initial Climb	5	4.81%
Climb	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	2	Climb	7	6.73%
Climb-to cruise	0	0	0	0	0	0	0	0	0	0	0	0	3	1	1	5			
Cruise	0	0	0	0	0	0	0	0	1	1	0	2	1	1	1	3			
Cruise-normal	0	0	0	0	0	0	1	1	0	0	0	0	2	0	2	4	Cruise	8	7.69%
Cruise-holding (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1			
Descent	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	1			
Descent-normal	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	Descent	2	1.92%
Descent-emergency	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Descent-uncontrolled	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Approach	1	0	1	2	1	0	0	1	0	0	0	0	2	0	1	3			
Approach-VFR pattern-downwind	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Approach	19	18.27%
Approach-VFR pattern-base turn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Approach-VFR pattern-base to final	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	3			
Approach-VFR pattern-final approach	0	0	0	0	0	0	0	0	1	0	1	2	2	1	4	7			
Approach-go-around (VFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Approach-IAF to FAF/outer marker (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Approach-FAF/outer marker to threshold	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	4			
Approach-circling (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Approach-missed approach (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2			
Landing-aborted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Landing	28	26.92%
Landing	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	2			
Landing-flare/touchdown	0	0	0	0	0	0	0	0	0	0	2	2	0	0	7	7			
Landing-roll	0	0	4	4	0	0	2	2	0	0	1	1	0	0	19	19			
Maneuvering	1	0	0	1	2	0	0	2	1	0	0	1	11	0	1	12	Maneuvering	13	12.50%
Maneuvering-aerial application	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1			
Maneuvering-turn to reverse direction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Maneuvering-turn to landing area (emer)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Hover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	Other ??/NR	8	7.69%
Unknown	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1			
Not reported	0	0	2	2	0	0	1	1	0	0	1	1	1	0	4	5			
Total:	3	1	7	11	3	0	6	9	5	1	10	16	43	6	55	104		104	100.00%

Table 3.21
General Aviation Accidents by Phase of Flight Operation
Total, Fixed Wing Aircraft
[References 3.49 to 3.57]

Total, Fixed Wing Aircraft Phase of Operation	1986				1987				1988				1989				1990				1991			
	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Acc.	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Acc.	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Acc.	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Acc.	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Acc.	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Acc.
Standing	0	0	1	1	0	0	0	0	0	0	3	3	0	0	1	1	0	1	0	1	0	0	2	2
Standing-preflight	1	0	0	1	0	1	0	1	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	3
Standing-starting engine(s)	0	5	17	22	1	2	17	20	0	3	15	18	0	0	13	13	0	1	7	8	0	2	5	7
Standing-engine(s) operating	1	0	5	6	2	2	9	13	1	1	6	8	1	4	9	14	0	1	6	7	2	1	10	13
Standing-engine(s) not operating	0	0	0	0	0	1	1	2	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Standing-idling rotors	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxi	1	0	13	14	0	0	5	5	1	0	6	7	0	0	5	5	2	0	9	11	0	1	5	6
Taxi-to takeoff	0	0	21	21	0	0	32	32	0	1	24	25	0	0	22	22	0	0	26	26	0	0	16	16
Taxi-from landing	0	1	18	19	0	0	28	28	1	0	30	31	1	0	26	27	0	0	19	19	0	2	16	18
Taxi-aerial	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Takeoff	8	5	24	37	2	6	18	26	5	5	20	30	4	3	21	28	8	8	22	38	12	4	25	41
Takeoff-aborted	0	0	0	0	0	0	0	0	0	1	15	16	0	0	0	0	0	0	0	0	0	0	0	0
Takeoff-ground run	4	6	107	117	2	9	109	120	1	2	77	80	2	1	77	80	5	3	73	81	1	7	81	89
Takeoff-initial climb	68	54	217	339	48	67	209	324	66	64	175	305	61	51	194	306	61	60	173	294	49	57	179	285
Climb	12	6	19	37	5	4	12	21	5	3	14	22	9	2	7	18	7	5	8	20	15	10	19	44
Climb-to cruise	21	5	26	52	14	8	29	51	25	4	25	54	11	2	14	27	13	7	14	34	13	4	22	39
Cruise	34	15	105	154	33	8	78	119	41	16	88	145	48	17	95	160	38	16	79	133	50	22	105	177
Cruise-normal	44	35	158	237	59	18	145	222	59	27	150	236	60	17	135	212	34	13	129	176	34	23	110	167
Cruise-holding (IFR)	0	0	1	1	0	0	0	0	1	0	3	4	0	0	1	1	0	0	0	0	0	0	1	1
Descent	12	0	9	21	4	1	4	9	9	1	7	17	9	1	5	15	5	1	8	14	3	5	6	14
Descent-normal	10	7	25	42	8	6	30	44	5	1	38	44	5	2	19	26	9	5	21	35	4	5	23	32
Descent-emergency	2	2	4	8	0	0	5	5	1	0	1	2	0	0	2	2	0	0	1	1	2	1	2	5
Descent-uncontrolled	3	1	1	5	4	0	2	6	0	1	0	1	1	0	2	3	2	0	2	4	3	0	2	5
Approach	11	6	20	37	6	6	22	34	11	6	21	38	15	7	33	55	13	3	15	31	13	1	21	35
Approach-VFR pattern-downwind	5	2	16	23	9	4	11	24	3	4	12	19	6	2	8	16	12	2	16	30	5	4	11	20
Approach-VFR pattern-base turn	5	0	5	10	1	3	3	7	3	2	5	10	3	1	4	8	5	1	9	15	3	1	3	7
Approach-VFR pattern-base to final	9	2	7	18	9	1	7	17	5	2	7	14	10	5	6	21	6	3	12	21	8	2	13	23
Approach-VFR pattern-final approach	13	30	84	127	11	17	87	115	8	23	72	103	14	16	79	109	21	9	88	118	15	9	62	86
Approach-go-around (VFR)	4	9	46	59	6	11	32	49	8	7	39	54	4	5	29	38	7	8	26	41	7	8	36	51
Approach-IAF to FAF/outer marker (IFR)	3	3	1	7	5	0	0	5	8	1	2	11	8	1	0	9	5	1	2	8	5	1	1	7
Approach-FAF/outer marker to threshold	18	6	8	32	7	4	5	16	7	5	5	17	4	0	4	8	9	1	6	16	6	3	6	15
Approach-circling (IFR)	2	0	2	4	3	0	0	3	3	1	2	6	0	0	1	1	1	0	0	1	1	2	0	3
Approach-missed approach (IFR)	2	2	4	8	4	0	1	5	5	0	2	7	1	0	0	1	4	0	1	5	3	1	1	5
Landing-aborted	0	0	0	0	0	0	0	0	3	4	18	25	0	0	0	0	0	0	0	0	0	0	0	0
Landing	4	7	40	51	4	3	34	41	0	1	39	40	2	2	40	44	1	2	22	25	1	3	12	16
Landing-flare/touchdown	3	9	210	222	2	9	223	234	2	5	166	173	3	8	161	172	3	6	153	162	0	2	159	161
Landing-roll	7	6	290	303	0	11	309	320	1	9	262	272	2	7	242	251	2	6	257	265	1	0	233	234
Maneuvering	95	30	55	180	119	20	49	188	104	21	56	181	69	23	61	153	91	13	43	147	91	27	56	174
Maneuvering-aerial application	8	8	42	58	9	11	45	65	6	14	42	62	18	7	39	64	11	6	42	59	11	10	46	67
Maneuvering-turn to reverse direction	10	2	19	31	5	8	8	21	10	2	9	21	7	2	0	9	11	4	9	24	9	3	9	21
Maneuvering-turn to landing area (emer)	0	0	2	2	1	0	0	1	0	0	7	7	0	0	1	1	2	0	0	2	1	0	1	2
Hover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	3	0	3	6	4	1	21	26	0	0	1	1	4	6	56	66	6	5	55	66	9	3	41	53
Unknown	13	2	1	16	13	1	3	17	11	1	2	14	17	0	2	19	18	0	3	21	12	0	1	13
Not reported	1	0	1	2	7	0	2	9	2	0	4	6	1	0	0	1	6	1	10	17	9	0	9	18
Total:	437	266	1627	2330	407	243	1595	2245	421	238	1471	2130	400	192	1415	2007	418	192	1367	1977	399	225	1351	1975

Table 3.21 (Continued)
General Aviation Accidents by Phase of Flight Operation
Total, Fixed Wing Aircraft
[References 3.49 to 3.57]

Total, Fixed Wing Aircraft Phase of Operation	1992				1993				1994				TOTAL				Flight Phase	No.	Pct.
	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Acc.	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Acc.	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Acc.	Fatal Acc.	Injury Acc.	Pr. Acc.	Dm Acc.			
Standing	0	0	0	0	0	1	1	2	0	0	0	0	0	2	8	10	Standing	227	1.25%
Standing-preflight	0	1	0	1	0	0	0	0	0	0	0	0	2	3	2	7			
Standing-starting engine(s)	0	1	4	5	1	0	10	11	0	1	8	9	2	15	96	113			
Standing-engine(s) operating	2	0	2	4	3	3	4	10	3	8	5	16	15	20	56	91			
Standing-engine(s) not operating	0	0	0	0	0	0	1	1	1	1	0	2	1	2	3	6			
Standing-idling rotors	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Taxi	2	0	5	7	0	0	8	8	2	0	8	10	8	1	64	73	Taxi	456	2.52%
Taxi-to takeoff	0	2	15	17	0	1	21	22	1	1	13	15	1	5	190	196			
Taxi-from landing	0	1	15	16	0	1	14	15	0	0	13	13	2	5	179	186			
Taxi-aerial	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1			
Takeoff	5	2	13	20	5	3	15	23	7	10	30	47	56	46	188	290	Takeoff	1127	6.22%
Takeoff-aborted	0	0	0	0	0	0	0	0	0	1	22	23	0	2	37	39			
Takeoff-ground run	0	6	73	79	3	0	74	77	5	6	64	75	23	40	735	798			
Takeoff-initial climb	55	47	162	264	48	47	167	262	64	48	149	261	520	495	1625	2640			
Climb	8	1	14	23	10	3	18	31	7	8	13	28	78	42	124	244	Climb	594	3.28%
Climb-to cruise	10	3	18	31	9	5	14	28	14	5	15	34	130	43	177	350			
Cruise	44	15	81	140	46	25	108	179	38	23	107	168	372	157	846	1375	Cruise	3053	16.85%
Cruise-normal	48	16	115	179	32	10	98	140	29	12	61	102	399	171	1101	1671			
Cruise-holding (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	1	0	6	7			
Descent	6	2	3	11	10	0	6	16	4	2	5	11	62	13	53	128			
Descent-normal	12	2	28	42	4	0	25	29	6	3	20	29	63	31	229	323	Descent	520	2.87%
Descent-emergency	1	0	2	3	1	1	3	5	2	0	1	3	9	4	21	34			
Descent-uncontrolled	1	3	2	6	0	1	2	3	2	0	0	2	16	6	13	35			
Approach	13	7	11	31	10	2	16	28	7	9	13	29	99	47	172	318	Approach	2348	12.96%
Approach-VFR pattern-downwind	3	1	14	18	3	3	8	14	3	4	11	18	49	26	107	182			
Approach-VFR pattern-base turn	2	1	6	9	4	2	3	9	3	2	1	6	29	13	39	81			
Approach-VFR pattern-base to final	6	3	6	15	7	0	10	17	2	1	11	14	62	19	79	160			
Approach-VFR pattern-final approach	13	12	68	93	10	12	68	90	13	13	58	84	118	141	666	925			
Approach-go-around (VFR)	7	3	25	35	3	6	37	46	6	5	17	28	52	62	287	401			
Approach-IAF to FAF/outer marker (IFR)	4	0	2	6	1	1	1	3	1	0	1	2	40	8	10	58			
Approach-FAF/outer marker to threshold	10	2	5	17	4	2	7	13	4	2	5	11	69	25	51	145			
Approach-circling (IFR)	1	1	1	3	3	0	1	4	3	1	0	4	17	5	7	29			
Approach-missed approach (IFR)	4	1	2	7	1	2	1	4	7	0	0	7	31	6	12	49			
Landing-aborted	0	0	0	0	0	0	0	0	1	2	17	20	4	6	35	45	Landing	4319	23.84%
Landing	3	2	34	39	0	5	33	38	2	0	28	30	17	25	282	324			
Landing-flare/touchdown	3	7	158	168	4	3	137	144	2	6	149	157	22	55	1516	1593			
Landing-roll	3	4	222	229	2	6	238	246	1	8	228	237	19	57	2281	2357			
Maneuvering	90	18	49	157	105	25	43	173	92	14	53	159	856	191	465	1512			
Maneuvering-aerial application	6	10	36	52	11	7	31	49	13	10	46	69	93	83	369	545	Maneuvering	2254	12.44%
Maneuvering-turn to reverse direction	10	5	9	24	4	5	7	16	3	5	0	8	69	36	70	175			
Maneuvering-turn to landing area (emer)	1	1	1	3	0	0	1	1	1	0	2	3	6	1	15	22			
Hover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Other	10	5	42	57	3	3	43	49	0	0	1	1	39	23	263	325			
Unknown	14	0	7	21	14	3	1	18	7	0	2	9	119	7	22	148	Other/?/NR	581	3.21%
Not reported	6	0	13	19	9	3	11	23	5	1	7	13	46	5	57	108			
Total:	403	185	1263	1851	370	191	1286	1847	361	212	1184	1757	3616	1944	12559	18119		18119	100.00%

Table 3.22
General Aviation Accidents by Phase of Flight Operation
Reciprocating Engine, Rotary Wing (Helicopters)
[References 3.49 to 3.57]

Reciprocating Engine, Rotary Wing (Helicopters)	1986				1987				1988				1989				1990				1991			
Phase of Operation	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Acc.	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Acc.	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Acc.	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Acc.	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Acc.	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Acc.
Standing	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Standing-preflight	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Standing-starting engine(s)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Standing-engine(s) operating	0	0	2	2	0	0	1	1	0	0	1	1	1	3	0	4	0	1	0	1	0	0	0	0
Standing-engine(s) not operating	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Standing-idling rotors	1	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	1	1	2	4	0	0	1	1
Taxi	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Taxi-to takeoff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Taxi-from landing	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxi-aerial	0	0	1	1	0	0	2	2	0	0	5	5	0	1	3	4	0	0	1	1	0	0	1	1
Takeoff	1	1	0	2	0	2	2	4	1	1	7	9	0	0	5	5	0	1	7	8	2	2	4	8
Takeoff-aborted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Takeoff-ground run	0	0	0	0	0	1	3	4	0	0	0	0	0	1	1	2	0	0	0	0	1	0	0	1
Takeoff-initial climb	1	0	8	9	1	1	9	11	5	4	10	19	0	4	8	12	2	1	10	13	5	0	7	12
Climb	0	0	1	1	1	0	0	1	0	1	0	1	0	0	1	1	0	0	0	0	0	0	1	1
Climb-to cruise	0	0	0	0	0	0	0	0	1	1	1	3	0	0	1	1	0	0	0	0	0	1	1	2
Cruise	3	4	6	13	3	2	3	8	2	0	1	3	2	2	8	12	4	2	8	14	3	0	4	7
Cruise-normal	0	0	13	13	3	1	9	13	2	1	9	12	1	2	9	12	1	2	13	16	2	0	5	7
Cruise-holding (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Descent	1	1	1	3	0	0	2	2	0	0	1	1	0	0	1	1	0	0	2	2	0	0	2	2
Descent-normal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	1
Descent-emergency	0	0	3	3	0	0	1	1	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0
Descent-uncontrolled	0	0	0	0	1	0	1	2	0	0	0	0	0	0	0	0	0	1	1	2	1	0	0	1
Approach	1	1	1	3	0	0	1	1	0	1	1	2	0	0	1	1	0	0	1	1	1	2	2	5
Approach-VFR pattern-downwind	1	1	0	2	0	0	0	0	1	0	1	2	0	0	1	1	0	0	1	1	0	0	1	1
Approach-VFR pattern-base turn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Approach-VFR pattern-base to final	0	0	1	1	1	0	1	2	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	2
Approach-VFR pattern-final approach	1	0	3	4	1	1	3	5	0	1	2	3	0	1	1	2	0	1	4	5	1	0	1	2
Approach-go-around (VFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	2	0	0	0	0
Approach-IAF to FAF/outer marker (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Approach-FAF/outer marker to threshold	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Approach-circling (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Approach-missed approach (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Landing-aborted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Landing	0	0	3	3	0	0	5	5	0	0	3	3	0	0	3	3	0	0	5	5	0	0	5	5
Landing-flare/touchdown	0	0	7	7	0	0	15	15	0	2	8	10	0	1	8	9	1	0	9	10	0	0	15	15
Landing-roll	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0
Maneuvering	7	1	6	14	2	0	5	7	1	1	3	5	7	3	5	15	5	0	10	15	2	2	11	15
Maneuvering-aerial application	2	3	13	18	0	3	10	13	1	0	14	15	2	3	4	9	1	2	10	13	0	1	14	15
Maneuvering-turn to reverse direction	0	2	0	2	1	0	2	3	0	0	5	5	1	1	3	5	0	1	1	2	0	0	4	4
Maneuvering-turn to landing area (emer)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hover	0	2	12	14	1	1	10	12	0	0	12	12	0	1	17	18	1	1	11	13	0	2	12	14
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Unknown	0	0	0	0	1	0	0	1	2	0	0	2	0	0	0	0	0	0	0	0	1	1	0	2
Not reported	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
Total:	21	16	81	118	16	13	85	114	16	13	87	116	14	23	83	120	16	14	104	134	19	13	93	125

Table 3.22 (Continued)
General Aviation Accidents by Phase of Flight Operation
Reciprocating Engine, Rotary Wing (Helicopters)
[References 3.49 to 3.57]

Reciprocating Engine, Rotary Wing (Helicopters) Phase of Operation	1992				1993				1994				TOTAL				Flight Phase	No.	Pct.		
	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Acc.	Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Acc.	Dm. Acc.	Total Acc.						
Standing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	Standing	24	2.27%
Standing-preflight	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Standing-starting engine(s)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Standing-engine(s) operating	0	1	0	1	0	0	0	0	0	0	0	2	2	1	5	6	12				
Standing-engine(s) not operating	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1				
Standing-idling rotors	0	0	0	0	0	1	0	0	1	0	1	1	2	3	2	5	10				
Taxi	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2	2	Taxi	27	2.56%
Taxi-to takeoff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1			
Taxi-from landing	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1				
Taxi-aerial	0	0	5	5	0	1	2	3	0	0	1	1	1	0	2	21	23				
Takeoff	0	1	6	7	0	1	3	4	0	0	3	3	4	9	37	50	59	Takeoff	59	5.59%	
Takeoff-aborted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
Takeoff-ground run	0	0	2	2	0	0	0	0	0	0	0	0	1	2	6	9					
Takeoff-initial climb	2	0	5	7	3	2	8	13	1	0	9	10	20	12	74	106	106	Initial Climb	106	10.04%	
Climb	1	0	0	1	0	0	2	2	2	0	1	3	4	1	6	11					
Climb-to cruise	0	2	0	2	0	0	0	0	0	1	0	1	1	5	3	9	9	Climb	20	1.89%	
Cruise	7	1	10	18	4	1	6	11	4	2	10	16	32	14	56	102					
Cruise-normal	5	1	5	11	3	0	4	7	2	1	5	8	19	8	72	99					
Cruise-holding (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
Descent	0	0	5	5	1	0	0	1	0	0	0	0	2	1	14	17	34	Descent	34	3.22%	
Descent-normal	0	0	0	0	0	0	1	1	0	0	0	0	0	1	2	3					
Descent-emergency	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	6					
Descent-uncontrolled	0	0	1	1	0	0	2	2	0	0	0	0	2	1	5	8					
Approach	0	0	1	1	1	1	2	4	1	0	2	3	4	5	12	21					
Approach-VFR pattern-downwind	1	0	1	2	1	0	0	1	0	0	0	0	4	1	5	10	78	Approach	78	7.39%	
Approach-VFR pattern-base turn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
Approach-VFR pattern-base to final	0	0	1	1	0	0	1	1	0	0	0	0	1	1	6	8					
Approach-VFR pattern-final approach	1	0	5	6	0	0	2	2	2	0	3	5	6	4	24	34					
Approach-go-around (VFR)	0	0	0	0	1	0	1	2	0	0	0	0	1	0	4	5					
Approach-IAF to FAF/outer marker (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
Approach-FAF/outer marker to threshold	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
Approach-circling (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
Approach-missed approach (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
Landing-aborted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
Landing	1	0	3	4	0	0	4	4	1	0	3	4	2	0	34	36	147				Landing
Landing-flare/touchdown	0	0	15	15	1	1	10	12	0	0	13	13	2	4	100	106					
Landing-roll	0	0	1	1	0	0	0	0	0	0	2	2	0	0	5	5					
Maneuvering	3	2	8	13	1	1	5	7	4	0	5	9	32	10	58	100					
Maneuvering-aerial application	0	0	5	5	1	0	11	12	2	2	8	12	9	14	89	112	348	Maneuvering	348	32.95%	
Maneuvering-turn to reverse direction	0	0	3	3	0	0	2	2	0	0	0	0	2	4	20	26					
Maneuvering-turn to landing area (emer)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
Hover	1	1	5	7	1	0	8	9	0	1	10	11	4	9	97	110					
Other	0	0	0	0	0	0	1	1	0	0	0	0	0	0	2	2					
Unknown	0	0	0	0	0	0	0	0	2	0	0	2	6	1	0	7	12	Other/?/NR	12	1.14%	
Not reported	0	0	1	1	0	0	0	0	0	0	0	0	0	0	3	3					
Total:	22	9	89	120	19	8	75	102	21	8	78	107	164	117	775	1056	1056	100.00%			

Table 3.23
General Aviation Accidents by Phase of Flight Operation
Turbine Engine, Rotary Wing (Helicopters)
[References 3.49 to 3.57]

Turbine Engine, Rotary Wing (Helicopters) Phase of Operation	1986					1987					1988					1989					1990					1991						
	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Acc.	Total Acc.		
Standing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	
Standing-preflight	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Standing-starting engine(s)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Standing-engine(s) operating	0	0	0	0	0	0	0	1	1	1	0	0	1	1	1	0	0	0	0	0	0	0	1	0	1	0	1	0	1	0	1	
Standing-engine(s) not operating	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Standing-idling rotors	0	0	1	1	1	0	0	0	0	0	0	1	0	1	1	0	1	0	2	2	0	1	0	1	0	0	0	0	0	0	0	
Taxi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Taxi-to takeoff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Taxi-from landing	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Taxi-aerial	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	1	1	1	1	1	
Takeoff	0	2	3	5	10	1	1	1	3	5	0	1	5	6	12	0	0	3	3	6	2	1	1	4	0	0	0	0	0	0	0	0
Takeoff-aborted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Takeoff-ground run	1	0	0	1	2	0	0	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Takeoff-initial climb	0	4	7	11	22	1	2	2	5	10	0	1	2	3	6	2	4	0	6	12	2	0	2	4	3	1	1	5	5	5	5	
Climb	0	0	0	0	0	1	0	0	1	2	0	0	1	1	2	0	0	2	2	4	0	0	0	0	0	0	1	1	1	1	1	
Climb-to cruise	0	0	1	1	2	0	0	1	1	2	0	0	0	0	0	1	0	0	1	2	0	0	1	1	0	0	0	0	0	0	0	
Cruise	4	0	4	8	16	2	1	3	6	11	1	2	2	5	10	5	2	4	11	22	2	1	8	11	2	1	7	10	10	10	10	
Cruise-normal	3	2	7	12	22	2	0	4	6	12	2	3	5	10	20	0	1	2	3	6	0	0	3	3	1	0	1	2	2	2	2	
Cruise-holding (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	
Descent	1	0	1	2	4	0	0	0	0	0	0	0	3	3	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Descent-normal	0	0	2	2	4	0	0	0	0	0	0	0	1	1	2	0	0	1	1	2	0	0	0	0	0	0	0	0	0	0	0	
Descent-emergency	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1		
Descent-uncontrolled	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Approach	0	0	2	2	4	0	0	0	0	0	0	0	2	2	4	1	0	2	3	6	0	1	0	1	2	0	0	0	0	0	0	
Approach-VFR pattern-downwind	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	
Approach-VFR pattern-base turn	0	0	0	0	0	0	0	0	0	0	1	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Approach-VFR pattern-base to final	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Approach-VFR pattern-final approach	0	0	1	1	2	0	1	3	4	8	0	1	1	2	4	1	0	2	3	6	0	0	2	2	0	1	1	2	2	2	2	
Approach-go-around (VFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Approach-IAF to FAF/outer marker (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Approach-FAF/outer marker to threshold	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Approach-circling (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Approach-missed approach (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Landing-aborted	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Landing	0	0	1	1	2	0	0	2	2	4	0	0	1	1	2	0	0	1	1	2	0	0	4	4	0	0	1	1	1	1	1	1
Landing-flare/touchdown	0	0	2	2	4	0	0	5	5	10	0	0	7	7	14	0	0	4	4	8	0	0	4	4	0	0	6	6	6	6	6	6
Landing-roll	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maneuvering	5	1	3	9	18	1	2	6	9	18	1	0	1	2	4	3	1	5	9	18	0	1	8	9	1	1	1	3	3	3	3	3
Maneuvering-aerial application	0	0	1	1	2	0	0	1	1	2	0	0	2	2	4	1	0	4	5	10	1	1	1	3	0	0	2	2	2	2	2	2
Maneuvering-turn to reverse direction	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	1	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0
Maneuvering-turn to landing area (emergency)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hover	4	1	8	13	26	1	1	9	11	22	0	7	6	13	26	1	3	6	10	20	2	3	4	9	1	0	2	3	3	3	3	3
Other	0	0	0	0	0	0	0	1	1	2	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	1	1	1	1	1	1
Unknown	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Not reported	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
Total:	18	10	45	73	146	9	8	40	57	114	5	16	43	64	124	16	11	39	66	9	11	42	62	10	5	26	41	41	41	41	41	41

Table 3.23 (Continued)
General Aviation Accidents by Phase of Flight Operation
Turbine Engine, Rotary Wing (Helicopters)
[References 3.49 to 3.57]

Turbine Engine, Rotary Wing (Helicopters) Phase of Operation	1992				1993				1994				TOTAL				Flight Phase	No.	Pct.
	Fatal Acc.	Injury Acc.	Pd. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.			
Standing	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	Standing	14	2.47%
Standing-preflight	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Standing-starting engine(s)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Standing-engine(s) operating	0	0	1	1	0	1	0	1	0	0	0	0	0	2	3	5			
Standing-engine(s) not operating	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Standing-idling rotors	0	0	0	0	0	0	2	2	0	0	1	1	0	2	6	8			
Taxi	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	Taxi	10	1.77%
Taxi-to takeoff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Taxi-from landing	0	0	0	0	0	0	1	1	0	0	0	0	0	0	2	2			
Taxi-aerial	1	0	0	1	0	0	2	2	0	0	0	0	1	0	6	7			
Takeoff	0	0	0	0	0	0	0	0	1	0	2	3	4	5	15	24	Takeoff	26	4.59%
Takeoff-aborted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Takeoff-ground run	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2			
Takeoff-initial climb	0	0	2	2	2	0	3	5	0	1	2	3	10	13	21	44			
Climb	0	0	0	0	0	0	0	0	0	0	2	2	1	0	6	7	Climb	12	2.12%
Climb-to cruise	0	0	0	0	0	0	1	1	0	0	0	0	1	0	4	5			
Cruise	6	2	2	10	2	2	3	7	5	3	6	14	29	14	39	82	Cruise	136	24.03%
Cruise-normal	4	1	3	8	0	1	3	4	1	1	3	5	13	9	31	53			
Cruise-holding (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1			
Descent	0	0	1	1	0	0	0	0	2	0	1	3	3	0	6	9	Descent	17	3.00%
Descent-normal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4			
Descent-emergency	0	0	0	0	0	0	0	0	1	0	1	2	1	0	2	3			
Descent-uncontrolled	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	1			
Approach	1	0	1	2	0	1	2	3	0	0	2	2	4	2	11	17	Approach	40	7.07%
Approach-VFR pattern-downwind	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1			
Approach-VFR pattern-base turn	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1			
Approach-VFR pattern-base to final	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Approach-VFR pattern-final approach	0	0	2	2	0	0	1	1	1	0	1	2	2	3	14	19			
Approach-go-around (VFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Approach-IAF to FAF/outer marker (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Approach-FAF/outer marker to threshold	0	0	0	0	0	0	0	0	2	0	0	2	2	0	0	2			
Approach-circling (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Approach-missed approach (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Landing-aborted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	Landing	56	9.89%
Landing	0	1	1	2	0	0	2	2	0	1	0	1	0	2	13	15			
Landing-flare/touchdown	0	0	5	5	0	0	1	1	0	1	4	5	0	1	38	39			
Landing-roll	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1			
Maneuvering	5	0	5	10	3	3	9	15	3	5	11	19	22	14	49	85	Maneuvering	201	35.51%
Maneuvering-aerial application	0	1	0	1	0	1	1	2	0	2	1	3	2	5	13	20			
Maneuvering-turn to reverse direction	0	0	1	1	0	0	0	0	1	0	0	1	2	0	2	4			
Maneuvering-turn to landing area (emer)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Hover	0	1	9	10	5	1	4	10	4	1	8	13	18	18	56	92			
Other	1	0	0	1	0	0	0	0	0	0	0	0	1	1	2	4	Other/?/NR	10	1.77%
Unknown	0	0	0	0	1	0	0	1	1	0	0	1	2	0	0	2			
Not reported	1	0	1	2	0	0	1	1	0	0	0	0	1	0	3	4			
Total:	19	6	34	59	14	10	36	60	22	15	47	84	122	92	352	566		566	100.00%

Table 3.24
General Aviation Accidents by Phase of Flight Operation
Total, Rotary Wing (Helicopters)
[References 3.49 to 3.57]

Total, Rotary Wing (Helicopters) Phase of Operation	1986				1987				1988				1989				1990				1991			
	Fatal Acc.	Injury Acc.	Pd. Dm Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pd. Dm Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pd. Dm Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pd. Dm Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pd. Dm Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pd. Dm Acc.	Total Acc.
Standing	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Standing-preflight	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Standing-starting engine(s)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Standing-engine(s) operating	0	0	2	2	0	0	2	2	0	0	2	2	1	3	0	4	0	1	0	1	0	1	0	1
Standing-engine(s) not operating	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Standing-idling rotors	1	0	1	2	0	0	0	0	0	1	1	2	0	0	2	2	1	2	2	5	0	0	1	1
Taxi	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Taxi-to takeoff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Taxi-from landing	1	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Taxi-aerial	0	0	2	2	0	0	2	2	0	0	5	5	0	1	3	4	0	0	3	3	0	0	2	2
Takeoff	1	3	3	7	1	3	3	7	1	2	12	15	0	0	8	8	2	2	8	12	2	2	4	8
Takeoff-aborted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Takeoff-ground run	1	0	0	1	0	1	4	5	0	0	0	0	0	1	1	2	0	0	0	0	1	0	0	1
Takeoff-initial climb	1	4	15	20	2	3	11	16	5	5	12	22	2	8	8	18	4	1	12	17	8	1	8	17
Climb	0	0	1	1	2	0	0	2	0	1	1	2	0	0	3	3	0	0	0	0	0	0	2	2
Climb-to cruise	0	0	1	1	0	0	1	1	1	1	1	3	1	0	1	2	0	0	1	1	0	1	1	2
Cruise	7	4	10	21	5	3	6	14	3	2	3	8	7	4	12	23	6	3	16	25	5	1	11	17
Cruise-normal	3	2	20	25	5	1	13	19	4	4	14	22	1	3	11	15	1	2	16	19	3	0	6	9
Cruise-holding (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Descent	2	1	2	5	0	0	2	2	0	0	4	4	0	0	1	1	0	0	2	2	0	0	2	2
Descent-normal	0	0	2	2	0	0	0	0	0	0	1	1	0	0	2	2	0	0	0	0	0	1	0	1
Descent-emergency	0	0	3	3	0	0	1	1	0	0	0	0	0	0	0	0	0	0	2	2	0	0	1	1
Descent-uncontrolled	0	0	0	0	1	0	1	2	0	0	0	0	0	0	0	0	0	1	1	2	1	0	0	1
Approach	1	1	3	5	0	0	1	1	0	1	3	4	1	0	3	4	0	1	1	2	3	2	2	7
Approach-VFR pattern-downwind	1	1	0	2	0	0	0	0	1	0	1	2	0	0	1	1	0	0	2	2	0	0	1	1
Approach-VFR pattern-base turn	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Approach-VFR pattern-base to final	0	0	1	1	1	0	1	2	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	2
Approach-VFR pattern-final approach	1	0	4	5	1	2	6	9	0	2	3	5	1	1	3	5	0	1	6	7	1	1	2	4
Approach-go-around (VFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	2	0	0	0	0
Approach-IAF to FAF/outer marker (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Approach-FAF/outer marker to threshold (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Approach-circling (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Approach-missed approach (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Landing-aborted	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Landing	0	0	4	4	0	0	7	7	0	0	4	4	0	0	4	4	0	0	9	9	0	0	6	6
Landing-flare/touchdown	0	0	9	9	0	0	20	20	0	2	15	17	0	1	12	13	1	0	13	14	0	0	21	21
Landing-roll	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0
Maneuvering	12	2	9	23	3	2	11	16	2	1	4	7	10	4	10	24	5	1	18	24	3	3	12	18
Maneuvering-aerial application	2	3	14	19	0	3	11	14	1	0	16	17	3	3	8	14	2	3	11	16	0	1	16	17
Maneuvering-turn to reverse direction	0	2	0	2	1	0	2	3	0	0	6	6	2	1	3	6	0	1	1	2	0	0	4	4
Maneuvering-turn to landing area (emergency)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hover	4	3	20	27	2	2	19	23	0	7	18	25	1	4	23	28	3	4	15	22	1	2	14	17
Other	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	1	0	1	0	0	1	1
Unknown	0	0	0	0	1	0	0	1	2	0	0	2	0	0	0	0	0	0	0	0	1	1	0	2
Not reported	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	1	1
Total:	39	26	126	191	25	21	125	171	21	29	130	180	30	34	122	186	25	25	146	196	29	18	119	166

Table 3.24 (Continued)
General Aviation Accidents by Phase of Flight Operation
Total, Rotary Wing (Helicopters)
[References 3.49 to 3.57]

Total, Rotary Wing (Helicopters) Phase of Operation	1992				1993				1994				TOTAL				Flight Phase	No.	Pct.
	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Acc.	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Acc.	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Acc.	Fatal Acc.	Injury Acc.	Pr. Acc.	Dm Acc.			
Standing	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2	Standing	38	2.34%
Standing-preflight	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Standing-starting engine(s)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Standing-engine(s) operating	0	1	1	2	0	1	0	1	0	0	2	2	1	7	9	17			
Standing-engine(s) not operating	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1			
Standing-idling rotors	0	0	0	0	1	0	2	3	0	1	2	3	3	4	11	18			
Taxi	0	0	1	1	0	0	0	0	0	0	1	1	0	0	3	3	Taxi	37	2.28%
Taxi-to takeoff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1			
Taxi-from landing	0	0	0	0	0	0	1	1	0	0	0	0	1	0	2	3			
Taxi-aerial	1	0	5	6	0	1	4	5	0	0	1	1	1	2	27	30			
Takeoff	0	1	6	7	0	1	3	4	1	0	5	6	8	14	52	74			
Takeoff-aborted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Takeoff-ground run	0	0	2	2	0	0	0	0	0	0	0	0	2	2	7	11	Takeoff	85	5.24%
Takeoff-initial climb	2	0	7	9	5	2	11	18	1	1	11	13	30	25	95	150			
Climb	1	0	0	1	0	0	2	2	2	0	3	5	5	1	12	18	Climb	32	1.97%
Climb-to cruise	0	2	0	2	0	0	1	1	0	1	0	1	2	5	7	14			
Cruise	13	3	12	28	6	3	9	18	9	5	16	30	61	28	95	184	Cruise	337	20.78%
Cruise-normal	9	2	8	19	3	1	7	11	3	2	8	13	32	17	103	152			
Cruise-holding (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1			
Descent	0	0	6	6	1	0	0	1	2	0	1	3	5	1	20	26			
Descent-normal	0	0	0	0	0	0	1	1	0	0	0	0	0	1	6	7	Descent	51	3.14%
Descent-emergency	0	0	0	0	0	0	0	0	1	0	1	2	1	0	8	9			
Descent-uncontrolled	0	0	1	1	1	0	2	3	0	0	0	0	3	1	5	9			
Approach	1	0	2	3	1	2	4	7	1	0	4	5	8	7	23	38			
Approach-VFR pattern-downwind	1	0	1	2	1	0	0	1	0	0	0	0	4	1	6	11			
Approach-VFR pattern-base turn	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1			
Approach-VFR pattern-base to final	0	0	1	1	0	0	1	1	0	0	0	0	1	1	6	8	Approach	118	7.27%
Approach-VFR pattern-final approach	1	0	7	8	0	0	3	3	3	0	4	7	8	7	38	53			
Approach-go-around (VFR)	0	0	0	0	1	0	1	2	0	0	0	0	1	0	4	5			
Approach-IAF to FAF/outer marker (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Approach-FAF/outer marker to threshold	0	0	0	0	0	0	0	0	2	0	0	2	2	0	0	2			
Approach-circling (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Approach-missed approach (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Landing-aborted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1			
Landing	1	1	4	6	0	0	6	6	1	1	3	5	2	2	47	51			
Landing-flare/touchdown	0	0	20	20	1	1	11	13	0	1	17	18	2	5	138	145	Landing	203	12.52%
Landing-roll	0	0	1	1	0	0	0	0	0	0	3	3	0	0	6	6			
Maneuvering	8	2	13	23	4	4	14	22	7	5	16	28	54	24	107	185			
Maneuvering-aerial application	0	1	5	6	1	1	12	14	2	4	9	15	11	19	102	132	Maneuvering	549	33.85%
Maneuvering-turn to reverse direction	0	0	4	4	0	0	2	2	1	0	0	1	4	4	22	30			
Maneuvering-turn to landing area (emer)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Hover	1	2	14	17	6	1	12	19	4	2	18	24	22	27	153	202			
Other	1	0	0	1	0	0	1	1	0	0	0	0	1	1	4	6			
Unknown	0	0	0	0	1	0	0	1	3	0	0	3	8	1	0	9	Other/?/NR	22	1.36%
Not reported	1	0	2	3	0	0	1	1	0	0	0	0	1	0	6	7			
Total:	41	15	123	179	33	18	111	162	43	23	125	191	286	209	1127	1622		1622	100.00%

Table 3.25
General Aviation Accidents by Phase of Flight Operation
Total Powered Aircraft
[References 3.49 to 3.57]

Total Powered Aircraft Phase of Operation	1986				1987				1988				1989				1990				1991			
	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Acc.	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Acc.	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Acc.	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Acc.	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Acc.	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Acc.
Standing	1	0	1	2	0	0	0	0	0	0	3	3	0	0	1	1	0	2	0	2	0	0	2	2
Standing-preflight	1	0	0	1	0	1	0	1	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	3
Standing-starting engine(s)	0	5	17	22	1	2	17	20	0	3	15	18	0	0	13	13	0	1	7	8	0	2	5	7
Standing-engine(s) operating	1	0	7	8	2	2	11	15	1	1	8	10	2	7	9	18	0	2	6	8	2	2	10	14
Standing-engine(s) not operating	0	0	0	0	0	2	1	3	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Standing-idling rotors	1	0	1	2	0	0	0	0	0	1	1	2	0	0	2	2	1	2	2	5	0	0	1	1
Taxi	1	0	13	14	0	0	5	5	1	0	7	8	0	0	5	5	2	0	9	11	0	1	5	6
Taxi-to takeoff	0	0	21	21	0	0	32	32	0	1	24	25	0	0	22	22	0	0	27	27	0	0	16	16
Taxi-from landing	1	1	18	20	0	0	28	28	1	0	31	32	1	0	26	27	0	0	19	19	0	2	16	18
Taxi-aerial	0	0	2	2	0	0	2	2	0	0	5	5	0	1	3	4	0	0	4	4	0	0	2	2
Takeoff	9	8	27	44	3	9	21	33	6	7	32	45	4	3	29	36	10	10	30	50	14	6	29	49
Takeoff-aborted	0	0	0	0	0	0	0	0	0	1	15	16	0	0	0	0	0	0	0	0	0	0	0	0
Takeoff-ground run	5	6	107	118	2	10	113	125	1	2	77	80	2	2	78	82	5	3	73	81	2	7	81	90
Takeoff-initial climb	69	58	232	359	50	70	220	340	71	69	187	327	63	59	202	324	65	61	185	311	57	58	187	302
Climb	12	6	20	38	7	4	12	23	5	4	15	24	9	2	10	21	7	5	8	20	15	10	21	46
Climb-to cruise	21	5	27	53	14	8	30	52	26	5	26	57	12	2	15	29	13	7	15	35	13	5	23	41
Cruise	41	19	115	175	38	11	84	133	44	18	91	153	55	21	107	183	44	19	95	158	55	23	116	194
Cruise-normal	47	37	178	262	64	19	158	241	63	31	164	258	61	20	146	227	35	15	145	195	37	23	116	176
Cruise-holding (IFR)	0	0	1	1	0	0	0	0	1	0	3	4	0	0	2	2	0	0	0	0	0	0	1	1
Descent	14	1	11	26	4	1	6	11	9	1	11	21	9	1	6	16	5	1	10	16	3	5	8	16
Descent-normal	10	7	27	44	8	6	30	44	5	1	39	45	5	2	21	28	9	5	21	35	4	6	23	33
Descent-emergency	2	2	7	11	0	0	6	6	1	0	1	2	0	0	2	2	0	0	3	3	2	1	3	6
Descent-uncontrolled	3	1	1	5	5	0	3	8	0	1	0	1	1	0	2	3	2	1	3	6	4	0	2	6
Approach	12	7	23	42	6	6	23	35	11	7	24	42	16	7	36	59	13	4	16	33	16	3	23	42
Approach-VFR pattern-downwind	6	3	16	25	9	4	11	24	4	4	13	21	6	2	9	17	12	2	18	32	5	4	12	21
Approach-VFR pattern-base turn	5	0	5	10	1	3	3	7	4	2	5	11	3	1	4	8	5	1	9	15	3	1	3	7
Approach-VFR pattern-base to final	9	2	8	19	10	1	8	19	5	2	7	14	10	5	6	21	6	3	13	22	8	3	14	25
Approach-VFR pattern-final approach	14	30	88	132	12	19	93	124	8	25	75	108	15	17	82	114	21	10	94	125	16	10	64	90
Approach-go-around (VFR)	4	9	46	59	6	11	32	49	8	7	39	54	4	5	30	39	7	8	28	43	7	8	36	51
Approach-IAF to FAF/outer marker (IFR)	3	3	1	7	5	0	0	5	8	1	2	11	8	1	0	9	5	1	2	8	5	1	1	7
Approach-FAF/outer marker to threshold	18	6	8	32	7	4	5	16	7	5	5	17	4	0	4	8	9	1	6	16	6	3	6	15
Approach-circling (IFR)	2	0	2	4	3	0	0	3	3	1	2	6	0	0	1	1	1	0	0	1	1	2	0	3
Approach-missed approach (IFR)	2	2	4	8	4	0	1	5	5	0	2	7	1	0	0	1	4	0	1	5	3	1	1	5
Landing-aborted	0	0	0	0	0	0	0	0	3	4	19	26	0	0	0	0	0	0	0	0	0	0	0	0
Landing	4	7	44	55	4	3	41	48	0	1	43	44	2	2	44	48	1	2	31	34	1	3	18	22
Landing-flare/touchdown	3	9	219	231	2	9	243	254	2	7	181	190	3	9	173	185	4	6	166	176	0	2	180	182
Landing-roll	7	6	290	303	0	11	309	320	1	9	263	273	2	7	242	251	2	6	258	266	1	0	233	234
Maneuvering	107	32	64	203	122	22	60	204	106	22	60	188	79	27	71	177	96	14	61	171	94	30	68	192
Maneuvering-aerial application	10	11	56	77	9	14	56	79	7	14	58	79	21	10	47	78	13	9	53	75	11	11	62	84
Maneuvering-turn to reverse direction	10	4	19	33	6	8	10	24	10	2	15	27	9	3	3	15	11	5	10	26	9	3	13	25
Maneuvering-turn to landing area (emer)	0	0	2	2	1	0	0	1	0	0	7	7	0	0	1	1	2	0	0	2	1	0	1	2
Hover	4	3	20	27	2	2	19	23	0	7	18	25	1	4	23	28	3	4	15	22	1	2	14	17
Other	3	0	3	6	4	1	22	27	0	0	1	1	4	6	57	67	6	6	55	67	9	3	42	54
Unknown	13	2	1	16	14	1	3	18	13	1	2	16	17	0	2	19	18	0	3	21	13	1	1	15
Not reported	1	0	1	2	7	0	2	9	2	0	4	6	1	0	0	1	6	1	12	19	9	0	10	19
Total:	476	292	1753	2521	432	264	1720	2416	442	267	1601	2310	430	226	1537	2193	443	217	1513	2173	428	243	1470	2141

Table 3.25 (Continued)
General Aviation Accidents by Phase of Flight Operation
Total Powered Aircraft
[References 3.49 to 3.57]

Total Powered Aircraft Phase of Operation	1992					1993					1994					TOTAL					Flight Phase	No.	Pct.
	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pd. Acc.	Dm Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Acc.	Dm Acc.	Total Acc.			
Standing	0	0	0	0	0	0	1	1	2	0	0	0	0	0	1	3	8	12					
Standing-preflight	0	1	0	1	0	0	0	0	0	0	0	0	0	0	2	3	2	7					
Standing-starting engine(s)	0	1	4	5	1	0	10	11	0	1	8	9	2	15	96	113							
Standing-engine(s) operating	2	1	3	6	3	4	4	11	3	8	7	18	16	27	65	108							
Standing-engine(s) not operating	0	0	0	0	0	0	0	1	1	1	1	0	2	1	3	3	7						
Standing-idling rotors	0	0	0	0	1	0	2	3	0	1	2	3	3	4	11	18					Standing	265	1.34%
Taxi	2	0	6	8	0	0	8	8	2	0	9	11	8	1	67	76							
Taxi-to takeoff	0	2	15	17	0	1	21	22	1	1	13	15	1	5	191	197							
Taxi-from landing	0	1	15	16	0	1	15	16	0	0	13	13	3	5	181	189							
Taxi-aerial	1	0	5	6	0	1	4	5	0	0	1	1	1	2	28	31					Taxi	493	2.50%
Takeoff	5	3	19	27	5	4	18	27	8	10	35	53	64	60	240	364							
Takeoff-aborted	0	0	0	0	0	0	0	0	0	1	22	23	0	2	37	39							
Takeoff-ground run	0	6	75	81	3	0	74	77	5	6	64	75	25	42	742	809					Takeoff	1212	6.14%
Takeoff-initial climb	57	47	169	273	53	49	178	280	65	49	160	274	550	520	1720	2790					Initial Climb	2790	14.13%
Climb	9	1	14	24	10	3	20	33	9	8	16	33	83	43	136	262							
Climb-to cruise	10	5	18	33	9	5	15	29	14	6	15	35	132	48	184	364					Climb	626	3.17%
Cruise	57	18	93	168	52	28	117	197	47	28	123	198	433	185	941	1559							
Cruise-normal	57	18	123	198	35	11	105	151	32	14	69	115	431	188	1204	1823							
Cruise-holding (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	1	0	7	8					Cruise	3390	17.17%
Descent	6	2	9	17	11	0	6	17	6	2	6	14	67	14	73	154							
Descent-normal	12	2	28	42	4	0	26	30	6	3	20	29	63	32	235	330							
Descent-emergency	1	0	2	3	1	1	3	5	3	0	2	5	10	4	29	43							
Descent-uncontrolled	1	3	3	7	1	1	4	6	2	0	0	2	19	7	18	44					Descent	571	2.89%
Approach	14	7	13	34	11	4	20	35	8	9	17	34	107	54	195	356							
Approach-VFR pattern-downwind	4	1	15	20	4	3	8	15	3	4	11	18	53	27	113	193							
Approach-VFR pattern-base turn	2	1	6	9	4	2	3	9	3	2	1	6	30	13	39	82							
Approach-VFR pattern-base to final	6	3	7	16	7	0	11	18	2	1	11	14	63	20	85	168							
Approach-VFR pattern-final approach	14	12	75	101	10	12	71	93	16	13	62	91	126	148	704	978							
Approach-go-around (VFR)	7	3	25	35	4	6	38	48	6	5	17	28	53	62	291	406							
Approach-IAF to FAF/outer marker (IFR)	4	0	2	6	1	1	1	3	1	0	1	2	40	8	10	58							
Approach-FAF/outer marker to threshold	10	2	5	17	4	2	7	13	6	2	5	13	71	25	51	147							
Approach-circling (IFR)	1	1	1	3	3	0	1	4	3	1	0	4	17	5	7	29							
Approach-missed approach (IFR)	4	1	2	7	1	2	1	4	7	0	0	7	31	6	12	49					Approach	2466	12.49%
Landing-aborted	0	0	0	0	0	0	0	0	1	2	17	20	4	6	36	46							
Landing	4	3	38	45	0	5	39	44	3	1	31	35	19	27	329	375							
Landing-flare/touchdown	3	7	178	188	5	4	148	157	2	7	166	175	24	60	1654	1738							
Landing-roll	3	4	223	230	2	6	238	246	1	8	231	240	19	57	2287	2363					Landing	4522	22.91%
Maneuvering	98	20	62	180	109	29	57	195	99	19	69	187	910	215	572	1697							
Maneuvering-aerial application	6	11	41	58	12	8	43	63	15	14	55	84	104	102	471	677							
Maneuvering-turn to reverse direction	10	5	13	28	4	5	9	18	4	5	0	9	73	40	92	205							
Maneuvering-turn to landing area (emer)	1	1	1	3	0	0	1	1	1	0	2	3	6	1	15	22							
Hover	1	2	14	17	6	1	12	19	4	2	18	24	22	27	153	202					Maneuvering	2803	14.20%
Other	11	5	42	58	3	3	44	50	0	0	1	1	40	24	267	331							
Unknown	14	0	7	21	15	3	1	19	10	0	2	12	127	8	22	157							
Not reported	7	0	15	22	9	3	12	24	5	1	7	13	47	5	63	115					Other ??/NR	603	3.05%
Total:	444	200	1386	2030	403	209	1397	2009	404	235	1309	1948	3902	2153	13686	19741						19741	100.00%

Table 3.26
General Aviation Accidents by Phase of Flight Operation
Gliders
[References 3.49 to 3.57]

Gliders	1986				1987				1988				1989				1990				1991				
	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	
Phase of Operation																									
Standing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Standing-preflight	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Standing-starting engine(s)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Standing-engine(s) operating	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Standing-engine(s) not operating	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Standing-idling rotors	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Taxi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Taxi-to takeoff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Taxi-from landing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Taxi-aerial	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Takeoff	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	1	
Takeoff-aborted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Takeoff-ground run	0	0	1	1	0	0	0	0	0	0	0	1	1	0	0	2	2	0	0	3	3	0	1	1	2
Takeoff-initial climb	2	1	10	13	0	1	4	5	2	2	4	8	0	1	3	4	0	3	3	6	1	1	2	4	
Climb	0	0	1	1	0	1	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	
Climb-to cruise	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Cruise	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	
Cruise-normal	0	1	3	4	0	0	2	2	2	0	1	3	0	0	2	2	0	0	0	0	0	0	0	0	
Cruise-holding (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Descent	0	0	0	0	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	
Descent-normal	0	1	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	2	
Descent-emergency	0	0	2	2	0	1	1	2	0	0	1	1	0	0	1	1	0	0	1	1	0	1	1	2	
Descent-uncontrolled	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Approach	0	1	1	2	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	3	3	
Approach-VFR pattern-downwind	0	1	0	1	0	0	0	0	0	0	1	1	0	1	1	2	0	0	0	0	0	0	0	0	
Approach-VFR pattern-base turn	0	1	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	
Approach-VFR pattern-base to final	0	2	0	2	0	0	2	2	1	0	0	1	0	2	0	2	0	0	1	1	1	1	1	3	
Approach-VFR pattern-final approach	2	3	11	16	0	0	4	4	0	3	3	6	0	1	3	4	1	1	5	7	0	3	7	10	
Approach-go-around (VFR)	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Approach-IAF to FAF/outer marker (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Approach-FAF/outer marker to threshold	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Approach-circling (IFR)	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Approach-missed approach (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Landing-aborted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Landing	0	0	4	4	0	0	1	1	0	1	2	3	0	0	0	0	0	1	1	2	0	1	1	2	
Landing-flare/touchdown	0	1	3	4	0	0	3	3	0	0	4	4	0	1	1	2	0	2	1	3	0	1	3	4	
Landing-roll	1	1	0	2	0	0	3	3	0	0	1	1	0	0	1	1	0	0	4	4	0	0	1	1	
Maneuvering	3	3	2	8	2	1	2	5	4	1	3	8	1	0	1	2	3	0	2	5	1	1	3	5	
Maneuvering-aerial application	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Maneuvering-turn to reverse direction	1	0	0	1	1	1	1	3	1	0	3	4	0	0	0	0	1	0	0	1	0	0	0	0	
Maneuvering-turn to landing area (emergency)	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	1	0	0	1	1	0	0	1	1	
Hover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Other	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	
Unknown	1	0	0	1	1	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	
Not reported	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Total:	10	16	43	69	4	6	26	36	13	7	25	45	1	6	16	23	5	8	27	40	5	10	28	43	

Table 3.26 (Continued)
General Aviation Accidents by Phase of Flight Operation
Gliders
[References 3.49 to 3.57]

Gliders Phase of Operation	1992				1993				1994				TOTAL				Flight Phase	No.	Pct.
	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.			
Standing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Standing	0	0.00%
Standing-preflight	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Standing-starting engine(s)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Standing-engine(s) operating	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Standing-engine(s) not operating	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Standing-idling rotors	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Taxi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Taxi	0	0.00%
Taxi-to takeoff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Taxi-from landing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Taxi-aerial	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Takeoff	0	0	1	1	0	0	1	1	0	0	2	2	0	0	7	7			
Takeoff-aborted	0	0	0	0	0	0	0	0	0	0	3	3	0	0	3	3	Takeoff	26	7.10%
Takeoff-ground run	0	0	5	5	0	1	0	1	0	0	1	1	0	2	14	16			
Takeoff-initial climb	2	2	3	7	0	2	3	5	0	1	1	2	7	14	33	54	Initial Climb	54	14.75%
Climb	0	0	0	0	0	0	0	0	0	1	0	1	0	2	2	4	Climb	5	1.37%
Climb-to cruise	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1			
Cruise	0	2	3	5	0	0	2	2	0	0	0	0	0	2	7	9	Cruise	23	6.28%
Cruise-normal	1	0	1	2	0	0	1	1	0	0	0	0	3	1	10	14			
Cruise-holding (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Descent	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	3	Descent	19	5.19%
Descent-normal	0	0	0	0	0	0	0	0	0	0	0	0	1	1	4	6			
Descent-emergency	0	0	0	0	0	0	0	0	0	0	0	0	0	2	7	9			
Descent-uncontrolled	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1			
Approach	0	0	0	0	0	0	1	1	0	0	0	0	0	1	7	8			
Approach-VFR pattern-downwind	0	0	0	0	0	0	1	1	0	0	0	0	0	2	3	5	Approach	104	28.42%
Approach-VFR pattern-base turn	0	1	0	1	0	0	0	0	0	0	0	0	1	3	0	4			
Approach-VFR pattern-base to final	0	0	1	1	0	0	1	1	1	1	1	3	3	6	7	16			
Approach-VFR pattern-final approach	1	3	4	8	0	1	5	6	1	0	6	7	5	15	48	68			
Approach-go-around (VFR)	0	0	0	0	0	0	1	1	0	0	0	0	0	0	2	2			
Approach-IAF to FAF/outer marker (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Approach-FAF/outer marker to threshold	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Approach-circling (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1			
Approach-missed approach (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Landing-aborted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Landing	0	1	1	2	0	0	0	0	0	0	3	3	0	4	13	17	Landing	63	17.21%
Landing-flare/touchdown	0	0	2	2	0	0	1	1	0	0	2	2	0	5	20	25			
Landing-roll	0	0	2	2	0	0	3	3	0	1	3	4	1	2	18	21			
Maneuvering	4	0	3	7	0	0	2	2	3	2	3	8	21	8	21	50			
Maneuvering-aerial application	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Maneuvering	66	18.03%
Maneuvering-turn to reverse direction	0	0	0	0	0	0	0	0	0	0	0	0	4	1	4	9			
Maneuvering-turn to landing area (emer)	0	0	0	0	0	1	1	2	0	0	1	1	0	2	5	7			
Hover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	Other/?/NR	6	1.64%
Unknown	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	3			
Not reported	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Total:	8	9	27	44	0	5	23	28	5	6	27	38	51	73	242	366		366	100.00%

Table 3.27
General Aviation Accidents by Phase of Flight Operation
Balloons
[References 3.49 to 3.57]

Balloons Phase of Operation	1986				1987				1988				1989				1990				1991			
	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.
Standing	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Standing-preflight	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Standing-starting engine(s)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Standing-engine(s) operating	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Standing-engine(s) not operating	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Standing-idling rotors	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxi-to takeoff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxi-from landing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxi-aerial	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Takeoff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
Takeoff-aborted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Takeoff-ground run	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Takeoff-initial climb	0	1	0	1	0	1	0	1	0	2	0	2	0	0	1	1	1	1	0	2	0	1	0	1
Climb	0	0	0	0	0	2	2	4	0	0	0	0	2	0	0	2	1	0	0	1	0	0	0	0
Climb-to cruise	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cruise	0	1	2	3	0	0	0	0	0	0	2	2	0	0	1	1	1	8	1	10	0	0	1	1
Cruise-normal	1	2	1	4	0	2	1	3	0	1	0	1	0	1	0	1	0	0	2	2	0	0	1	1
Cruise-holding (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Descent	0	0	0	0	2	0	1	3	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
Descent-normal	0	0	0	0	0	0	0	0	0	1	3	4	0	1	1	2	0	0	0	0	0	0	0	0
Descent-emergency	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Descent-uncontrolled	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Approach	0	0	0	0	1	1	0	2	0	0	0	0	1	0	0	1	0	0	0	0	0	2	1	3
Approach-VFR pattern-downwind	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Approach-VFR pattern-base turn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Approach-VFR pattern-base to final	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Approach-VFR pattern-final approach	0	0	1	1	0	1	0	1	0	1	0	1	0	2	1	3	0	0	1	1	0	0	0	0
Approach-go-around (VFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Approach-LAF to FAF/outer marker (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Approach-FAF/outer marker to threshold	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Approach-circling (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Approach-missed approach (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Landing-aborted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Landing	0	4	2	6	0	1	1	2	0	5	4	9	0	4	1	5	0	1	1	2	0	2	0	2
Landing-flare/touchdown	0	6	2	8	0	6	1	7	0	5	1	6	0	3	0	3	0	6	0	6	1	4	2	7
Landing-roll	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maneuvering	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maneuvering-aerial application	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maneuvering-turn to reverse direction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maneuvering-turn to landing area (emer)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	1	1	0	1	0	1	0	0	0	0	0	0	2	2	1	0	0	1	1	0	0	1
Unknown	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Not reported	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total:	1	14	9	24	3	17	9	29	0	15	10	25	3	12	7	22	4	17	5	26	2	9	5	16

Table 3.27 (Continued)
General Aviation Accidents by Phase of Flight Operation
Balloons
[References 3.49 to 3.57]

Balloons Phase of Operation	1992				1993				1994				TOTAL				Flight Phase	No.	Pct.
	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.			
Standing	0	0	0	0	0	0	1	1	0	0	0	0	0	0	2	2	Standing	3	1.52%
Standing-preflight	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Standing-starting engine(s)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Standing-engine(s) operating	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	1			
Standing-engine(s) not operating	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Standing-idling rotors	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Taxi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Taxi	0	0.00%
Taxi-to takeoff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Taxi-from landing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Taxi-aerial	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Takeoff	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	2	Takeoff	2	1.01%
Takeoff-aborted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Takeoff-ground run	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Takeoff-initial climb	0	0	0	0	0	1	0	1	0	0	1	1	1	7	2	10	Initial Climb	10	5.05%
Climb	0	2	0	2	0	0	0	0	0	0	0	0	3	4	2	9	Climb	9	4.55%
Climb-to cruise	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Cruise	0	1	1	2	1	1	0	2	0	2	1	3	2	13	9	24	Cruise	36	18.18%
Cruise-normal	0	0	0	0	0	0	0	0	0	0	0	0	1	6	5	12			
Cruise-holding (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Descent	0	0	0	0	0	0	0	0	0	0	0	0	2	1	1	4			
Descent-normal	0	0	0	0	0	0	0	0	0	1	0	1	0	3	4	7	Descent	14	7.07%
Descent-emergency	0	1	0	1	0	0	0	0	0	0	0	0	0	1	1	2			
Descent-uncontrolled	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1			
Approach	0	0	1	1	1	1	0	2	0	1	1	2	3	5	3	11			
Approach-VFR pattern-downwind	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Approach	19	9.60%
Approach-VFR pattern-base turn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Approach-VFR pattern-base to final	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Approach-VFR pattern-final approach	0	0	0	0	0	0	0	0	0	1	0	1	0	5	3	8			
Approach-go-around (VFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Approach-IAF to FAF/outer marker (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Approach-FAF/outer marker to threshold	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Approach-circling (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Approach-missed approach (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Landing-aborted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Landing	1	1	2	4	0	3	3	6	0	2	1	3	1	23	15	39	Landing	95	47.98%
Landing-flare/touchdown	0	4	0	4	0	6	2	8	0	7	0	7	1	47	8	56			
Landing-roll	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Maneuvering	1	0	0	1	0	0	1	1	0	0	0	0	1	2	1	4			
Maneuvering-aerial application	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Maneuvering	4	2.02%
Maneuvering-turn to reverse direction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Maneuvering-turn to landing area (emer)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Hover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Other	0	0	0	0	0	0	0	0	0	0	0	0	2	1	3	6	Other/?/NR	6	3.03%
Unknown	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Not reported	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Total:	2	10	4	16	2	12	7	21	0	14	5	19	17	120	61	198		198	100.00%

Table 3.28
General Aviation Accidents by Phase of Flight Operation
Other Aircraft
[References 3.49 to 3.57]

Other Aircraft Phase of Operation	1986				1987				1988				1989				1990				1991			
	Fatal Acc.	Injury Acc.	Pr. Acc.	Dm. Total Acc.	Fatal Acc.	Injury Acc.	Pr. Acc.	Dm. Total Acc.	Fatal Acc.	Injury Acc.	Pr. Acc.	Dm. Total Acc.	Fatal Acc.	Injury Acc.	Pr. Acc.	Dm. Total Acc.	Fatal Acc.	Injury Acc.	Pr. Acc.	Dm. Total Acc.	Fatal Acc.	Injury Acc.	Pr. Acc.	Dm. Total Acc.
Standing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Standing-preflight	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Standing-starting engine(s)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Standing-engine(s) operating	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Standing-engine(s) not operating	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Standing-idling rotors	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxi-to takeoff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxi-from landing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxi-aerial	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Takeoff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Takeoff-aborted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Takeoff-ground run	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Takeoff-initial climb	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
Climb	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
Climb-to cruise	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cruise	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	1	1	0	0	1
Cruise-normal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cruise-holding (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Descent	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Descent-normal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Descent-emergency	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Descent-uncontrolled	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Approach	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Approach-VFR pattern-downwind	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Approach-VFR pattern-base turn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Approach-VFR pattern-base to final	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Approach-VFR pattern-final approach	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Approach-go-around (VFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Approach-IAF to FAF/outer marker (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Approach-FAF/outer marker to threshold	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Approach-circling (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Approach-missed approach (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Landing-aborted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Landing	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Landing-flare/touchdown	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
Landing-roll	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maneuvering	0	0	0	0	1	1	0	2	0	1	1	2	1	0	0	1	0	0	0	0	0	0	0	0
Maneuvering-aerial application	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maneuvering-turn to reverse direction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maneuvering-turn to landing area (emer)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unknown	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Not reported	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Total:	0	0	0	0	1	4	0	5	0	1	2	3	2	0	2	4	0	0	1	1	1	2	0	3

Table 3.28 (Continued)
General Aviation Accidents by Phase of Flight Operation
Other Aircraft
[References 3.49 to 3.57]

Other Aircraft Phase of Operation	1992				1993				1994				TOTAL				Flight Phase	No.	Pct.
	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.			
Standing	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	Standing	1	3.70%
Standing-preflight	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Standing-starting engine(s)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Standing-engine(s) operating	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Standing-engine(s) not operating	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Standing-idling rotors	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Taxi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Taxi	0	0.00%
Taxi-to takeoff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Taxi-from landing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Taxi-aerial	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Takeoff	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	Takeoff	2	7.41%
Takeoff-aborted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1			
Takeoff-ground run	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0			
Takeoff-initial climb	0	0	1	1	0	0	1	1	0	0	0	0	0	1	0	1			
Climb	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2	5	Climb	1	3.70%
Climb-to cruise	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1			
Cruise	0	0	0	0	0	1	0	1	0	1	2	3	1	2	4	7			
Cruise-normal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Cruise-holding (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Cruise	7	25.93%
Descent	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Descent-normal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Descent-emergency	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Descent-uncontrolled	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Descent	0	0.00%
Approach	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	2			
Approach-VFR pattern-downwind	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Approach-VFR pattern-base turn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Approach-VFR pattern-base to final	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Approach	2	7.41%
Approach-VFR pattern-final approach	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Approach-go-around (VFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Approach-IAF to FAF/outer marker (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Approach-FAF/outer marker to threshold	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Approach-circling (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Approach-missed approach (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Landing-aborted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Landing	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	Landing	2	7.41%
Landing-flare/touchdown	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1			
Landing-roll	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Maneuvering	0	0	0	0	0	0	0	0	0	0	0	0	2	2	1	5			
Maneuvering-aerial application	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Maneuvering	6	22.22%
Maneuvering-turn to reverse direction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Maneuvering-turn to landing area (emer)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Hover	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1			
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Other/?/NR	1	3.70%
Unknown	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Not reported	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1			
Total:	0	0	3	3	0	2	1	3	0	1	4	5	4	10	13	27		27	100.00%

Table 3.29
General Aviation Accidents by Phase of Flight Operation
Total Aircraft, [References 3.49 to 3.57]

Total Aircraft Phase of Operation	1986				1987				1988				1989				1990				1991			
	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.
Standing	1	0	1	2	0	0	1	1	0	0	3	3	0	0	1	1	0	2	0	2	0	0	2	2
Standing-preflight	1	0	0	1	0	1	0	1	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	3
Standing-starting engine(s)	0	5	17	22	1	2	17	20	0	3	15	18	0	0	13	13	0	1	7	8	0	2	5	7
Standing-engine(s) operating	1	0	7	8	2	2	11	15	1	1	8	10	2	7	9	18	0	2	6	8	2	2	10	14
Standing-engine(s) not operating	0	0	0	0	0	2	1	3	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Standing-idling rotors	1	0	1	2	0	0	0	0	0	1	1	2	0	0	2	2	1	2	2	5	0	0	1	1
Taxi	1	0	13	14	0	0	5	5	1	0	7	8	0	0	5	5	2	0	9	11	0	1	5	6
Taxi-to takeoff	0	0	21	21	0	0	32	32	0	1	24	25	0	0	22	22	0	0	27	27	0	0	16	16
Taxi-from landing	1	1	18	20	0	0	28	28	1	0	31	32	1	0	26	27	0	0	19	19	0	2	16	18
Taxi-aerial	0	0	2	2	0	0	2	2	0	0	5	5	0	1	3	4	0	0	4	4	0	0	2	2
Takeoff	9	8	28	45	3	9	21	33	6	7	32	45	4	3	29	36	10	11	31	52	14	6	30	50
Takeoff-aborted	0	0	0	0	0	0	0	0	0	1	15	16	0	0	0	0	0	0	0	0	0	0	0	0
Takeoff-ground run	5	6	108	119	2	10	113	125	1	2	78	81	2	2	80	84	5	3	76	84	2	8	82	92
Takeoff-initial climb	71	60	242	373	50	73	224	347	73	73	191	337	63	60	206	329	66	65	188	319	58	62	189	309
Climb	12	6	21	39	7	7	14	28	5	4	16	25	12	2	10	24	8	5	8	21	15	10	21	46
Climb-to cruise	21	5	27	53	14	8	30	52	26	5	26	57	12	2	15	29	13	7	15	35	13	5	23	41
Cruise	41	20	117	178	38	11	84	133	44	18	93	155	55	21	109	185	45	27	99	171	56	23	117	196
Cruise-normal	48	40	182	270	64	21	161	246	65	32	165	262	61	21	148	230	35	15	147	197	37	23	117	177
Cruise-holding (IFR)	0	0	1	1	0	0	0	0	1	0	3	4	0	0	2	2	0	0	0	0	0	0	1	1
Descent	14	1	11	26	6	1	8	15	10	1	11	22	9	2	6	17	5	1	10	16	4	5	8	17
Descent-normal	10	8	29	47	8	6	30	44	5	2	42	49	5	3	22	30	9	5	22	36	5	6	24	35
Descent-emergency	2	2	9	13	0	1	8	9	1	0	2	3	0	0	3	3	0	0	4	4	2	2	4	8
Descent-uncontrolled	3	1	1	5	5	0	4	9	0	1	0	1	1	0	2	3	2	1	3	6	4	0	2	6
Approach	12	8	24	44	7	8	24	39	11	7	24	42	17	7	36	60	13	4	17	34	16	5	27	48
Approach-VFR pattern-downwind	6	4	16	26	9	4	11	24	4	4	14	22	6	3	10	19	12	2	18	32	5	4	12	21
Approach-VFR pattern-base turn	5	1	5	11	1	3	3	7	5	2	5	12	3	1	4	8	5	2	9	16	3	1	3	7
Approach-VFR pattern-base to final	9	4	8	21	10	1	10	21	6	2	7	15	10	7	6	23	6	3	14	23	9	4	15	28
Approach-VFR pattern-final approach	16	33	100	149	12	20	97	129	8	29	78	115	15	20	86	121	22	11	100	133	16	13	71	100
Approach-go-around (VFR)	4	9	47	60	6	11	32	49	8	7	39	54	4	5	30	39	7	8	28	43	7	8	36	51
Approach-IAF to FAF/outer marker (IFR)	3	3	1	7	5	0	0	5	8	1	2	11	8	1	0	9	5	1	2	8	5	1	1	7
Approach-FAF/outer marker to threshold	18	6	8	32	7	4	5	16	7	5	5	17	4	0	4	8	9	1	6	16	6	3	6	15
Approach-circling (IFR)	2	0	3	5	3	0	0	3	3	1	2	6	0	0	1	1	1	0	0	1	1	2	0	3
Approach-missed approach (IFR)	2	2	4	8	4	0	1	5	5	0	2	7	1	0	0	1	4	0	1	5	3	1	1	5
Landing-aborted	0	0	0	0	0	0	0	0	3	4	19	26	0	0	0	0	0	0	0	0	0	0	0	0
Landing	4	11	50	65	4	5	43	52	0	7	49	56	2	6	45	53	1	4	33	38	1	6	19	26
Landing-flare/touchdown	3	16	224	243	2	15	247	264	2	12	186	200	3	13	175	191	4	14	167	185	1	7	185	193
Landing-roll	8	7	290	305	0	11	312	323	1	9	264	274	2	7	243	252	2	6	262	270	1	0	234	235
Maneuvering	110	35	66	211	125	26	62	213	110	24	64	198	81	27	72	180	99	14	63	176	95	31	71	197
Maneuvering-aerial application	10	11	56	77	9	14	56	79	7	14	58	79	21	10	47	78	13	9	53	75	11	11	62	84
Maneuvering-turn to reverse direction	11	4	19	34	7	9	11	27	11	2	18	31	9	3	3	15	12	5	10	27	9	3	13	25
Maneuvering-turn to landing area (emer)	0	0	2	2	1	1	0	2	0	0	7	7	0	0	2	2	2	0	1	3	1	0	2	3
Hover	4	3	20	27	2	2	19	23	0	7	18	25	1	4	23	28	3	4	15	22	1	2	14	17
Other	3	0	4	7	4	2	23	29	0	0	1	1	4	6	59	69	7	6	55	68	10	3	44	57
Unknown	14	2	1	17	15	1	3	19	14	1	2	17	17	0	2	19	18	0	3	21	13	1	1	15
Not reported	1	0	1	2	7	0	2	9	2	0	5	7	1	0	0	1	6	1	12	19	9	0	10	19
Total:	487	322	1805	2614	440	291	1755	2486	455	290	1638	2383	436	244	1562	2242	452	242	1546	2240	436	264	1503	2203
	Sub. Minor/ Dest. Dam. None Total				Sub. Minor/ Dest. Dam. None Total				Sub. Minor/ Dest. Dam. None Total				Sub. Minor/ Dest. Dam. None Total				Sub. Minor/ Dest. Dam. None Total				Sub. Minor/ Dest. Dam. None Total			
Aircraft Damage	748	1832	35	2615	688	1800	34	2522	683	1702	29	2414	616	1620	26	2262	613	1597	31	2241	592	1583	33	2208

Table 3.29 (Continued)
General Aviation Accidents by Phase of Flight Operation
Total Aircraft, [References 3.49 to 3.57]

Total Aircraft Phase of Operation	1992				1993				1994				TOTAL				Flight Phase	No.	Pct.
	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.	Fatal Acc.	Injury Acc.	Pr. Dm. Acc.	Total Acc.			
Standing	0	0	0	0	0	1	2	3	0	0	1	1	1	3	11	15	Standing	269	1.32%
Standing-preflight	0	1	0	1	0	0	0	0	0	0	0	0	2	3	2	7			
Standing-starting engine(s)	0	1	4	5	1	0	10	11	0	1	8	9	2	15	96	113			
Standing-engine(s) operating	2	2	3	7	3	4	4	11	3	8	7	18	16	28	65	109			
Standing-engine(s) not operating	0	0	0	0	0	0	1	1	1	1	0	2	1	3	3	7			
Standing-idling rotors	0	0	0	0	1	0	2	3	0	1	2	3	3	4	11	18			
Taxi	2	0	6	8	0	0	8	8	2	0	9	11	8	1	67	76	Taxi	493	2.42%
Taxi-to takeoff	0	2	15	17	0	1	21	22	1	1	13	15	1	5	191	197			
Taxi-from landing	0	1	15	16	0	1	15	16	0	0	13	13	3	5	181	189			
Taxi-aerial	1	0	5	6	0	1	4	5	0	0	1	1	1	2	28	31			
Takeoff	5	3	21	29	5	4	19	28	8	10	38	56	64	61	249	374	Takeoff	1242	6.11%
Takeoff-aborted	0	0	0	0	0	0	0	0	0	1	25	26	0	2	40	42			
Takeoff-ground run	0	6	80	86	3	2	74	79	5	6	65	76	25	45	756	826			
Takeoff-initial climb	59	49	173	281	53	52	182	287	65	50	162	277	558	544	1757	2859			
Climb	9	3	14	26	10	3	20	33	9	9	16	34	87	49	140	276	Climb	641	3.15%
Climb-to cruise	10	5	18	33	9	5	15	29	14	6	16	36	132	48	185	365			
Cruise	57	21	97	175	53	30	119	202	47	31	126	204	436	202	961	1599			
Cruise-normal	58	18	124	200	35	11	106	152	32	14	69	115	435	195	1219	1849			
Cruise-holding (IFR)	0	0	0	0	0	0	0	0	0	0	0	0	1	0	7	8	Cruise	3456	17.00%
Descent	6	2	9	17	11	0	6	17	6	2	6	14	71	15	75	161			
Descent-normal	12	2	28	42	4	0	26	30	6	4	20	30	64	36	243	343			
Descent-emergency	1	1	2	4	1	1	3	5	3	0	2	5	10	7	37	54			
Descent-uncontrolled	1	3	4	8	1	1	4	6	2	0	0	2	19	7	20	46	Descent	604	2.97%
Approach	14	7	14	35	12	5	21	38	8	10	19	37	110	61	206	377			
Approach-VFR pattern-downwind	4	1	15	20	4	3	9	16	3	4	11	18	53	29	116	198			
Approach-VFR pattern-base turn	2	2	6	10	4	2	3	9	3	2	1	6	31	16	39	86			
Approach-VFR pattern-base to final	6	3	8	17	7	0	12	19	3	2	12	17	66	26	92	184	Approach	2591	12.74%
Approach-VFR pattern-final approach	15	15	79	109	10	13	76	99	17	14	68	99	131	168	755	1054			
Approach-go-around (VFR)	7	3	25	35	4	6	39	49	6	5	17	28	53	62	293	408			
Approach-IAF to FAF/outer marker (IFR)	4	0	2	6	1	1	1	3	1	0	1	2	40	8	10	58			
Approach-FAF/outer marker to threshold	10	2	5	17	4	2	7	13	6	2	5	13	71	25	51	147			
Approach-circling (IFR)	1	1	1	3	3	0	1	4	3	1	0	4	17	5	8	30			
Approach-missed approach (IFR)	4	1	2	7	1	2	1	4	7	0	0	7	31	6	12	49			
Landing	0	0	0	0	0	0	0	0	1	2	17	20	4	6	36	46	Landing	4682	23.03%
Landing-flare/touchdown	3	11	180	194	5	10	151	166	2	14	168	184	25	112	1683	1820			
Landing-roll	3	4	225	232	2	6	241	249	1	9	234	244	20	59	2305	2384			
Maneuvering	103	20	65	188	109	29	60	198	102	21	72	195	934	227	595	1756	Maneuvering	2879	14.16%
Maneuvering-aerial application	6	11	41	58	12	8	43	63	15	14	55	84	104	102	471	677			
Maneuvering-turn to reverse direction	10	5	13	28	4	5	9	18	4	5	0	9	77	41	96	214			
Maneuvering-turn to landing area (emer)	1	1	1	3	0	1	2	3	1	0	3	4	6	3	20	29			
Hover	1	2	15	18	6	1	12	19	4	2	18	24	22	27	154	203			
Other	11	5	42	58	3	3	44	50	0	0	1	1	42	25	273	340	Other/?/NR	616	3.03%
Unknown	14	0	7	21	15	3	1	19	10	0	2	12	130	8	22	160			
Not reported	7	0	15	22	9	3	12	24	5	1	7	13	47	5	64	116			
Total:	454	219	1420	2093	405	228	1428	2061	409	256	1345	2010	3974	2356	14002	20332		20332	100.00%
	Sub. Minor/ Dest. Dam. None Total				Sub. Minor/ Dest. Dam. None Total				Sub. Minor/ Dest. Dam. None Total				Sub. Minor/ Dest. Dam. None Total						
Aircraft Damage	570	1501	20	2091	557	1475	28	2060	538	1444	28	2010	5605	14554	264	20423			

Table 3.30
General Aviation Accidents, 1986-1994
by Flight Phases and by Aircraft Subcategories Summary
[References 3.49 - 3.57]

Aircraft Subcategories	Standing No. Pct.	Taxi No. Pct.	Takeoff No. Pct.	Initial Climb No. Pct.	Climb No. Pct.	Cruise No. Pct.	Descent No. Pct.	Approach No. Pct.	Landing No. Pct.	Maneuvering No. Pct.	Other/?/NR No. Pct.	Total No. Pct.
Single Engine Reciprocating Fixed Wing	203 1.25%	397 2.44%	1013 6.23%	2421 14.89%	509 3.13%	2740 16.85%	468 2.88%	2010 12.36%	3902 23.99%	2102 12.92%	499 3.07%	16264 100.00%
Multi Engine Reciprocating Fixed Wing	17 1.21%	43 3.06%	80 5.69%	176 12.51%	62 4.41%	261 18.55%	36 2.56%	264 18.76%	333 23.67%	71 5.05%	64 4.55%	1407 100.00%
Turboprop Fixed Wing	7 2.03%	14 4.07%	22 6.40%	38 11.05%	16 4.65%	44 12.79%	14 4.07%	55 15.99%	56 16.28%	68 19.77%	10 2.91%	344 100.00%
Turbojet Fixed Wing	0 0.00%	2 1.92%	12 11.54%	5 4.81%	7 6.73%	8 7.69%	2 1.92%	19 18.27%	28 26.92%	13 12.50%	8 7.69%	104 100.00%
Total Fixed Wing	227 1.25%	456 2.52%	1127 6.22%	2640 14.57%	594 3.28%	3053 16.85%	520 2.87%	2348 12.96%	4319 23.84%	2254 12.44%	581 3.21%	18119 100.00%
Reciprocating Engine Rotary Wing	24 2.27%	27 2.56%	59 5.59%	106 10.04%	20 1.89%	201 19.03%	34 3.22%	78 7.39%	147 13.92%	348 32.95%	12 1.14%	1056 100.00%
Turbine Engine Rotary Wing	14 2.47%	10 1.77%	26 4.59%	44 7.77%	12 2.12%	136 24.03%	17 3.00%	40 7.07%	56 9.89%	201 35.51%	10 1.77%	566 100.00%
Total Rotary Wing	38 2.34%	37 2.28%	85 5.24%	150 9.25%	32 1.97%	337 20.78%	51 3.14%	118 7.27%	203 12.52%	549 33.85%	22 1.36%	1622 100.00%
Total Powered Aircraft	265 1.34%	493 2.50%	1212 6.14%	2790 14.13%	626 3.17%	3390 17.17%	571 2.89%	2466 12.49%	4522 22.91%	2803 14.20%	603 3.05%	19741 100.00%
Glinters	0 0.00%	0 0.00%	26 7.10%	54 14.75%	5 1.37%	23 6.28%	19 5.19%	104 28.42%	63 17.21%	66 18.03%	6 1.64%	366 100.00%
Balloons	3 1.52%	0 0.00%	2 1.01%	10 5.05%	9 4.55%	36 18.18%	14 7.07%	19 9.60%	95 47.98%	4 2.02%	6 3.03%	198 100.00%
Other	1 3.70%	0 0.00%	2 7.41%	5 18.52%	1 3.70%	7 25.93%	0 0.00%	2 7.41%	2 7.41%	6 22.22%	1 3.70%	27 100.00%
Total Aircraft	269 1.32%	493 2.42%	1242 6.11%	2859 14.06%	641 3.15%	3456 17.00%	604 2.97%	2591 12.74%	4682 23.03%	2879 14.16%	616 3.03%	20332 100.00%

Table 3.31
General Aviation Accidents, 1986-1994 by Flight Phases and by Aircraft Subcategories Summary
Maneuvering Accidents and Accidents During Standing, Taxi, and Other Flight Phases Deleted
[References 3.49 - 3.57]

Aircraft Subcategories			Takeoff		Initial Climb		Climb		Cruise		Descent		Approach		Landing				Total	
			No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.			No.	Pct.
Single Engine Reciprocating Fixed Wing			1013	7.75%	2421	18.53%	509	3.90%	2740	20.98%	468	3.58%	2010	15.39%	3902	29.87%			13063	100.00%
Multi Engine Reciprocating Fixed Wing			80	6.60%	176	14.52%	62	5.12%	261	21.53%	36	2.97%	264	21.78%	333	27.48%			1212	100.00%
Turboprop Fixed Wing			22	8.98%	38	15.51%	16	6.53%	44	17.96%	14	5.71%	55	22.45%	56	22.86%			245	100.00%
Turbojet Fixed Wing			12	14.81%	5	6.17%	7	8.64%	8	9.88%	2	2.47%	19	23.46%	28	34.57%			81	100.00%
Total Fixed Wing			1127	7.72%	2640	18.08%	594	4.07%	3053	20.91%	520	3.56%	2348	16.08%	4319	29.58%			14601	100.00%
Reciprocating Engine Rotary Wing			59	9.15%	106	16.43%	20	3.10%	201	31.16%	34	5.27%	78	12.09%	147	22.79%			645	100.00%
Turbine Engine Rotary Wing			26	7.85%	44	13.29%	12	3.63%	136	41.09%	17	5.14%	40	12.08%	56	16.92%			331	100.00%
Total Rotary Wing			85	8.71%	150	15.37%	32	3.28%	337	34.53%	51	5.23%	118	12.09%	203	20.80%			976	100.00%
Total Powered Aircraft			1212	7.78%	2790	17.91%	626	4.02%	3390	21.76%	571	3.67%	2466	15.83%	4522	29.03%			15577	100.00%
Gliders			26	8.84%	54	18.37%	5	1.70%	23	7.82%	19	6.46%	104	35.37%	63	21.43%			294	100.00%
Balloons			2	1.08%	10	5.41%	9	4.86%	36	19.46%	14	7.57%	19	10.27%	95	51.35%			185	100.00%
Other			2	10.53%	5	26.32%	1	5.26%	7	36.84%	0	0.00%	2	10.53%	2	10.53%			19	100.00%
Total Aircraft			1242	7.73%	2859	17.79%	641	3.99%	3456	21.50%	604	3.76%	2591	16.12%	4682	29.13%			16075	100.00%

Table 3.32
General Aviation Operations
Single-Engine Reciprocating, Fixed Wing, 1986-1994
[References 3.34 to 3.42]

Parameter (Ref. Table No.)	1986	1987	1988	1989	1990	1991	1992	1993	1994
Population (2.1)	208,605	209,295	202,913	208,082	207,384	206,371	192,420	193,135	190,292
No. Active (2.1)	171,777	171,035	164,760	170,370	165,073	154,102	143,580	139,304	133,460
Total Hours Flown (2.1)	21,938,642	22,140,926	21,946,454	22,306,870	23,696,582	20,528,898	18,074,428	17,074,194	16,330,807
Commuter Hrs. (3.2)	294,599	288,040	67,106	86,055	242,447	118,973	113,563	0	0
Air Taxi Hrs. (3.2)	708,644	590,922	709,953	707,069	368,340	541,826	464,447	377,368	303,304
GA Hrs. = Total Hrs.									
-Commuter Hrs.- Air Taxi Hrs.	20,935,399	21,261,964	21,169,395	21,513,746	23,085,795	19,868,099	17,496,418	16,696,826	16,027,503
Total Day Hours Flown (4.1)	19,560,278	19,716,454	19,701,670	19,406,490	20,528,366	12,206,819	16,144,922	15,000,116	13,687,366
Total Night Hours Flown (4.1)	1,960,101	2,051,813	2,131,828	2,763,525	2,973,917	1,452,960	1,929,506	3,010,695	1,561,120
VMC Day Hours Flown (4.2)	18,312,246	18,672,258	18,545,108	18,280,300	19,322,588	11,732,973	15,441,143	14,230,163	12,892,258
VMC Night Hours Flown (4.2)	1,625,145	1,708,727	1,806,772	2,384,284	2,596,552	1,347,864	1,779,197	1,764,789	1,399,585
Total VMC Hours Flown (4.2)	19,937,391	20,380,985	20,351,880	20,664,584	21,919,140	13,080,837	17,220,340	15,994,952	14,291,843
IMC Day Hours Flown (4.3)	1,251,111	1,042,742	1,153,862	1,122,622	1,203,108	478,833	703,779	769,955	795,182
IMC Night Hours Flown (4.3)	337,111	342,849	323,200	382,574	373,057	105,446	150,309	1,292,238	161,536
Total IMC Hours Flown (4.3)	1,588,222	1,385,591	1,477,062	1,505,196	1,576,165	584,279	854,088	2,062,193	956,718
Total Landings (2.5)	32,427,255	33,664,442	34,362,721	34,070,471	37,914,218	33,935,464	29,052,448	24,068,971	24,559,429
Local Landings (2.6)	23,114,102	24,342,136	25,171,113	24,634,231	28,745,999	24,976,273	21,168,229	17,163,561	17,786,510
Cross Country Landings (2.7)	9,266,973	9,266,726	9,148,458	9,404,824	9,131,370	8,946,030	7,879,566	6,882,758	6,760,062
Estimated Flights (hours/avg. trip time)									
Commuter Flights	435,443	437,954	105,071	131,436	387,912	196,669	182,539	0	0
Air Taxi Flights	1,047,439	898,475	1,111,611	1,079,944	589,339	895,670	746,542	531,964	456,130
Estimated Flights (nmiles/avg. trip length)									
Commuter Flights	453,757	463,783	115,820	134,112	428,032	199,813	252,610	0	0
Air Taxi Flights	1,039,913	946,676	1,146,194	1,113,830	636,329	907,118	839,986	466,789	412,082
GA Flights = Total Landings-Commuter Flts.-Air Taxi Flts.									
Based on hrs./avg. trip time	30,944,373	32,328,013	33,146,039	32,859,090	36,936,967	32,843,125	28,123,367	23,537,007	24,103,299
Based on nmiles/avg. trip length	30,933,585	32,253,983	33,100,707	32,822,530	36,849,858	32,828,533	27,959,852	23,602,182	24,147,347
Total Nautical Miles Flown (3.3)	2,152,352,000	2,164,970,000	2,158,429,000	2,284,631,000	2,297,273,000	2,413,032,000	1,784,714,000	1,659,552,000	1,631,922,000
Commuter Nmiles (3.3)	30,118,000	29,826,000	7,275,000	8,993,000	25,935,000	14,208,000	15,518,000	0	0
Air Taxi Nmiles (3.3)	69,024,000	60,881,000	71,996,000	74,689,000	38,556,000	64,502,000	51,601,000	32,185,000	27,382,000
GA Nmiles = Total Nmiles									
-Commuter Nmiles -Air Taxi Nmiles	2,053,210,000	2,074,263,000	2,079,158,000	2,200,949,000	2,232,782,000	2,334,322,000	1,717,595,000	1,627,367,000	1,604,540,000
Average Speed (nmiles/hour)	98.11	97.78	98.35	102.42	96.95	117.54	98.74	97.20	99.93
Average Trip Length (nmiles/landing)	66.37	64.31	62.81	67.06	60.59	71.11	61.43	68.95	66.45
Average Trip Time (hour/landing)	0.68	0.66	0.64	0.65	0.63	0.60	0.62	0.71	0.66
Average Commuter Speed (nmiles/hour)	102.23	103.55	108.41	104.50	106.97	119.42	136.65	N.A.	N.A.
Average Air Taxi Speed (nmiles/hour)	97.40	103.03	101.41	105.63	104.68	119.05	111.10	85.29	90.28
GA Average Speed (nmiles/hour)	98.07	97.56	98.22	102.30	96.72	117.49	98.17	97.47	100.11

N/A = Information not available

N.A. = Not Applicable

1993 and 1994 data adjusted to include experimental aircraft in appropriate subcategories.

Table 3.32 (Continued)
General Aviation Operations
Single-Engine Reciprocating, Fixed Wing, 1986-1994
[References 3.34 to 3.42]

Parameter (Ref. Table No.)	Total	Average	Pct. of Fixed Wing	Pct. of Tot. Aircraft
Population (2.1)		202,055	84.65%	78.00%
No. Active (2.1)		157,051	83.78%	78.14%
Total Hours Flown (2.1)	184,037,801	20,448,645	73.57%	66.68%
Commuter Hrs. (3.2)	1,210,783	134,531		
Air Taxi Hrs. (3.2)	4,771,873	530,208		
GA Hrs. = Total Hrs.				
-Commuter Hrs. - Air Taxi Hrs.	178,055,145	19,783,905	78.80%	72.53%
Total Day Hours Flown (4.1)	155,952,481	17,328,053	77.33%	70.80%
Total Night Hours Flown (4.1)	19,835,465	2,203,941	55.83%	52.12%
VMC Day Hours Flown (4.2)	147,429,037	16,381,004	81.19%	73.75%
VMC Night Hours Flown (4.2)	16,412,915	1,823,657	65.02%	59.24%
Total VMC Hours Flown (4.2)	163,841,952	18,204,661	79.21%	71.99%
IMC Day Hours Flown (4.3)	8,521,194	946,799	42.41%	42.23%
IMC Night Hours Flown (4.3)	3,468,320	385,369	33.58%	33.37%
Total IMC Hours Flown (4.3)	11,989,514	1,332,168	39.41%	39.22%
Total Landings (2.5)	284,055,419	31,561,713	81.35%	70.43%
Local Landings (2.6)	207,102,154	23,011,350	92.37%	80.37%
Cross Country Landings (2.7)	76,686,767	8,520,752	61.51%	55.52%
Estimated Flights (hours/avg. trip time)				
Commuter Flights	1,877,025	208,558		
Air Taxi Flights	7,357,114	817,457		
Estimated Flights (nmiles/avg. trip length)				
Commuter Flights	2,047,925	227,547		
Air Taxi Flights	7,508,917	834,324		
GA Flights = Total Landings - Commuter Flts. - Air Taxi Flts.				
Based on hrs./avg. trip time	274,821,280	30,535,698		
Based on nmiles/avg. trip length	274,498,578	30,499,842		
Total Nautical Miles Flown (3.3)	18,546,875,000	2,060,763,889	57.61%	54.62%
Commuter Nmiles (3.3)	131,873,000	14,652,556		
Air Taxi Nmiles (3.3)	490,816,000	54,535,111		
GA Nmiles = Total Nmiles				
-Commuter Nmiles - Air Taxi Nmiles	17,924,186,000	1,991,576,222	63.68%	60.56%
Average Speed (nmiles/hour)	100.78	100.78		
Average Trip Length (nmiles/landing)	65.29	65.45		
Average Trip Time (hour/landing)	0.65	0.65		
Average Commuter Speed (nmiles/hour)	108.92	111.68		
Average Air Taxi Speed (nmiles/hour)	102.86	101.98		
GA Average Speed (nmiles/hour)	100.67	100.68		

N/A = Information not available

N.A. = Not Applicable

1993 and 1994 data adjusted to include experimental aircraft in appropriate subcategories.

Table 3.33
General Aviation Operations
Multi-Engine Reciprocating, Fixed Wing, 1986-1994
[References 3.34 to 3.42]

Parameter (Ref. Table No.)	1986	1987	1988	1989	1990	1991	1992	1993	1994
Population (2.1)	28,645	27,679	26,498	26,722	26,674	26,095	23,298	22,134	22,127
No. Active (2.1)	23,869	23,419	22,797	23,445	22,700	21,246	18,536	16,565	15,763
Total Hours Flown (2.1)	4,922,215	4,898,421	4,279,602	4,664,601	4,276,233	3,561,730	3,176,476	2,525,537	2,615,577
Commuter Hrs. (3.2)	425,119	572,401	268,807	332,564	220,018	127,333	293,027	0	0
Air Taxi Hrs. (3.2)	999,243	943,264	1,009,393	1,051,176	1,010,269	582,037	576,472	483,273	644,590
GA Hrs. = Total Hrs.									
-Commuter Hrs.- Air Taxi Hrs.	3,497,853	3,382,756	3,001,402	3,280,861	3,045,946	2,852,360	2,306,977	2,042,264	1,970,987
Total Day Hours Flown (4.1)	3,802,384	3,688,649	3,440,545	3,452,765	3,087,215	1,504,413	2,550,141	1,472,874	1,836,896
Total Night Hours Flown (4.1)	1,076,946	957,365	853,327	1,164,902	1,130,368	362,107	626,335	926,635	501,412
VMC Day Hours Flown (4.2)	2,972,293	2,937,703	2,794,605	2,782,354	2,472,211	1,203,372	2,088,109	1,111,936	1,470,398
VMC Night Hours Flown (4.2)	671,192	602,320	537,536	753,503	758,087	236,234	458,402	356,671	358,578
Total VMC Hours Flown (4.2)	3,643,485	3,540,023	3,332,141	3,535,857	3,230,298	1,439,606	2,546,511	1,468,607	1,828,976
IMC Day Hours Flown (4.3)	834,699	743,443	642,513	665,553	614,842	302,229	462,032	360,938	366,499
IMC Night Hours Flown (4.3)	410,328	349,289	316,823	411,380	371,785	123,086	167,933	569,964	142,834
Total IMC Hours Flown (4.3)	1,245,027	1,092,732	959,336	1,076,933	986,627	425,315	629,965	930,902	509,333
Total Landings (2.5)	5,287,776	3,768,708	3,990,514	4,736,298	4,094,349	3,561,076	3,090,811	2,338,243	2,629,132
Local Landings (2.6)	1,736,977	1,125,457	1,229,611	1,562,348	1,407,703	1,378,897	1,010,598	766,344	993,893
Cross Country Landings (2.7)	3,558,962	2,633,282	2,755,256	3,177,093	2,669,158	2,174,064	2,066,577	1,565,341	1,620,023
Estimated Flights (hours/avg. trip time)									
Commuter Flights	456,692	440,389	250,649	337,676	210,660	127,310	285,124	0	0
Air Taxi Flights	1,073,454	725,721	941,208	1,067,333	967,299	581,930	560,925	447,433	647,931
Estimated Flights (nmiles/avg. trip length)									
Commuter Flights	461,228	456,169	258,951	370,147	237,081	125,021	295,102	0	0
Air Taxi Flights	1,137,267	735,136	959,459	1,129,482	1,016,818	611,083	613,296	370,802	599,505
GA Flights = Total Landings-Commuter Flts.-Air Taxi Flts.									
Based on hrs./avg. trip time	3,757,630	2,602,598	2,798,657	3,331,289	2,916,391	2,851,836	2,244,761	1,890,810	1,981,201
Based on nmiles/avg. trip length	3,689,282	2,577,403	2,772,104	3,236,670	2,840,450	2,824,972	2,182,413	1,967,441	2,029,627
Total Nautical Miles Flown (3.3)	712,362,000	721,110,000	628,062,000	701,948,000	622,215,000	506,927,000	459,220,000	341,383,000	361,914,000
Commuter Nmiles (3.3)	62,136,000	87,284,000	40,756,000	54,858,000	36,029,000	17,797,000	43,845,000	0	0
Air Taxi Nmiles (3.3)	153,211,000	140,662,000	151,008,000	167,396,000	154,525,000	86,989,000	91,121,000	54,137,000	82,525,000
GA Nmiles = Total Nmiles									
-Commuter Nmiles -Air Taxi Nmiles	497,015,000	493,164,000	436,298,000	479,694,000	431,661,000	402,141,000	324,254,000	287,246,000	279,389,000
Average Speed (nmiles/hour)	144.72	147.21	146.76	150.48	145.51	142.33	144.57	135.17	138.37
Average Trip Length (nmiles/landing)	134.72	191.34	157.39	148.21	151.97	142.35	148.58	146.00	137.66
Average Trip Time (hour/landing)	0.93	1.30	1.07	0.98	1.04	1.00	1.03	1.08	0.99
Average Commuter Speed (nmiles/hour)	146.16	152.49	151.62	164.95	163.75	139.77	149.63	N.A.	N.A.
Average Air Taxi Speed (nmiles/hour)	153.33	149.12	149.60	159.25	152.95	149.46	158.07	112.02	128.03
GA Average Speed (nmiles/hour)	142.09	145.79	145.36	146.21	141.72	140.99	140.55	140.65	141.75

N/A = Information not available

N.A. = Not Applicable

1993 and 1994 data adjusted to include experimental aircraft in appropriate subcategories.

Table 3.33 (Continued)
General Aviation Operations
Multi-Engine Reciprocating, Fixed Wing, 1986-1994
[References 3.34 to 3.42]

Parameter (Ref. Table No.)	Total	Average	Pct. of Fixed Wing	Pct. of Tot. Aircraft
Population (2.1)		25,541	10.70%	9.86%
No. Active (2.1)		20,927	11.16%	10.41%
Total Hours Flown (2.1)	34,920,392	3,880,044	13.96%	12.65%
Commuter Hrs. (3.2)	2,239,269	248,808		
Air Taxi Hrs. (3.2)	7,299,717	811,080		
GA Hrs. = Total Hrs.				
-Commuter Hrs.- Air Taxi Hrs.	25,381,406	2,820,156	11.23%	10.34%
Total Day Hours Flown (4.1)	24,835,882	2,759,542	12.31%	11.28%
Total Night Hours Flown (4.1)	7,599,397	844,377	21.39%	19.97%
VMC Day Hours Flown (4.2)	19,832,981	2,203,665	10.92%	9.92%
VMC Night Hours Flown (4.2)	4,732,523	525,836	18.75%	17.08%
Total VMC Hours Flown (4.2)	24,565,504	2,729,500	11.88%	10.79%
IMC Day Hours Flown (4.3)	4,992,748	554,750	24.85%	24.74%
IMC Night Hours Flown (4.3)	2,863,422	318,158	27.72%	27.55%
Total IMC Hours Flown (4.3)	7,856,170	872,908	25.82%	25.70%
Total Landings (2.5)	33,496,907	3,721,879	9.59%	8.31%
Local Landings (2.6)	11,211,828	1,245,759	5.00%	4.35%
Cross Country Landings (2.7)	22,219,756	2,468,862	17.82%	16.09%
Estimated Flights (hours/avg. trip time)				
Commuter Flights	2,108,499	234,278		
Air Taxi Flights	7,013,235	779,248		
Estimated Flights (nmiles/avg. trip length)				
Commuter Flights	2,203,698	244,855		
Air Taxi Flights	7,172,846	796,983		
GA Flights = Total Landings-Commuter Flts.-Air Taxi Flts.				
Based on hrs./avg. trip time	24,375,173	2,708,353		
Based on nmiles/avg. trip length	24,120,363	2,680,040		
Total Nautical Miles Flown (3.3)	5,055,141,000	561,682,333	15.70%	14.89%
Commuter Nmiles (3.3)	342,705,000	38,078,333		
Air Taxi Nmiles (3.3)	1,081,574,000	120,174,889		
GA Nmiles = Total Nmiles				
-Commuter Nmiles -Air Taxi Nmiles	3,630,862,000	403,429,111	12.90%	12.27%
Average Speed (nmiles/hour)	144.76	143.90		
Average Trip Length (nmiles/landing)	150.91	150.91		
Average Trip Time (hour/landing)	1.04	1.05		
Average Commuter Speed (nmiles/hour)	153.04	152.62		
Average Air Taxi Speed (nmiles/hour)	148.17	145.76		
GA Average Speed (nmiles/hour)	143.05	142.79		

N/A = Information not available

N.A. = Not Applicable

1993 and 1994 data adjusted to include experimental aircraft in appropriate subcategories.

Table 3.34
General Aviation Operations
Turboprop, Fixed Wing, 1986-1994
[References 3.34 to 3.42]

Parameter (Ref. Table No.)	1986	1987	1988	1989	1990	1991	1992	1993	1994
Population (2.1)	6,632	5,871	5,783	6,876	6,411	6,279	6,072	5,988	5,762
No. Active (2.1)	5,964	5,274	5,259	6,324	5,652	4,920	4,704	4,450	4,313
Total Hours Flown (2.1)	2,881,538	2,177,061	2,369,947	3,131,961	2,521,281	1,512,668	1,477,709	1,232,450	1,112,264
Commuter Hrs. (3.2)	1,332,308	488,415	647,906	1,061,206	887,897	310,559	260,319	0	0
Air Taxi Hrs. (3.2)	203,967	281,419	306,331	296,808	305,458	272,018	199,954	200,089	194,596
GA Hrs. = Total Hrs.									
-Commuter Hrs. - Air Taxi Hrs.	1,345,263	1,407,227	1,415,710	1,773,947	1,327,926	930,091	1,017,436	1,032,361	917,668
Total Day Hours Flown (4.1)	2,094,417	1,603,608	1,741,087	2,104,888	1,776,603	727,139	1,169,086	386,437	680,864
Total Night Hours Flown (4.1)	693,101	484,619	671,376	946,522	687,500	268,549	308,623	497,763	187,847
VMC Day Hours Flown (4.2)	1,235,962	1,110,557	1,368,623	1,516,658	1,210,805	533,764	892,193	219,758	534,292
VMC Night Hours Flown (4.2)	286,953	255,935	429,652	559,103	393,212	160,006	183,617	129,518	128,290
Total VMC Hours Flown (4.2)	1,522,915	1,366,492	1,798,275	2,075,761	1,604,017	693,770	1,075,810	349,276	662,582
IMC Day Hours Flown (4.3)	859,883	494,213	374,547	589,747	579,791	195,151	276,893	166,680	146,572
IMC Night Hours Flown (4.3)	405,092	228,889	242,367	388,205	298,200	108,984	125,006	368,244	59,556
Total IMC Hours Flown (4.3)	1,264,975	723,102	616,914	977,952	877,991	304,135	401,899	534,924	206,128
Total Landings (2.5)	3,074,229	2,490,601	2,417,659	3,863,795	2,904,657	2,033,602	1,743,365	1,307,109	1,401,896
Local Landings (2.6)	608,250	533,688	310,552	700,860	743,809	608,507	558,064	335,975	554,627
Cross Country Landings (2.7)	2,507,347	1,965,041	2,100,909	3,155,838	2,175,570	1,408,911	1,207,006	976,700	851,407
Estimated Flights (hours/avg. trip time)									
Commuter Flights	1,421,401	558,756	660,950	1,309,174	1,022,907	417,510	307,118	0	0
Air Taxi Flights	217,606	321,949	312,498	366,162	351,905	365,696	235,901	212,210	245,269
Estimated Flights (nmiles/avg. trip length)									
Commuter Flights	1,414,358	557,773	663,598	1,351,273	1,051,242	427,781	357,458	0	0
Air Taxi Flights	228,354	328,684	337,870	380,423	358,429	393,197	272,485	147,905	203,191
GA Flights = Total Landings - Commuter Flts. - Air Taxi Flts.									
Based on hrs./avg. trip time	1,435,222	1,609,896	1,444,211	2,188,459	1,529,845	1,250,397	1,200,346	1,094,899	1,156,627
Based on nmiles/avg. trip length	1,431,517	1,604,144	1,416,192	2,132,099	1,494,987	1,212,624	1,113,423	1,159,204	1,198,705
Total Nautical Miles Flown (3.3)	550,215,000	406,624,000	457,579,000	593,875,000	493,971,000	289,827,000	280,381,000	194,893,000	197,288,000
Commuter Nmiles (3.3)	253,137,000	91,064,000	125,596,000	207,694,000	178,776,000	60,967,000	57,489,000	0	0
Air Taxi Nmiles (3.3)	40,870,000	53,662,000	63,947,000	58,472,000	60,955,000	56,038,000	43,823,000	22,053,000	28,595,000
GA Nmiles = Total Nmiles									
-Commuter Nmiles - Air Taxi Nmiles	256,208,000	261,898,000	268,036,000	327,709,000	254,240,000	172,822,000	179,069,000	172,840,000	168,693,000
Average Speed (nmiles/hour)	190.94	186.78	193.08	189.62	195.92	191.60	189.74	158.13	177.38
Average Trip Length (nmiles/landing)	178.98	163.26	189.27	153.70	170.06	142.52	160.83	149.10	140.73
Average Trip Time (hour/landing)	0.94	0.87	0.98	0.81	0.87	0.74	0.85	0.94	0.79
Average Commuter Speed (nmiles/hour)	190.00	186.45	193.85	195.72	201.35	196.31	220.84	N.A.	N.A.
Average Air Taxi Speed (nmiles/hour)	200.38	190.68	208.75	197.00	199.55	206.01	219.17	110.22	146.95
GA Average Speed (nmiles/hour)	190.45	186.11	189.33	184.73	191.46	185.81	176.00	167.42	183.83

N/A = Information not available

N.A. = Not Applicable

1993 and 1994 data adjusted to include experimental aircraft in appropriate subcategories.

Table 3.34 (Continued)
General Aviation Operations
Turboprop, Fixed Wing, 1986-1994
[References 3.34 to 3.42]

Parameter (Ref. Table No.)	Total	Average	Pct. of Fixed Wing	Pct. of Tot. Aircraft
Population (2.1)		6,186	2.59%	2.39%
No. Active (2.1)		5,207	2.78%	2.59%
Total Hours Flown (2.1)	18,416,879	2,046,320	7.36%	6.67%
Commuter Hrs. (3.2)	4,988,610	554,290		
Air Taxi Hrs. (3.2)	2,260,640	251,182		
GA Hrs. = Total Hrs.				
-Commuter Hrs.- Air Taxi Hrs.	11,167,629	1,240,848	4.94%	4.55%
Total Day Hours Flown (4.1)	12,284,129	1,364,903	6.09%	5.58%
Total Night Hours Flown (4.1)	4,745,900	527,322	13.36%	12.47%
VMC Day Hours Flown (4.2)	8,622,612	958,068	4.75%	4.31%
VMC Night Hours Flown (4.2)	2,526,286	280,698	10.01%	9.12%
Total VMC Hours Flown (4.2)	11,148,898	1,238,766	5.39%	4.90%
IMC Day Hours Flown (4.3)	3,683,477	409,275	18.33%	18.25%
IMC Night Hours Flown (4.3)	2,224,543	247,171	21.54%	21.40%
Total IMC Hours Flown (4.3)	5,908,020	656,447	19.42%	19.32%
Total Landings (2.5)	21,236,913	2,359,657	6.08%	5.27%
Local Landings (2.6)	4,954,332	550,481	2.21%	1.92%
Cross Country Landings (2.7)	16,348,729	1,816,525	13.11%	11.84%
Estimated Flights (hours/avg. trip time)				
Commuter Flights	5,697,816	633,091		
Air Taxi Flights	2,629,195	292,133		
Estimated Flights (nmiles/avg. trip length)				
Commuter Flights	5,823,483	647,054		
Air Taxi Flights	2,650,537	294,504		
GA Flights = Total Landings-Commuter Flts.-Air Taxi Flts.				
Based on hrs./avg. trip time	12,909,902	1,434,434		
Based on nmiles/avg. trip length	12,762,894	1,418,099		
Total Nautical Miles Flown (3.3)	3,464,653,000	384,961,444	10.76%	10.20%
Commuter Nmiles (3.3)	974,723,000	108,302,556		
Air Taxi Nmiles (3.3)	428,415,000	47,601,667		
GA Nmiles = Total Nmiles				
-Commuter Nmiles -Air Taxi Nmiles	2,061,515,000	229,057,222	7.32%	6.97%
Average Speed (nmiles/hour)	188.12	185.91		
Average Trip Length (nmiles/landing)	163.14	160.94		
Average Trip Time (hour/landing)	0.87	0.87		
Average Commuter Speed (nmiles/hour)	195.39	197.79		
Average Air Taxi Speed (nmiles/hour)	189.51	186.52		
GA Average Speed (nmiles/hour)	184.60	183.90		

N/A = Information not available

N.A. = Not Applicable

1993 and 1994 data adjusted to include experimental aircraft in appropriate subcategories.

Table 3.35
General Aviation Operations
Turbojet, Fixed Wing, 1986-1994
[References 3.34 to 3.42]

Parameter (Ref. Table No.)	1986	1987	1988	1989	1990	1991	1992	1993	1994
Population (2.1)	4,961	4,789	4,555	4,736	4,891	5,041	4,866	5,062	5,385
No. Active (2.1)	4,480	4,338	4,187	4,402	4,374	4,353	4,022	4,068	4,317
Total Hours Flown (2.1)	1,654,308	1,527,760	1,677,752	1,654,096	1,511,560	1,236,283	1,072,292	1,178,873	1,254,770
Commuter Hrs. (3.2)	381	4,625	2,805	8,593	0	4,282	9,511	0	0
Air Taxi Hrs. (3.2)	198,634	171,266	194,228	216,227	147,365	185,657	74,787	107,491	97,659
GA Hrs. = Total Hrs.									
-Commuter Hrs.- Air Taxi Hrs.	1,455,293	1,351,869	1,480,719	1,429,276	1,364,195	1,046,344	987,994	1,071,382	1,157,111
Total Day Hours Flown (4.1)	1,276,996	1,138,852	1,227,229	1,168,399	1,085,973	726,577	838,941	297,320	850,458
Total Night Hours Flown (4.1)	368,424	365,923	399,843	476,069	441,692	205,652	233,351	607,918	246,314
VMC Day Hours Flown (4.2)	782,825	708,106	814,273	831,548	752,716	499,085	576,120	119,150	627,605
VMC Night Hours Flown (4.2)	185,746	181,436	190,991	279,966	246,844	97,029	131,061	120,158	138,314
Total VMC Hours Flown (4.2)	968,571	889,542	1,005,264	1,111,514	999,560	596,114	707,181	239,308	765,919
IMC Day Hours Flown (4.3)	488,584	431,007	411,888	338,644	334,679	228,608	262,821	178,169	222,855
IMC Night Hours Flown (4.3)	181,363	184,718	207,292	197,360	195,253	108,714	102,290	487,759	108,345
Total IMC Hours Flown (4.3)	669,947	615,725	619,180	536,004	529,932	337,322	365,111	665,928	331,200
Total Landings (2.5)	1,284,427	1,234,563	1,298,001	1,455,010	1,256,966	971,172	929,511	884,744	1,054,017
Local Landings (2.6)	151,676	116,368	71,502	190,286	76,793	84,485	56,986	72,330	117,838
Cross Country Landings (2.7)	1,130,769	1,115,781	1,225,081	1,269,027	1,182,918	885,844	874,324	814,790	929,175
Estimated Flights (hours/avg. trip time)									
Commuter Flights	296	3,737	2,170	7,559	0	3,364	8,245	0	0
Air Taxi Flights	154,222	138,398	150,265	190,202	122,544	145,844	64,829	80,672	82,034
Estimated Flights (nmiles/avg. trip length)									
Commuter Flights	305	3,883	1,964	7,422	0	3,602	9,223	0	0
Air Taxi Flights	156,949	143,155	154,223	186,815	126,670	151,771	70,285	94,185	86,138
GA Flights = Total Landings-Commuter Flts.-Air Taxi Flts.									
Based on hrs./avg. trip time	1,129,909	1,092,428	1,145,565	1,257,249	1,134,422	821,964	856,438	804,072	971,983
Based on nmiles/avg. trip length	1,127,173	1,087,525	1,141,814	1,260,772	1,130,296	815,799	850,003	790,559	967,879
Total Nautical Miles Flown (3.3)	673,709,000	618,648,000	678,235,000	692,000,000	605,880,000	485,634,000	421,382,000	463,383,000	487,397,000
Commuter Nmiles (3.3)	160,000	1,946,000	1,026,000	3,530,000	0	1,801,000	4,181,000	0	0
Air Taxi Nmiles (3.3)	82,323,000	71,736,000	80,585,000	88,849,000	61,057,000	75,893,000	31,863,000	49,329,000	39,832,000
GA Nmiles = Total Nmiles									
-Commuter Nmiles -Air Taxi Nmiles	591,226,000	544,966,000	596,624,000	599,621,000	544,823,000	407,940,000	385,338,000	414,054,000	447,565,000
Average Speed (nmiles/hour)	407.25	404.94	404.25	418.36	400.83	392.82	392.97	393.07	388.44
Average Trip Length (nmiles/landing)	524.52	501.11	522.52	475.60	482.02	500.05	453.34	523.75	462.42
Average Trip Time (hour/landing)	1.29	1.24	1.29	1.14	1.20	1.27	1.15	1.33	1.19
Average Commuter Speed (nmiles/hour)	419.95	420.76	365.78	410.80	0.00	420.60	439.60	N.A.	N.A.
Average Air Taxi Speed (nmiles/hour)	414.45	418.86	414.90	410.91	414.32	408.78	426.05	458.91	407.87
GA Average Speed (nmiles/hour)	406.26	403.12	402.93	419.53	399.37	389.87	390.02	386.47	386.80

N/A = Information not available

N.A. = Not Applicable

1993 and 1994 data adjusted to include experimental aircraft in appropriate subcategories.

Table 3.35 (Continued)
General Aviation Operations
Turbojet, Fixed Wing, 1986-1994
[References 3.34 to 3.42]

Parameter (Ref. Table No.)	Total	Average	Pct. of Fixed Wing	Pct. of Tot. Aircraft
Population (2.1)		4,921	2.06%	1.90%
No. Active (2.1)		4,282	2.28%	2.13%
Total Hours Flown (2.1)	12,767,694	1,418,633	5.10%	4.63%
Commuter Hrs. (3.2)	30,197	3,355		
Air Taxi Hrs. (3.2)	1,393,314	154,813		
GA Hrs. = Total Hrs.				
-Commuter Hrs.- Air Taxi Hrs.	11,344,183	1,260,465	5.02%	4.62%
Total Day Hours Flown (4.1)	8,610,745	956,749	4.27%	3.91%
Total Night Hours Flown (4.1)	3,345,186	371,687	9.42%	8.79%
VMC Day Hours Flown (4.2)	5,711,428	634,603	3.15%	2.86%
VMC Night Hours Flown (4.2)	1,571,545	174,616	6.23%	5.67%
Total VMC Hours Flown (4.2)	7,282,973	809,219	3.52%	3.20%
IMC Day Hours Flown (4.3)	2,897,255	321,917	14.42%	14.36%
IMC Night Hours Flown (4.3)	1,773,094	197,010	17.17%	17.06%
Total IMC Hours Flown (4.3)	4,670,349	518,928	15.35%	15.28%
Total Landings (2.5)	10,368,411	1,152,046	2.97%	2.57%
Local Landings (2.6)	938,264	104,252	0.42%	0.36%
Cross Country Landings (2.7)	9,427,709	1,047,523	7.56%	6.83%
Estimated Flights (hours/avg. trip time)				
Commuter Flights	25,370	2,819		
Air Taxi Flights	1,129,011	125,446		
Estimated Flights (nmiles/avg. trip length)				
Commuter Flights	26,399	2,933		
Air Taxi Flights	1,170,191	130,021		
GA Flights = Total Landings-Commuter Flts.-Air Taxi Flts.				
Based on hrs./avg. trip time	9,214,030	1,023,781		
Based on nmiles/avg. trip length	9,171,821	1,019,091		
Total Nautical Miles Flown (3.3)	5,126,268,000	569,585,333	15.92%	15.10%
Commuter Nmiles (3.3)	12,644,000	1,404,889		
Air Taxi Nmiles (3.3)	581,467,000	64,607,444		
GA Nmiles = Total Nmiles				
-Commuter Nmiles -Air Taxi Nmiles	4,532,157,000	503,573,000	16.10%	15.31%
Average Speed (nmiles/hour)	401.50	400.32		
Average Trip Length (nmiles/landing)	494.41	493.92		
Average Trip Time (hour/landing)	1.23	1.23		
Average Commuter Speed (nmiles/hour)	418.72	353.92		
Average Air Taxi Speed (nmiles/hour)	417.33	419.45		
GA Average Speed (nmiles/hour)	399.51	398.26		

N/A = Information not available

N.A. = Not Applicable

1993 and 1994 data adjusted to include experimental aircraft in appropriate subcategories.

Table 3.36
General Aviation Operations
Total, Fixed Wing, 1986-1994
[References 3.34 to 3.42]

Parameter (Ref. Table No.)	1986	1987	1988	1989	1990	1991	1992	1993	1994
Population (2.1)	248,843	247,634	239,749	246,416	245,360	243,786	226,656	226,319	223,566
No. Active (2.1)	206,090	204,066	197,003	204,541	197,799	184,621	170,842	164,387	157,853
Total Hours Flown (2.1)	31,396,703	30,744,168	30,273,755	31,757,528	32,005,656	26,839,579	23,800,905	22,011,054	21,313,418
Commuter Hrs. (3.2)	2,052,407	1,353,481	986,624	1,488,418	1,350,362	561,147	676,420	0	0
Air Taxi Hrs. (3.2)	2,110,488	1,986,871	2,219,905	2,271,280	1,831,432	1,581,538	1,315,660	1,168,221	1,240,149
GA Hrs. = Total Hrs.									
-Commuter Hrs.- Air Taxi Hrs.	27,233,808	27,403,816	27,067,226	27,997,830	28,823,862	24,696,894	21,808,825	20,842,833	20,073,269
Total Day Hours Flown (4.1)	26,734,075	26,147,563	26,110,531	26,132,542	26,478,157	15,164,948	20,703,090	17,156,747	17,055,584
Total Night Hours Flown (4.1)	4,098,572	3,859,720	4,056,374	5,351,018	5,233,477	2,289,268	3,097,815	5,043,011	2,496,693
VMC Day Hours Flown (4.2)	23,303,326	23,428,624	23,522,609	23,410,860	23,758,320	13,969,194	18,997,565	15,681,007	15,524,553
VMC Night Hours Flown (4.2)	2,769,036	2,748,418	2,964,951	3,976,856	3,994,695	1,841,133	2,552,277	2,371,136	2,024,767
Total VMC Hours Flown (4.2)	26,072,362	26,177,042	26,487,560	27,387,716	27,753,015	15,810,327	21,549,842	18,052,143	17,549,320
IMC Day Hours Flown (4.3)	3,434,277	2,711,405	2,582,810	2,716,566	2,732,420	1,204,821	1,705,525	1,475,742	1,531,108
IMC Night Hours Flown (4.3)	1,333,894	1,105,745	1,089,682	1,379,519	1,238,295	446,230	545,538	2,718,205	472,271
Total IMC Hours Flown (4.3)	4,768,171	3,817,150	3,672,492	4,096,085	3,970,715	1,651,051	2,251,063	4,193,947	2,003,379
Total Landings (2.5)	42,073,687	41,158,314	42,068,895	44,125,574	46,170,190	40,501,314	34,816,135	28,599,067	29,644,474
Local Landings (2.6)	25,611,005	26,117,649	26,782,778	27,087,725	30,974,304	27,048,162	22,793,877	18,338,210	19,452,868
Cross Country Landings (2.7)	16,464,051	14,980,830	15,229,704	17,006,782	15,159,016	13,414,849	12,027,473	10,239,589	10,160,667
Estimated Flights (hours/avg. trip time)									
Commuter Flights	2,750,363	1,811,953	1,371,029	2,068,086	1,947,983	846,779	989,472	0	0
Air Taxi Flights	2,828,195	2,659,895	3,084,816	3,155,835	2,641,957	2,386,564	1,924,557	1,517,875	1,724,902
Estimated Flights (nmiles/avg. trip length)									
Commuter Flights	3,555,855	2,211,047	1,873,250	2,840,953	2,765,383	1,038,700	1,430,528	0	0
Air Taxi Flights	3,554,589	3,440,330	3,942,027	4,021,755	3,619,477	3,106,268	2,581,434	1,696,062	1,973,708
GA Flights = Total Landings-Commuter Flts.-Air Taxi Flts.									
Based on hrs./avg. trip time	36,495,129	36,686,466	37,613,051	38,901,653	41,580,250	37,267,971	31,902,106	27,081,192	27,919,572
Based on nmiles/avg. trip length	34,963,242	35,506,937	36,253,617	37,262,866	39,785,330	36,356,347	30,804,173	26,903,005	27,670,766
Total Nautical Miles Flown (3.3)	4,088,638,000	3,911,352,000	3,922,305,000	4,272,454,000	4,019,339,000	3,695,420,000	2,945,697,000	2,659,211,000	2,678,521,000
Commuter Nmiles (3.3)	345,551,000	210,120,000	174,653,000	275,075,000	240,740,000	94,773,000	121,033,000	0	0
Air Taxi Nmiles (3.3)	345,428,000	326,941,000	367,536,000	389,406,000	315,093,000	283,422,000	218,408,000	157,704,000	178,334,000
GA Nmiles = Total Nmiles									
-Commuter Nmiles -Air Taxi Nmiles	3,397,659,000	3,374,291,000	3,380,116,000	3,607,973,000	3,463,506,000	3,317,225,000	2,606,256,000	2,501,507,000	2,500,187,000
Average Speed (nmiles/hour)	130.23	127.22	129.56	134.53	125.58	137.69	123.76	120.81	125.67
Average Trip Length (nmiles/landing)	97.18	95.03	93.24	96.82	87.05	91.24	84.61	92.98	90.35
Average Trip Time (hour/landing)	0.75	0.75	0.72	0.72	0.69	0.66	0.68	0.77	0.72
Average Commuter Speed (nmiles/hour)	168.36	155.24	177.02	184.81	178.28	168.89	178.93	N.A.	N.A.
Average Air Taxi Speed (nmiles/hour)	163.67	164.55	165.56	171.45	172.05	179.21	166.01	135.00	143.80
GA Average Speed (nmiles/hour)	124.76	123.13	124.88	128.87	120.16	134.32	119.50	120.02	124.55

N/A = Information not available

N.A. = Not Applicable

1993 and 1994 data adjusted to include experimental aircraft in appropriate subcategories.

Table 3.36 (Continued)
General Aviation Operations
Total, Fixed Wing, 1986-1994
[References 3.34 to 3.42]

Parameter (Ref. Table No.)	Total	Average	Pct. of Fixed Wing	Pct. of Tot. Aircraft
Population (2.1)		238,703	100.00%	92.15%
No. Active (2.1)		187,467	100.00%	93.27%
Total Hours Flown (2.1)	250,142,766	27,793,641	100.00%	90.64%
Commuter Hrs. (3.2)	8,468,859	940,984		
Air Taxi Hrs. (3.2)	15,725,544	1,747,283		
GA Hrs. = Total Hrs.				
-Commuter Hrs. - Air Taxi Hrs.	225,948,363	25,105,374	100.00%	92.04%
Total Day Hours Flown (4.1)	201,683,237	22,409,249	100.00%	91.56%
Total Night Hours Flown (4.1)	35,525,948	3,947,328	100.00%	93.35%
VMC Day Hours Flown (4.2)	181,596,058	20,177,340	100.00%	90.85%
VMC Night Hours Flown (4.2)	25,243,269	2,804,808	100.00%	91.11%
Total VMC Hours Flown (4.2)	206,839,327	22,982,147	100.00%	90.88%
IMC Day Hours Flown (4.3)	20,094,674	2,232,742	100.00%	99.58%
IMC Night Hours Flown (4.3)	10,329,379	1,147,709	100.00%	99.38%
Total IMC Hours Flown (4.3)	30,424,053	3,380,450	100.00%	99.52%
Total Landings (2.5)	349,157,650	38,795,294	100.00%	86.57%
Local Landings (2.6)	224,206,578	24,911,842	100.00%	87.00%
Cross Country Landings (2.7)	124,682,961	13,853,662	100.00%	90.27%
Estimated Flights (hours/avg. trip time)				
Commuter Flights	11,785,665	1,309,518		
Air Taxi Flights	21,924,597	2,436,066		
Estimated Flights (nmiles/avg. trip length)				
Commuter Flights	15,715,716	1,746,191		
Air Taxi Flights	27,935,650	3,103,961		
GA Flights = Total Landings-Commuter Flts.-Air Taxi Flts.				
Based on hrs./avg. trip time	315,447,389	35,049,710		
Based on nmiles/avg. trip length	305,506,284	33,945,143		
Total Nautical Miles Flown (3.3)	32,192,937,000	3,576,993,000	100.00%	94.81%
Commuter Nmiles (3.3)	1,461,945,000	162,438,333		
Air Taxi Nmiles (3.3)	2,582,272,000	286,919,111		
GA Nmiles = Total Nmiles				
-Commuter Nmiles - Air Taxi Nmiles	28,148,720,000	3,127,635,556	100.00%	95.10%
Average Speed (nmiles/hour)	128.70	128.34		
Average Trip Length (nmiles/landing)	92.20	92.06		
Average Trip Time (hour/landing)	0.72	0.72		
Average Commuter Speed (nmiles/hour)	172.63	173.08		
Average Air Taxi Speed (nmiles/hour)	164.21	162.37		
GA Average Speed (nmiles/hour)	124.58	124.47		

N/A = Information not available

N.A. = Not Applicable

1993 and 1994 data adjusted to include experimental aircraft in appropriate subcategories.

Table 3.37
General Aviation Operations
Reciprocating Engine, Rotary Wing (Helicopters), 1986-1994
[References 3.34 to 3.42]

Parameter (Ref. Table No.)	1986	1987	1988	1989	1990	1991	1992	1993	1994
Population (2.1)	5,566	5,555	5,334	5,784	5,802	5,848	5,209	5,729	5,351
No. Active (2.1)	2,921	2,813	2,584	3,244	3,459	2,470	2,211	2,497	2,382
Total Hours Flown (2.1)	804,458	651,687	575,955	748,773	774,774	583,688	416,375	425,485	396,183
Commuter Hrs. (3.2)	1,275	0	1,185	0	190	0	0	0	0
Air Taxi Hrs. (3.2)	14,300	5,311	5,392	20,172	0	2,502	27,426	917	242
GA Hrs. = Total Hrs.									
-Commuter Hrs.- Air Taxi Hrs.	788,883	646,376	569,378	728,601	774,584	581,186	388,949	424,568	395,941
Total Day Hours Flown (4.1)	641,145	586,072	494,242	N/A	642,194	433,246	360,264	334,668	274,133
Total Night Hours Flown (4.1)	167,818	80,280	85,191	N/A	133,148	68,658	56,111	37,490	38,766
VMC Day Hours Flown (4.2)	641,148	586,037	492,899	N/A	642,194	433,031	360,200	333,319	271,872
VMC Night Hours Flown (4.2)	167,178	80,280	84,747	N/A	133,148	68,658	56,079	34,528	38,213
Total VMC Hours Flown (4.2)	808,326	666,317	577,646	N/A	775,342	501,689	416,279	367,847	310,085
IMC Day Hours Flown (4.3)	0	34	1,321	N/A	N/A	215	64	1,349	2,269
IMC Night Hours Flown (4.3)	643	0	450	N/A	N/A	0	32	2,963	553
Total IMC Hours Flown (4.3)	643	34	1,771	N/A	N/A	215	96	4,312	2,822
Total Landings (2.5)	1,575,722	1,732,469	1,345,262	2,540,599	2,441,240	2,015,878	1,410,131	1,283,025	1,209,095
Local Landings (2.6)	1,428,205	1,365,577	1,102,592	N/A	2,076,490	1,861,442	1,263,327	1,167,289	1,066,085
Cross Country Landings (2.7)	158,061	367,024	235,980	N/A	355,030	149,109	148,994	122,200	154,992
Estimated Flights (hours/avg. trip time)									
Commuter Flights	2,497	0	2,768	0	599	0	0	0	0
Air Taxi Flights	28,010	14,119	12,594	68,444	0	8,641	92,883	2,765	739
Estimated Flights (nmiles/avg. trip length)									
Commuter Flights	2,781	0	2,567	0	743	0	0	0	0
Air Taxi Flights	28,618	20,167	13,212	68,629	0	9,437	101,097	6,066	904
GA Flights = Total Landings-Commuter Flts.-Air Taxi Flts.									
Based on hrs./avg. trip time	1,545,215	1,718,350	1,329,900	2,472,155	2,440,641	2,007,237	1,317,248	1,280,260	1,208,356
Based on nmiles/avg. trip length	1,544,323	1,712,302	1,329,484	2,471,970	2,440,497	2,006,441	1,309,034	1,276,959	1,208,191
Total Nautical Miles Flown (3.3)	48,729,000	37,197,000	31,973,000	42,720,000	42,737,000	33,325,000	24,033,000	24,535,000	25,404,000
Commuter Nmiles (3.3)	86,000	0	61,000	0	13,000	0	0	0	0
Air Taxi Nmiles (3.3)	885,000	433,000	314,000	1,154,000	0	156,000	1,723,000	116,000	19,000
GA Nmiles = Total Nmiles									
-Commuter Nmiles -Air Taxi Nmiles	47,758,000	36,764,000	31,598,000	41,566,000	42,724,000	33,169,000	22,310,000	24,419,000	25,385,000
Average Speed (nmiles/hour)	60.57	57.08	55.51	57.05	55.16	57.09	57.72	57.66	64.12
Average Trip Length (nmiles/landing)	30.92	21.47	23.77	16.81	17.51	16.53	17.04	19.12	21.01
Average Trip Time (hour/landing)	0.51	0.38	0.43	0.29	0.32	0.29	0.30	0.33	0.33
Average Commuter Speed (nmiles/hour)	67.45	N.A.	51.48	N.A.	68.42	N.A.	N.A.	N.A.	N.A.
Average Air Taxi Speed (nmiles/hour)	61.89	81.53	58.23	57.21	0.00	62.35	62.82	126.50	78.51
GA Average Speed (nmiles/hour)	60.54	56.88	55.50	57.05	55.16	57.07	57.36	57.51	64.11

N/A = Information not available

N.A. = Not Applicable

1993 and 1994 data adjusted to include experimental aircraft in appropriate subcategories.

Table 3.37 (Continued)
General Aviation Operations
Reciprocating Engine, Rotary Wing (Helicopters), 1986-1994
[References 3.34 to 3.42]

Parameter (Ref. Table No.)	Total	Average	Pct. of Tot. Aircraft
Population (2.1)		5,575	2.15%
No. Active (2.1)		2,731	1.36%
Total Hours Flown (2.1)	5,377,378	597,486	1.95%
Commuter Hrs. (3.2)	2,650	294	
Air Taxi Hrs. (3.2)	76,262	8,474	
GA Hrs. = Total Hrs.			
-Commuter Hrs.- Air Taxi Hrs.	5,298,466	588,718	2.16%
Total Day Hours Flown (4.1)	3,765,964	470,746	1.92%
Total Night Hours Flown (4.1)	667,462	83,433	1.97%
VMC Day Hours Flown (4.2)	3,760,700	470,088	2.12%
VMC Night Hours Flown (4.2)	662,831	82,854	2.69%
Total VMC Hours Flown (4.2)	4,423,531	552,941	2.19%
IMC Day Hours Flown (4.3)	5,252	750	0.03%
IMC Night Hours Flown (4.3)	4,641	663	0.06%
Total IMC Hours Flown (4.3)	9,893	1,413	0.04%
Total Landings (2.5)	15,553,421	1,728,158	3.86%
Local Landings (2.6)	11,331,007	1,416,376	4.95%
Cross Country Landings (2.7)	1,691,390	211,424	1.38%
Estimated Flights (hours/avg. trip time)			
Commuter Flights	5,864	652	
Air Taxi Flights	228,195	25,355	
Estimated Flights (nmiles/avg. trip length)			
Commuter Flights	6,090	677	
Air Taxi Flights	248,130	27,570	
GA Flights = Total Landings-Commuter Flts.-Air Taxi Flts.			
Based on hrs./avg. trip time	15,319,362	1,702,151	
Based on nmiles/avg. trip length	15,299,201	1,699,911	
Total Nautical Miles Flown (3.3)	310,653,000	34,517,000	0.91%
Commuter Nmiles (3.3)	160,000	17,778	
Air Taxi Nmiles (3.3)	4,800,000	533,333	
GA Nmiles = Total Nmiles			
-Commuter Nmiles -Air Taxi Nmiles	305,693,000	33,965,889	1.03%
Average Speed (nmiles/hour)	57.77	58.00	
Average Trip Length (nmiles/landing)	19.97	20.47	
Average Trip Time (hour/landing)	0.35	0.35	
Average Commuter Speed (nmiles/hour)	60.38	62.45	
Average Air Taxi Speed (nmiles/hour)	62.94	65.45	
GA Average Speed (nmiles/hour)	57.69	57.91	

N/A = Information not available

N.A. = Not Applicable

1993 and 1994 data adjusted to include experimental aircraft in appropriate subcategories.

Table 3.38
General Aviation Operations
Turbine Engine, Rotary Wing (Helicopters), 1986-1994
[References 3.34 to 3.42]

Parameter (Ref. Table No.)	1986	1987	1988	1989	1990	1991	1992	1993	1994
Population (2.1)	4,899	4,479	4,434	4,685	4,620	4,626	4,390	4,090	4,565
No. Active (2.1)	4,022	3,520	3,822	4,232	3,938	3,822	3,541	2,948	3,108
Total Hours Flown (2.1)	1,820,936	1,631,439	2,130,764	2,079,847	1,617,292	2,171,911	1,866,326	1,467,670	1,671,805
Commuter Hrs. (3.2)	131,669	5,198	130,227	14,378	93,508	3,224	16,135	0	0
Air Taxi Hrs. (3.2)	788,841	804,820	616,419	978,686	593,753	657,035	664,835	281,595	429,393
GA Hrs. = Total Hrs.									
-Commuter Hrs.- Air Taxi Hrs.	900,426	821,421	1,384,118	1,086,783	930,031	1,511,652	1,185,356	1,186,075	1,242,412
Total Day Hours Flown (4.1)	1,577,446	1,462,698	1,887,467	N/A	1,401,958	1,228,993	1,609,221	989,474	847,534
Total Night Hours Flown (4.1)	209,023	169,794	257,096	N/A	211,881	220,469	257,105	210,530	242,737
VMC Day Hours Flown (4.2)	1,563,634	1,451,160	1,874,178	N/A	1,392,627	1,226,337	1,601,491	985,496	841,237
VMC Night Hours Flown (4.2)	194,745	166,437	247,131	N/A	198,648	219,805	255,424	203,188	240,988
Total VMC Hours Flown (4.2)	1,758,379	1,617,597	2,121,309	N/A	1,591,275	1,446,142	1,856,915	1,188,684	1,082,225
IMC Day Hours Flown (4.3)	13,832	11,436	13,481	N/A	9,297	2,670	7,730	3,978	6,298
IMC Night Hours Flown (4.3)	14,244	3,372	9,882	N/A	13,128	666	1,681	7,342	1,749
Total IMC Hours Flown (4.3)	28,076	14,808	23,363	N/A	22,425	3,336	9,411	11,320	8,047
Total Landings (2.5)	3,450,604	3,182,811	4,003,396	4,715,450	3,763,986	4,725,551	2,783,251	2,639,668	3,608,748
Local Landings (2.6)	2,271,982	1,306,672	2,497,360	N/A	1,860,388	3,594,838	521,775	1,583,167	3,196,556
Cross Country Landings (2.7)	1,202,266	1,842,805	1,504,849	N/A	1,853,186	1,131,195	2,309,526	1,058,663	448,906
Estimated Flights (hours/avg. trip time)									
Commuter Flights	249,508	10,141	244,678	32,598	217,625	7,015	24,062	0	0
Air Taxi Flights	1,494,823	1,570,141	1,158,162	2,218,887	1,381,864	1,429,549	991,468	506,461	926,885
Estimated Flights (nmiles/avg. trip length)									
Commuter Flights	161,787	7,020	137,443	19,108	132,544	4,031	14,460	0	0
Air Taxi Flights	948,372	1,094,081	650,226	1,289,680	781,728	754,589	578,210	457,374	692,593
GA Flights = Total Landings-Commuter Flts.-Air Taxi Flts.									
Based on hrs./avg. trip time	1,706,273	1,602,529	2,600,557	2,463,965	2,164,497	3,288,988	1,767,721	2,133,207	2,681,863
Based on nmiles/avg. trip length	2,340,444	2,081,710	3,215,727	3,406,663	2,849,714	3,966,930	2,190,581	2,182,294	2,916,155
Total Nautical Miles Flown (3.3)	127,051,000	113,348,000	168,940,000	150,292,000	126,513,000	179,343,000	148,975,000	130,981,000	204,694,000
Commuter Nmiles (3.3)	5,957,000	250,000	5,800,000	609,000	4,455,000	153,000	774,000	0	0
Air Taxi Nmiles (3.3)	34,919,000	38,963,000	27,439,000	41,105,000	26,275,000	28,638,000	30,949,000	22,695,000	39,285,000
GA Nmiles = Total Nmiles									
-Commuter Nmiles -Air Taxi Nmiles	86,175,000	74,135,000	135,701,000	108,578,000	95,783,000	150,552,000	117,252,000	108,286,000	165,409,000
Average Speed (nmiles/hour)	69.77	69.48	79.29	72.26	78.23	82.57	79.82	89.24	122.44
Average Trip Length (nmiles/landing)	36.82	35.61	42.20	31.87	33.61	37.95	53.53	49.62	56.72
Average Trip Time (hour/landing)	0.53	0.51	0.53	0.44	0.43	0.46	0.67	0.56	0.46
Average Commuter Speed (nmiles/hour)	45.24	48.10	44.54	42.36	47.64	47.46	47.97	N.A.	N.A.
Average Air Taxi Speed (nmiles/hour)	44.27	48.41	44.51	42.00	44.25	43.59	46.55	80.59	91.49
GA Average Speed (nmiles/hour)	95.70	90.25	98.04	99.91	102.99	99.59	98.92	91.30	133.14

N/A = Information not available

N.A. = Not Applicable

1993 and 1994 data adjusted to include experimental aircraft in appropriate subcategories.

Table 3.38 (Continued)
General Aviation Operations
Turbine Engine, Rotary Wing (Helicopters), 1986-1994
[References 3.34 to 3.42]

Parameter (Ref. Table No.)	Total	Average	Pct. of Tot. Aircraft
Population (2.1)		4,532	1.75%
No. Active (2.1)		3,661	1.82%
Total Hours Flown (2.1)	16,457,990	1,828,666	5.96%
Commuter Hrs. (3.2)	394,339	43,815	
Air Taxi Hrs. (3.2)	5,815,377	646,153	
GA Hrs. = Total Hrs.			
Commuter Hrs.- Air Taxi Hrs.	10,248,274	1,138,697	4.17%
Total Day Hours Flown (4.1)	11,004,791	1,375,599	5.62%
Total Night Hours Flown (4.1)	1,778,635	222,329	5.26%
VMC Day Hours Flown (4.2)	10,936,160	1,367,020	6.15%
VMC Night Hours Flown (4.2)	1,726,366	215,796	7.01%
Total VMC Hours Flown (4.2)	12,662,526	1,582,816	6.26%
IMC Day Hours Flown (4.3)	68,722	8,590	0.38%
IMC Night Hours Flown (4.3)	52,064	6,508	0.56%
Total IMC Hours Flown (4.3)	120,786	15,098	0.44%
Total Landings (2.5)	32,873,465	3,652,607	8.15%
Local Landings (2.6)	16,832,738	2,104,092	7.35%
Cross Country Landings (2.7)	11,351,396	1,418,925	9.25%
Estimated Flights (hours/avg. trip time)			
Commuter Flights	785,626	87,292	
Air Taxi Flights	11,678,240	1,297,582	
Estimated Flights (nmiles/avg. trip length)			
Commuter Flights	476,394	52,933	
Air Taxi Flights	7,246,853	805,206	
GA Flights = Total Landings-Commuter Flts.-Air Taxi Flts.			
Based on hrs./avg. trip time	20,409,599	2,267,733	
Based on nmiles/avg. trip length	25,150,218	2,794,469	
Total Nautical Miles Flown (3.3)	1,350,137,000	150,015,222	3.98%
Commuter Nmiles (3.3)	17,998,000	1,999,778	
Air Taxi Nmiles (3.3)	290,268,000	32,252,000	
GA Nmiles = Total Nmiles			
Commuter Nmiles -Air Taxi Nmiles	1,041,871,000	115,763,444	3.52%
Average Speed (nmiles/hour)	82.04	82.57	
Average Trip Length (nmiles/landing)	41.07	41.99	
Average Trip Time (hour/landing)	0.50	0.51	
Average Commuter Speed (nmiles/hour)	45.64	46.19	
Average Air Taxi Speed (nmiles/hour)	49.91	53.96	
GA Average Speed (nmiles/hour)	101.66	101.09	

N/A = Information not available

N.A. = Not Applicable

1993 and 1994 data adjusted to include experimental aircraft in appropriate subcategories.

Table 3.39
General Aviation Operations
Total, Rotary Wing (Helicopters), 1986-1994
[References 3.34 to 3.42]

Parameter (Ref. Table No.)	1986	1987	1988	1989	1990	1991	1992	1993	1994
Population (2.1)	10,465	10,034	9,768	10,469	10,422	10,474	9,599	9,819	9,916
No. Active (2.1)	6,943	6,333	6,406	7,476	7,397	6,292	5,752	5,445	5,490
Total Hours Flown (2.1)	2,625,394	2,283,126	2,706,719	2,828,620	2,392,066	2,755,599	2,282,701	1,893,155	2,067,988
Commuter Hrs. (3.2)	132,944	5,198	131,412	14,378	93,698	3,224	16,135	0	0
Air Taxi Hrs. (3.2)	803,141	810,131	621,811	998,858	593,753	659,537	692,261	282,512	429,635
GA Hrs. = Total Hrs.									
-Commuter Hrs.- Air Taxi Hrs.	1,689,309	1,467,797	1,953,496	1,815,384	1,704,615	2,092,838	1,574,305	1,610,643	1,638,353
Total Day Hours Flown (4.1)	2,218,591	2,048,770	2,381,709	N/A	2,044,152	1,662,239	1,969,485	1,324,142	1,121,667
Total Night Hours Flown (4.1)	376,841	250,074	342,287	N/A	345,029	289,127	313,216	248,020	281,503
VMC Day Hours Flown (4.2)	2,204,782	2,037,197	2,367,077	N/A	2,034,821	1,659,368	1,961,691	1,318,815	1,113,109
VMC Night Hours Flown (4.2)	361,923	246,717	331,878	N/A	331,796	288,463	311,503	237,716	279,201
Total VMC Hours Flown (4.2)	2,566,705	2,283,914	2,698,955	N/A	2,366,617	1,947,831	2,273,194	1,556,531	1,392,310
IMC Day Hours Flown (4.3)	13,832	11,470	14,802	N/A	9,297	2,885	7,794	5,327	8,567
IMC Night Hours Flown (4.3)	14,887	3,372	10,332	N/A	13,128	666	1,713	10,305	2,302
Total IMC Hours Flown (4.3)	28,719	14,842	25,134	N/A	22,425	3,551	9,507	15,632	10,869
Total Landings (2.5)	5,026,326	4,915,280	5,348,658	7,256,049	6,205,226	6,741,429	4,193,382	3,922,693	4,817,843
Local Landings (2.6)	3,700,187	2,672,249	3,599,952	N/A	3,936,878	5,456,280	1,785,102	2,750,456	4,262,641
Cross Country Landings (2.7)	1,360,327	2,209,829	1,740,829	N/A	2,208,216	1,280,304	2,458,520	1,180,863	603,898
Estimated Flights (hours/avg. trip time)									
Commuter Flights	254,522	11,191	259,679	36,883	243,061	7,887	29,640	0	0
Air Taxi Flights	1,537,616	1,744,109	1,228,740	2,562,296	1,540,247	1,613,523	1,271,702	585,376	1,000,931
Estimated Flights (nmiles/avg. trip length)									
Commuter Flights	172,796	8,162	156,030	22,895	163,811	4,850	18,760	0	0
Air Taxi Flights	1,023,794	1,286,276	738,834	1,588,675	963,322	912,750	791,907	575,378	822,956
GA Flights = Total Landings-Commuter Flts.-Air Taxi Flts.									
Based on hrs./avg. trip time	3,234,188	3,159,980	3,860,239	4,656,870	4,421,919	5,120,019	2,892,040	3,337,317	3,816,912
Based on nmiles/avg. trip length	3,829,736	3,620,842	4,453,794	5,644,479	5,078,093	5,823,829	3,382,715	3,347,315	3,994,887
Total Nautical Miles Flown (3.3)	175,780,000	150,545,000	200,913,000	193,012,000	169,250,000	212,668,000	173,008,000	155,516,000	230,098,000
Commuter Nmiles (3.3)	6,043,000	250,000	5,861,000	609,000	4,468,000	153,000	774,000	0	0
Air Taxi Nmiles (3.3)	35,804,000	39,396,000	27,753,000	42,259,000	26,275,000	28,794,000	32,672,000	22,811,000	39,304,000
GA Nmiles = Total Nmiles									
-Commuter Nmiles -Air Taxi Nmiles	133,933,000	110,899,000	167,299,000	150,144,000	138,507,000	183,721,000	139,562,000	132,705,000	190,794,000
Average Speed (nmiles/hour)	66.95	65.94	74.23	68.24	70.75	77.18	75.79	82.15	111.27
Average Trip Length (nmiles/landing)	34.97	30.63	37.56	26.60	27.28	31.55	41.26	39.65	47.76
Average Trip Time (hour/landing)	0.52	0.46	0.51	0.39	0.39	0.41	0.54	0.48	0.43
Average Commuter Speed (nmiles/hour)	45.46	48.10	44.60	42.36	47.69	47.46	47.97	N.A.	N.A.
Average Air Taxi Speed (nmiles/hour)	44.58	48.63	44.63	42.31	44.25	43.66	47.20	80.74	91.48
GA Average Speed (nmiles/hour)	79.28	75.55	85.64	82.71	81.25	87.79	88.65	82.39	116.45

N/A = Information not available

N.A. = Not Applicable

1993 and 1994 data adjusted to include experimental aircraft in appropriate subcategories.

Table 3.39 (Continued)
General Aviation Operations
Total, Rotary Wing (Helicopters), 1986-1994
[References 3.34 to 3.42]

Parameter (Ref. Table No.)	Total	Average	Pct. of Tot. Aircraft
Population (2.1)		10,107	3.90%
No. Active (2.1)		6,393	3.18%
Total Hours Flown (2.1)	21,835,368	2,426,152	7.91%
Commuter Hrs. (3.2)	396,989	44,110	
Air Taxi Hrs. (3.2)	5,891,639	654,627	
GA Hrs. = Total Hrs.			
-Commuter Hrs. - Air Taxi Hrs.	15,546,740	1,727,416	6.33%
Total Day Hours Flown (4.1)	14,770,755	1,846,344	7.54%
Total Night Hours Flown (4.1)	2,446,097	305,762	7.23%
VMC Day Hours Flown (4.2)	14,696,860	1,837,108	8.27%
VMC Night Hours Flown (4.2)	2,389,197	298,650	9.70%
Total VMC Hours Flown (4.2)	17,086,057	2,135,757	8.45%
IMC Day Hours Flown (4.3)	73,974	9,247	0.41%
IMC Night Hours Flown (4.3)	56,705	7,088	0.61%
Total IMC Hours Flown (4.3)	130,679	16,335	0.48%
Total Landings (2.5)	48,426,886	5,380,765	12.01%
Local Landings (2.6)	28,163,745	3,520,468	12.30%
Cross Country Landings (2.7)	13,042,786	1,630,348	10.62%
Estimated Flights (hours/avg. trip time)			
Commuter Flights	842,863	93,651	
Air Taxi Flights	13,084,540	1,453,838	
Estimated Flights (nmiles/avg. trip length)			
Commuter Flights	547,304	60,812	
Air Taxi Flights	8,703,892	967,099	
GA Flights = Total Landings - Commuter Flts. - Air Taxi Flts.			
Based on hrs./avg. trip time	34,499,483	3,833,276	
Based on nmiles/avg. trip length	39,175,690	4,352,854	
Total Nautical Miles Flown (3.3)	1,660,790,000	184,532,222	4.89%
Commuter Nmiles (3.3)	18,158,000	2,017,556	
Air Taxi Nmiles (3.3)	295,068,000	32,785,333	
GA Nmiles = Total Nmiles			
-Commuter Nmiles - Air Taxi Nmiles	1,347,564,000	149,729,333	4.55%
Average Speed (nmiles/hour)	76.06	76.94	
Average Trip Length (nmiles/landing)	34.29	35.25	
Average Trip Time (hour/landing)	0.45	0.46	
Average Commuter Speed (nmiles/hour)	45.74	46.23	
Average Air Taxi Speed (nmiles/hour)	50.08	54.16	
GA Average Speed (nmiles/hour)	86.68	86.64	

N/A = Information not available

N.A. = Not Applicable

1993 and 1994 data adjusted to include experimental aircraft in appropriate subcategories.

Table 3.40
General Aviation Operations
Total Powered Aircraft, 1986-1994
[References 3.34 to 3.42]

Parameter (Ref. Table No.)	1986	1987	1988	1989	1990	1991	1992	1993	1994
Population (2.1)	259,308	257,668	249,517	256,885	255,782	254,260	236,255	236,138	233,482
No. Active (2.1)	213,033	210,399	203,409	212,017	205,196	190,913	176,594	169,832	163,343
Total Hours Flown (2.1)	34,022,097	33,027,294	32,980,474	34,586,148	34,397,722	29,595,178	26,083,606	23,904,209	23,381,406
Commuter Hrs. (3.2)	2,185,351	1,358,679	1,118,036	1,502,796	1,444,060	564,371	692,555	0	0
Air Taxi Hrs. (3.2)	2,913,629	2,797,002	2,841,716	3,270,138	2,425,185	2,241,075	2,007,921	1,450,733	1,669,784
GA Hrs. = Total Hrs.									
-Commuter Hrs.- Air Taxi Hrs.	28,923,117	28,871,613	29,020,722	29,813,214	30,528,477	26,789,732	23,383,130	22,453,476	21,711,622
Total Day Hours Flown (4.1)	28,952,666	28,196,333	28,492,240	26,132,542	28,522,309	16,827,187	22,672,575	18,480,889	18,177,251
Total Night Hours Flown (4.1)	4,475,413	4,109,794	4,398,661	5,351,018	5,578,506	2,578,395	3,411,031	5,291,031	2,778,196
VMC Day Hours Flown (4.2)	25,508,108	25,465,821	25,889,686	23,410,860	25,793,141	15,628,562	20,959,256	16,999,822	16,637,662
VMC Night Hours Flown (4.2)	3,130,959	2,995,135	3,296,829	3,976,856	4,326,491	2,129,596	2,863,780	2,608,852	2,303,968
Total VMC Hours Flown (4.2)	28,639,067	28,460,956	29,186,515	27,387,716	30,119,632	17,758,158	23,823,036	19,608,674	18,941,630
IMC Day Hours Flown (4.3)	3,448,109	2,722,875	2,597,612	2,716,566	2,741,717	1,207,706	1,713,319	1,481,069	1,539,675
IMC Night Hours Flown (4.3)	1,348,781	1,109,117	1,100,014	1,379,519	1,251,423	446,896	547,251	2,728,510	474,573
Total IMC Hours Flown (4.3)	4,796,890	3,831,992	3,697,626	4,096,085	3,993,140	1,654,602	2,260,570	4,209,579	2,014,248
Total Landings (2.5)	47,100,013	46,073,594	47,417,553	51,381,623	52,375,416	47,242,743	39,009,517	32,521,760	34,462,317
Local Landings (2.6)	29,311,192	28,789,898	30,382,730	27,087,725	34,911,182	32,504,442	24,578,979	21,088,666	23,715,509
Cross Country Landings (2.7)	17,824,378	17,190,659	16,970,533	17,006,782	17,367,232	14,695,153	14,485,993	11,420,452	10,764,565
Estimated Flights (hours/avg. trip time)									
Commuter Flights	3,025,388	1,895,379	1,607,452	2,232,573	2,198,786	900,905	1,035,755	0	0
Air Taxi Flights	4,033,613	3,901,862	4,085,667	4,858,159	3,692,689	3,577,425	3,002,960	1,973,727	2,461,128
Estimated Flights (nmiles/avg. trip length)									
Commuter Flights	3,883,316	2,386,201	2,075,935	3,172,142	3,066,157	1,147,509	1,523,591	0	0
Air Taxi Flights	4,210,664	4,155,315	4,545,876	4,966,928	4,268,571	3,774,209	3,140,569	2,085,696	2,578,650
GA Flights = Total Landings-Commuter Flts.-Air Taxi Flts.									
Based on hrs./avg. trip time	40,041,012	40,276,354	41,724,434	44,290,891	46,483,941	42,764,413	34,970,801	30,548,033	32,001,189
Based on nmiles/avg. trip length	39,006,033	39,532,078	40,795,742	43,242,553	45,040,688	42,321,026	34,345,356	30,436,064	31,883,667
Total Nautical Miles Flown (3.3)	4,264,418,000	4,061,897,000	4,123,218,000	4,465,466,000	4,188,589,000	3,908,088,000	3,118,705,000	2,814,727,000	2,908,619,000
Commuter Nmiles (3.3)	351,594,000	210,370,000	180,514,000	275,684,000	245,208,000	94,926,000	121,807,000	0	0
Air Taxi Nmiles (3.3)	381,232,000	366,337,000	395,289,000	431,665,000	341,368,000	312,216,000	251,080,000	180,515,000	217,638,000
GA Nmiles = Total Nmiles									
-Commuter Nmiles -Air Taxi Nmiles	3,531,592,000	3,485,190,000	3,547,415,000	3,758,117,000	3,602,013,000	3,500,946,000	2,745,818,000	2,634,212,000	2,690,981,000
Average Speed (nmiles/hour)	125.34	122.99	125.02	129.11	121.77	132.05	119.57	117.75	124.40
Average Trip Length (nmiles/landing)	90.54	88.16	86.96	86.91	79.97	82.72	79.95	86.55	84.40
Average Trip Time (hour/landing)	0.72	0.72	0.70	0.67	0.66	0.63	0.67	0.74	0.68
Average Commuter Speed (nmiles/hour)	160.89	154.83	161.46	183.45	169.80	168.20	175.88	N.A.	N.A.
Average Air Taxi Speed (nmiles/hour)	130.84	130.97	139.10	132.00	140.76	139.32	125.04	124.43	130.34
GA Average Speed (nmiles/hour)	122.10	120.71	122.24	126.06	117.99	130.68	117.43	117.32	123.94

N/A = Information not available

N.A. = Not Applicable

1993 and 1994 data adjusted to include experimental aircraft in appropriate subcategories.

Table 3.40 (Continued)
General Aviation Operations
Total Powered Aircraft, 1986-1994
[References 3.34 to 3.42]

Parameter (Ref. Table No.)	Total	Average	Pct. of Tot. Aircraft
Population (2.1)		248,811	96.05%
No. Active (2.1)		193,860	96.45%
Total Hours Flown (2.1)	271,978,134	30,219,793	98.55%
Commuter Hrs. (3.2)	8,865,848	985,094	
Air Taxi Hrs. (3.2)	21,617,183	2,401,909	
GA Hrs. = Total Hrs.			
-Commuter Hrs.- Air Taxi Hrs.	241,495,103	26,832,789	98.38%
Total Day Hours Flown (4.1)	216,453,992	24,050,444	98.27%
Total Night Hours Flown (4.1)	37,972,045	4,219,116	99.78%
VMC Day Hours Flown (4.2)	196,292,918	21,810,324	98.20%
VMC Night Hours Flown (4.2)	27,632,466	3,070,274	99.73%
Total VMC Hours Flown (4.2)	223,925,384	24,880,598	98.39%
IMC Day Hours Flown (4.3)	20,168,648	2,240,961	99.95%
IMC Night Hours Flown (4.3)	10,386,084	1,154,009	99.93%
Total IMC Hours Flown (4.3)	30,554,732	3,394,970	99.94%
Total Landings (2.5)	397,584,536	44,176,060	98.58%
Local Landings (2.6)	252,370,323	28,041,147	97.93%
Cross Country Landings (2.7)	137,725,747	15,302,861	99.72%
Estimated Flights (hours/avg. trip time)			
Commuter Flights	12,896,239	1,432,915	
Air Taxi Flights	31,587,228	3,509,692	
Estimated Flights (nmiles/avg. trip length)			
Commuter Flights	17,254,850	1,917,206	
Air Taxi Flights	33,726,479	3,747,387	
GA Flights = Total Landings-Commuter Flts.-Air Taxi Flts.			
Based on hrs./avg. trip time	353,101,069	39,233,452	
Based on nmiles/avg. trip length	346,603,207	38,511,467	
Total Nautical Miles Flown (3.3)	33,853,727,000	3,761,525,222	99.70%
Commuter Nmiles (3.3)	1,480,103,000	164,455,889	
Air Taxi Nmiles (3.3)	2,877,340,000	319,704,444	
GA Nmiles = Total Nmiles			
-Commuter Nmiles -Air Taxi Nmiles	29,496,284,000	3,277,364,889	99.66%
Average Speed (nmiles/hour)	124.47	124.22	
Average Trip Length (nmiles/landing)	85.15	85.13	
Average Trip Time (hour/landing)	0.68	0.69	
Average Commuter Speed (nmiles/hour)	166.94	167.79	
Average Air Taxi Speed (nmiles/hour)	133.10	132.53	
GA Average Speed (nmiles/hour)	122.14	122.05	

N/A = Information not available

N.A. = Not Applicable

1993 and 1994 data adjusted to include experimental aircraft in appropriate subcategories.

Table 3.41
General Aviation Operations
Other Aircraft (Glider, Balloons, Others), 1986-1994
[References 3.34 to 3.42]

Parameter (Ref. Table No.)	1986	1987	1988	1989	1990	1991	1992	1993	1994
Population (2.1)	9,309	9,732	9,917	10,306	10,562	10,781	9,739	9,832	11,955
No. Active (2.1)	7,010	6,783	6,857	7,721	7,032	7,563	7,836	6,168	7,252
Total Hours Flown (2.1)	394,256	415,888	612,998	428,680	368,804	459,360	409,872	435,672	484,565
Commuter Hrs. (3.2)	0	0	81	4,798	360	5,200	34	0	0
Air Taxi Hrs. (3.2)	0	0	0	0	10,722	0	881	0	0
GA Hrs. = Total Hrs.									
-Commuter Hrs. - Air Taxi Hrs.	394,256	415,888	612,917	423,882	357,722	454,160	408,957	435,672	484,565
Total Day Hours Flown (4.1)	395,345	414,083	597,619	427,567	362,950	366,903	396,242	496,716	352,684
Total Night Hours Flown (4.1)	1,796	111	22,107	3,071	2,269	3,330	13,630	24,909	11,622
VMC Day Hours Flown (4.2)	395,122	413,999	595,815	425,972	362,651	366,741	395,788	294,458	349,785
VMC Night Hours Flown (4.2)	1,775	91	22,107	3,060	1,886	3,324	13,531	18,662	10,973
Total VMC Hours Flown (4.2)	396,897	414,090	617,922	429,032	364,537	370,065	409,319	313,120	360,758
IMC Day Hours Flown (4.3)	224	84	1,739	1,692	298	110	454	2,593	2,907
IMC Night Hours Flown (4.3)	21	20	0	10	383	6	99	6,246	649
Total IMC Hours Flown (4.3)	245	104	1,739	1,702	681	116	553	8,839	3,556
Total Landings (2.5)	454,067	804,545	771,432	649,385	576,048	735,927	597,753	664,820	472,240
Local Landings (2.6)	408,917	745,048	721,463	615,754	552,123	702,785	544,831	606,182	427,290
Cross Country Landings (2.7)	45,174	60,487	39,980	33,908	23,425	33,255	49,736	58,629	46,453
Estimated Flights (hours/avg. trip time)									
Commuter Flights	0	0	102	7,268	562	8,331	50	0	0
Air Taxi Flights	0	0	0	0	16,747	0	1,285	0	0
Estimated Flights (nmiles/avg. trip length)									
Commuter Flights	0	0	0	0	0	0	0	0	0
Air Taxi Flights	0	0	0	0	0	0	0	0	0
GA Flights = Total Landings-Commuter Flts.-Air Taxi Flts.									
Based on hrs./avg. trip time	454,067	804,545	771,330	642,117	558,739	727,596	596,419	664,820	472,240
Based on nmiles/avg. trip length	454,067	804,545	771,432	649,385	576,048	735,927	597,753	664,820	472,240
Total Nautical Miles Flown (3.3)	12,613,000	9,504,000	15,856,000	12,267,000	7,914,000	10,013,000	13,444,000	11,522,000	8,750,000
Commuter Nmiles (3.3)	0	0	0	0	0	0	0	0	0
Air Taxi Nmiles (3.3)	0	0	0	0	0	0	0	0	0
GA Nmiles = Total Nmiles									
-Commuter Nmiles - Air Taxi Nmiles	12,613,000	9,504,000	15,856,000	12,267,000	7,914,000	10,013,000	13,444,000	11,522,000	8,750,000
Average Speed (nmiles/hour)	31.99	22.85	25.87	28.62	21.46	21.80	32.80	26.45	18.06
Average Trip Length (nmiles/landing)	27.78	11.81	20.55	18.89	13.74	13.61	22.49	17.33	18.53
Average Trip Time (hour/landing)	0.87	0.52	0.79	0.66	0.64	0.62	0.69	0.66	1.03
Average Commuter Speed (nmiles/hour)	N.A.	N.A.	0.00	0.00	0.00	0.00	0.00	N.A.	N.A.
Average Air Taxi Speed (nmiles/hour)	N.A.	N.A.	N.A.	N.A.	0.00	N.A.	0.00	N.A.	N.A.
GA Average Speed (nmiles/hour)	31.99	22.85	25.87	28.94	22.12	22.05	32.87	26.45	18.06

N/A = Information not available

N.A. = Not Applicable

1993 and 1994 data adjusted to include experimental aircraft in appropriate subcategories.

Table 3.41 (Continued)
General Aviation Operations
Other Aircraft (Gliders, Balloons, Others), 1986-1994
[References 3.34 to 3.42]

Parameter (Ref. Table No.)	Total	Average	Pct. of Tot. Aircraft
Population (2.1)		10,237	3.95%
No. Active (2.1)		7,136	3.55%
Total Hours Flown (2.1)	4,010,095	445,566	1.45%
Commuter Hrs. (3.2)	10,473	1,164	
Air Taxi Hrs. (3.2)	11,603	1,289	
GA Hrs. = Total Hrs.			
-Commuter Hrs.- Air Taxi Hrs.	3,988,019	443,113	1.62%
Total Day Hours Flown (4.1)	3,810,109	423,345	1.73%
Total Night Hours Flown (4.1)	82,845	9,205	0.22%
VMC Day Hours Flown (4.2)	3,600,331	400,037	1.80%
VMC Night Hours Flown (4.2)	75,409	8,379	0.27%
Total VMC Hours Flown (4.2)	3,675,740	408,416	1.61%
IMC Day Hours Flown (4.3)	10,101	1,122	0.05%
IMC Night Hours Flown (4.3)	7,434	826	0.07%
Total IMC Hours Flown (4.3)	17,535	1,948	0.06%
Total Landings (2.5)	5,726,217	636,246	1.42%
Local Landings (2.6)	5,324,393	591,599	2.07%
Cross Country Landings (2.7)	391,047	43,450	0.28%
Estimated Flights (hours/avg. trip time)			
Commuter Flights	16,313	1,813	
Air Taxi Flights	18,032	2,004	
Estimated Flights (nmiles/avg. trip length)			
Commuter Flights	0	0	
Air Taxi Flights	0	0	
GA Flights = Total Landings-Commuter Flts.-Air Taxi Flts.			
Based on hrs./avg. trip time	5,691,872	632,430	
Based on nmiles/avg. trip length	5,726,217	636,246	
Total Nautical Miles Flown (3.3)	101,883,000	11,320,333	0.30%
Commuter Nmiles (3.3)	0	0	
Air Taxi Nmiles (3.3)	0	0	
GA Nmiles = Total Nmiles			
-Commuter Nmiles -Air Taxi Nmiles	101,883,000	11,320,333	0.34%
Average Speed (nmiles/hour)	25.41	25.54	
Average Trip Length (nmiles/landing)	17.79	18.30	
Average Trip Time (hour/landing)	0.70	0.72	
Average Commuter Speed (nmiles/hour)	0.00	0.00	
Average Air Taxi Speed (nmiles/hour)	0.00	0.00	
GA Average Speed (nmiles/hour)	25.55	25.69	

N/A = Information not available

N.A. = Not Applicable

1993 and 1994 data adjusted to include experimental aircraft in appropriate subcategories.

Table 3.42
General Aviation Operations
Total Aircraft, 1986-1994
[References 3.34 to 3.42]

Parameter (Ref. Table No.)	1986	1987	1988	1989	1990	1991	1992	1993	1994
Population (2.1)	268,617	267,400	259,434	267,191	266,344	265,041	245,994	245,970	245,437
No. Active (2.1)	220,043	217,182	210,266	219,738	212,228	198,476	184,430	176,000	170,595
Total Hours Flown (2.1)	34,416,353	33,443,182	33,593,472	35,014,828	34,766,526	30,054,538	26,493,478	24,339,881	23,865,971
Commuter Hrs. (3.2)	2,185,351	1,358,679	1,118,117	1,507,594	1,444,420	569,571	692,589	0	0
Air Taxi Hrs. (3.2)	2,913,629	2,797,002	2,841,716	3,270,138	2,435,907	2,241,075	2,008,802	1,450,733	1,669,784
GA Hrs. = Total Hrs.									
-Commuter Hrs.- Air Taxi Hrs.	29,317,373	29,287,501	29,633,639	30,237,096	30,886,199	27,243,892	23,792,087	22,889,148	22,196,187
Total Day Hours Flown (4.1)	29,348,011	28,610,416	29,089,859	26,560,109	28,885,259	17,194,090	23,068,817	18,977,605	18,529,935
Total Night Hours Flown (4.1)	4,477,209	4,109,905	4,420,768	5,354,089	5,580,775	2,581,725	3,424,661	5,315,940	2,789,818
VMC Day Hours Flown (4.2)	25,903,230	25,879,820	26,485,501	23,836,832	26,155,792	15,995,303	21,355,044	17,294,280	16,987,447
VMC Night Hours Flown (4.2)	3,132,734	2,995,226	3,318,936	3,979,916	4,328,377	2,132,920	2,877,311	2,627,514	2,314,941
Total VMC Hours Flown (4.2)	29,035,964	28,875,046	29,804,437	27,816,748	30,484,169	18,128,223	24,232,355	19,921,794	19,302,388
IMC Day Hours Flown (4.3)	3,448,333	2,722,959	2,599,351	2,718,258	2,742,015	1,207,816	1,713,773	1,483,662	1,542,582
IMC Night Hours Flown (4.3)	1,348,802	1,109,137	1,100,014	1,379,529	1,251,806	446,902	547,350	2,734,756	475,222
Total IMC Hours Flown (4.3)	4,797,135	3,832,096	3,699,365	4,097,787	3,993,821	1,654,718	2,261,123	4,218,418	2,017,804
Total Landings (2.5)	47,554,080	46,878,139	48,188,985	52,031,008	52,951,464	47,978,670	39,607,270	33,186,580	34,934,557
Local Landings (2.6)	29,720,109	29,534,946	31,104,193	27,703,479	35,463,305	33,207,227	25,123,810	21,694,848	24,142,799
Cross Country Landings (2.7)	17,869,552	17,251,146	17,010,513	17,040,690	17,390,657	14,728,408	14,535,729	11,479,081	10,811,018
Estimated Flights (hours/avg. trip time)									
Commuter Flights	3,019,563	1,904,494	1,603,911	2,240,240	2,199,937	909,256	1,035,408	0	0
Air Taxi Flights	4,025,846	3,920,627	4,076,370	4,859,329	3,710,030	3,577,623	3,003,123	1,978,024	2,444,198
Estimated Flights (nmiles/avg. trip length)									
Commuter Flights	3,909,191	2,422,202	2,101,626	3,203,433	3,094,034	1,162,406	1,540,298	0	0
Air Taxi Flights	4,238,720	4,218,007	4,602,135	5,015,923	4,307,381	3,823,206	3,175,006	2,119,656	2,606,145
GA Flights = Total Landings-Commuter Flts.-Air Taxi Flts.									
Based on hrs./avg. trip time	40,508,670	41,053,018	42,508,705	44,931,438	47,041,498	43,491,792	35,568,739	31,208,556	32,490,359
Based on nmiles/avg. trip length	39,406,169	40,237,931	41,485,224	43,811,652	45,550,050	42,993,058	34,891,966	31,066,924	32,328,412
Total Nautical Miles Flown (3.3)	4,277,031,000	4,071,401,000	4,139,074,000	4,477,733,000	4,196,503,000	3,918,101,000	3,132,149,000	2,826,249,000	2,917,369,000
Commuter Nmiles (3.3)	351,594,000	210,370,000	180,514,000	275,684,000	245,208,000	94,926,000	121,807,000	0	0
Air Taxi Nmiles (3.3)	381,232,000	366,337,000	395,289,000	431,665,000	341,368,000	312,216,000	251,080,000	180,515,000	217,638,000
GA Nmiles = Total Nmiles									
-Commuter Nmiles -Air Taxi Nmiles	3,544,205,000	3,494,694,000	3,563,271,000	3,770,384,000	3,609,927,000	3,510,959,000	2,759,262,000	2,645,734,000	2,699,731,000
Average Speed (nmiles/hour)	124.27	121.74	123.21	127.88	120.71	130.37	118.22	116.12	122.24
Average Trip Length (nmiles/landing)	89.94	86.85	85.89	86.06	79.25	81.66	79.08	85.16	83.51
Average Trip Time (hour/landing)	0.72	0.71	0.70	0.67	0.66	0.63	0.67	0.73	0.68
Average Commuter Speed (nmiles/hour)	160.89	154.83	161.44	182.86	169.76	166.66	175.87	N.A.	N.A.
Average Air Taxi Speed (nmiles/hour)	130.84	130.97	139.10	132.00	140.14	139.32	124.99	124.43	130.34
GA Average Speed (nmiles/hour)	120.89	119.32	120.24	124.69	116.88	128.87	115.97	115.59	121.63

N/A = Information not available

N.A. = Not Applicable

1993 and 1994 data adjusted to include experimental aircraft in appropriate subcategories.

Table 3.42 (Continued)
General Aviation Operations
Total Aircraft, 1986-1994
[References 3.34 to 3.42]

Parameter (Ref. Table No.)	Total	Average	Pct. of Tot. Aircraft
Population (2.1)		259,048	100.00%
No. Active (2.1)		200,995	100.00%
Total Hours Flown (2.1)	275,988,229	30,665,359	100.00%
Commuter Hrs. (3.2)	8,876,321	986,258	
Air Taxi Hrs. (3.2)	21,628,786	2,403,198	
GA Hrs. = Total Hrs.			
-Commuter Hrs.- Air Taxi Hrs.	245,483,122	27,275,902	100.00%
Total Day Hours Flown (4.1)	220,264,101	24,473,789	100.00%
Total Night Hours Flown (4.1)	38,054,890	4,228,321	100.00%
VMC Day Hours Flown (4.2)	199,893,249	22,210,361	100.00%
VMC Night Hours Flown (4.2)	27,707,875	3,078,653	100.00%
Total VMC Hours Flown (4.2)	227,601,124	25,289,014	100.00%
IMC Day Hours Flown (4.3)	20,178,749	2,242,083	100.00%
IMC Night Hours Flown (4.3)	10,393,518	1,154,835	100.00%
Total IMC Hours Flown (4.3)	30,572,267	3,396,919	100.00%
Total Landings (2.5)	403,310,753	44,812,306	100.00%
Local Landings (2.6)	257,694,716	28,632,746	100.00%
Cross Country Landings (2.7)	138,116,794	15,346,310	100.00%
Estimated Flights (hours / avg. trip time)			
Commuter Flights	12,912,809	1,434,757	
Air Taxi Flights	31,595,169	3,510,574	
Estimated Flights (nmiles / avg. trip length)			
Commuter Flights	17,433,189	1,937,021	
Air Taxi Flights	34,106,179	3,789,575	
GA Flights = Total Landings-Commuter Flts.-Air Taxi Flts.			
Based on hrs. / avg. trip time	358,802,775	39,866,975	
Based on nmiles / avg. trip length	351,771,385	39,085,709	
Total Nautical Miles Flown (3.3)	33,955,610,000	3,772,845,556	100.00%
Commuter Nmiles (3.3)	1,480,103,000	164,455,889	
Air Taxi Nmiles (3.3)	2,877,340,000	319,704,444	
GA Nmiles = Total Nmiles			
-Commuter Nmiles -Air Taxi Nmiles	29,598,167,000	3,288,685,222	100.00%
Average Speed (nmiles / hour)	123.03	122.75	
Average Trip Length (nmiles / landing)	84.19	84.16	
Average Trip Time (hour / landing)	0.68	0.69	
Average Commuter Speed (nmiles / hour)	166.75	167.48	
Average Air Taxi Speed (nmiles / hour)	133.03	132.46	
GA Average Speed (nmiles / hour)	120.57	120.46	

N/A = Information not available

N.A. = Not Applicable

1993 and 1994 data adjusted to include experimental aircraft in appropriate subcategories.

Table 3.43
General Aviation Operations Summary, 1986-1994
[References 3.34 to 3.42]

Aircraft Subcategories	Average No. Active	Total Hrs. Flown	Total GA Hrs. Flown	Total Nmi. Flown (000)	Total GA Nmi. Flown (000)	Total Landings (flts.)	Est. GA Flights (based hrs./ avg. trip time)	Est. GA Flights (based nmi./ avg. trip dis.)	Average Est. No. GA Flights	Average Speed (nmi./hr.)	GA Average Speed (nmi./hr.)	Average Trip Length (nmi./flt.)	Average Trip Time (hrs./flt.)
Single-Engine Reciprocating, Fixed Wing	157,051	184,037,801	178,055,145	18,546,875	17,924,186	284,055,419	274,821,280	274,498,578	274,659,929	100.78	100.67	65.29	0.65
Multi-Engine Reciprocating, Fixed Wing	20,927	34,920,392	25,381,406	5,055,141	3,630,862	33,496,907	24,375,173	24,120,363	24,247,768	144.76	143.05	150.91	1.04
Turboprop Fixed Wing	5,207	18,416,879	11,167,629	3,464,653	2,061,515	21,236,913	12,909,902	12,762,894	12,836,398	188.12	184.60	163.14	0.87
Turbojet Fixed Wing	4,282	12,767,694	11,344,183	5,126,268	4,532,157	10,368,411	9,214,030	9,171,821	9,192,926	401.50	399.51	494.41	1.23
Total Fixed Wing	187,467	250,142,766	225,948,363	32,192,937	28,148,720	349,157,650	321,320,385	320,553,656	320,937,021	128.70	124.58	92.20	0.72
Reciprocating Engine, Rotary Wing	2,731	5,377,378	5,298,466	310,653	305,693	15,553,421	15,319,362	15,299,201	15,309,282	57.77	57.69	19.97	0.35
Turbine Engine Rotary Wi	3,661	16,457,990	10,248,274	1,350,137	1,041,871	32,873,465	20,409,599	25,150,218	22,779,909	82.04	101.66	41.07	0.50
Total Rotary Wing	6,392	21,835,368	15,546,740	1,660,790	1,347,564	48,426,886	35,728,961	40,449,419	38,089,190	76.06	86.68	34.29	0.45
Total Powered Aircraft	193,859	271,978,134	241,495,103	33,853,727	29,496,284	397,584,536	357,049,346	361,003,075	359,026,211	124.47	122.14	85.15	0.68
Other Aircraft	7,136	4,010,095	3,988,019	101,883	101,883	5,726,217	5,691,872	5,726,217	5,709,045	25.41	25.55	17.79	0.70
Total Aircraft	200,995	275,988,229	245,483,122	33,955,610	29,598,167	403,310,753	362,741,218	366,729,292	364,735,255	123.03	120.57	84.19	0.68

Table 3.44
General Aviation Accident Rates by Aircraft Subcategories
Based on Table 3.43, FAA General Aviation Activity Survey, Calendar Years 1986-1994 [Ref. 3.34 - 3.42]
and Table 3.31, NTSB Annual Review of Aircraft Accident Data, U.S. General Aviation, Calendar Years 1986-1994 [Ref. 3.49 - 3.57]

Aircraft Subcategories	Total GA Accidents	GA Hrs. Flown	GA Nmi. Flown	GA Miles Flown	Avg. GA Landings (flts.)	Acc./ Hrs.	Acc./ Nmi.	Acc./ Mile	Acc./ Landing
Single-Engine Reciprocating, Fixed Wing	13,063	178,055,145	17,924,186,000	20,626,740,993	274,659,929	7.34E-05	7.29E-07	6.33E-07	4.76E-05
Multi-Engine Reciprocating, Fixed Wing	1,212	25,381,406	3,630,862,000	4,178,312,480	24,247,768	4.78E-05	3.34E-07	2.90E-07	5.00E-05
Turboprop, Fixed Wing	245	11,167,629	2,061,515,000	2,372,344,047	12,836,398	2.19E-05	1.19E-07	1.03E-07	1.91E-05
Turbojet, Fixed Wing	81	11,344,183	4,532,157,000	5,215,502,036	9,192,926	7.14E-06	1.79E-08	1.55E-08	8.81E-06
Total, Fixed Wing	14,601	225,948,363	28,148,720,000	32,392,899,555	320,937,021	6.46E-05	5.19E-07	4.51E-07	4.55E-05
Reciprocating Engine, Rotary Wing	645	5,298,466	305,693,000	351,784,473	15,309,282	1.22E-04	2.11E-06	1.83E-06	4.21E-05
Turbine Engine, Rotary Wing	331	10,248,274	1,041,871,000	1,198,961,184	22,779,909	3.23E-05	3.18E-07	2.76E-07	1.45E-05
Total, Rotary Wing	976	15,546,740	1,347,564,000	1,550,745,657	38,089,191	6.28E-05	7.24E-07	6.29E-07	2.56E-05
Total Powered Aircraft	15,577	241,495,103	29,496,284,000	33,943,645,213	359,026,212	6.45E-05	5.28E-07	4.59E-07	4.34E-05
Other Aircraft	498	3,988,019	101,883,000	117,244,613	5,709,045	1.25E-04	4.89E-06	4.25E-06	8.72E-05
Total Aircraft	16,075	245,483,122	29,598,167,000	34,060,889,826	364,735,257	6.55E-05	5.43E-07	4.72E-07	4.41E-05

General Aviation accidents occurring in the Standing, Taxi, Manuevering, Other, Unknown, or Not Reported Flight Phases not included.

Table 3.45
General Aviation Single-Engine Reciprocating, Fixed Wing Crash Rates by Flight Phase

Flight Phases	No. of Accs.	Accs. Pct.	Average Pct. Flt. Time	Average Flt. Time (hours)	Assumed Average Velocity		Calculated Average Distance		Crash Rate by Flight Phases				Crash Rate by Combined Flight Phases			
					Miles	Knots	Miles	Knots	Crashes /Landing	Crashes /AC Hour	Crashes /Mile	Crashes /Knot	Crashes /Landing	Crashes /AC Hour	Crashes /Mile	Crashes /Knot
Takeoff	1,013	7.75%	1.28%	0.008	69.05	60.00	0.58	0.50	3.688E-06	4.426E-04	6.410E-06	7.376E-06	1.250E-05	7.502E-04	9.313E-06	1.072E-05
Initial Climb	2,421	18.53%	1.28%	0.008	92.06	80.00	0.77	0.67	8.815E-06	1.058E-03	1.149E-05	1.322E-05				
Climb to Cruise	509	3.90%	20.42%	0.133	119.68	104.00	15.96	13.87	1.853E-06	1.390E-05	1.161E-07	1.336E-07				
Cruise/ Enroute	2,740	20.98%	28.53%	0.186	126.59	110.00	23.59	20.50	9.976E-06	5.354E-05	4.229E-07	4.867E-07	1.353E-05	2.783E-05	2.275E-07	2.618E-07
Descent from Cruise	468	3.58%	25.52%	0.167	119.68	104.00	19.95	17.33	1.704E-06	1.022E-05	8.542E-08	9.830E-08				
Landing Approach	2,010	15.39%	21.69%	0.142	97.82	85.00	13.86	12.04	7.318E-06	5.166E-05	5.281E-07	6.077E-07				
Landing	3,902	29.87%	1.28%	0.008	57.54	50.00	0.48	0.42	1.421E-05	1.705E-03	2.963E-05	3.410E-05	2.152E-05	1.435E-04	1.501E-06	1.728E-06
TOTAL:	13,063	100.00%	100.00%	0.653			75.17	65.32	4.756E-05	7.283E-05	6.327E-07	7.281E-07	4.756E-05	7.283E-05	6.327E-07	7.281E-07

Bases for Crash Rates by Flight Phase, 1986-1994 Totals:

0.65 Hours Average Flight Duration
65.3 Nmiles Average Flight Distance
274,659,929 Landings

Table 3.46
General Aviation Multi-Engine Reciprocating, Fixed Wing Crash Rates by Flight Phase

Flight Phases	No. of Accs.	Accs. Pct.	Average Pct. Flt. Time	Average Flt. Time (hours)	Assumed Average Velocity		Calculated Average Distance		Crash Rate by Flight Phases				Crash Rate by Combined Flight Phases			
					Miles	Knots	Miles	Knots	Crashes /Landing	Crashes /AC Hour	Crashes /Mile	Crashes /Knot	Crashes /Landing	Crashes /AC Hour	Crashes /Mile	Crashes /Knot
Takeoff	80	6.60%	0.80%	0.008	86.31	75.00	0.72	0.63	3.299E-06	3.959E-04	4.587E-06	5.279E-06	1.056E-05	6.335E-04	5.794E-06	6.668E-06
Initial Climb	176	14.52%	0.80%	0.008	132.34	115.00	1.10	0.96	7.258E-06	8.710E-04	6.582E-06	7.574E-06				
Climb to Cruise	62	5.12%	11.22%	0.117	149.60	130.00	17.45	15.17	2.557E-06	2.192E-05	1.465E-07	1.686E-07				
Cruise/ Enroute	261	21.53%	60.74%	0.632	178.37	155.00	112.67	97.91	1.076E-05	1.704E-05	9.553E-08	1.099E-07	1.481E-05	1.648E-05	9.437E-08	1.086E-07
Descent from Cruise	36	2.97%	14.42%	0.150	178.37	155.00	26.76	23.25	1.485E-06	9.898E-06	5.549E-08	6.386E-08				
Landing Approach	264	21.78%	11.22%	0.117	123.13	107.00	14.37	12.48	1.089E-05	9.332E-05	7.579E-07	8.722E-07				
Landing	333	27.48%	0.80%	0.008	74.80	65.00	0.62	0.54	1.373E-05	1.648E-03	2.203E-05	2.535E-05	2.462E-05	1.970E-04	1.643E-06	1.890E-06
TOTAL:	1,212	100.00%	100.00%	1.040			173.69	150.93	4.998E-05	4.806E-05	2.878E-07	3.312E-07	4.998E-05	4.806E-05	2.878E-07	3.312E-07

Bases for Crash Rates by Flight Phase, 1986-1994 Totals:

1.04 Hours Average Flight Duration
150.9 Nmiles Average Flight Distance
24,247,768 Landings

Table 3.47
General Aviation Turboprop, Fixed Wing Crash Rates by Flight Phase

Flight Phases	No. of Accs.		Average Pct. Flt. Time		Assumed Average Velocity		Calculated Average Distance		Crash Rate by Flight Phases				Crash Rate by Combined Flight Phases			
	Accs.	Pct.	Flt. Time	(hours)	Miles	Knots	Miles	Knots	Crashes /Landing	Crashes /AC Hour	Crashes /Mile	Crashes /Knot	Crashes /Landing	Crashes /AC Hour	Crashes /Mile	Crashes /Knot
Takeoff	22	8.98%	0.96%	0.008	100.00	85.00	0.83	0.71	1.714E-06	2.057E-04	2.057E-06	2.420E-06	4.674E-06	2.805E-04	2.102E-06	2.439E-06
Initial Climb	38	15.51%	0.96%	0.008	166.86	145.00	1.39	1.21	2.960E-06	3.552E-04	2.129E-06	2.450E-06				
Climb to Cruise	16	6.53%	21.07%	0.183	218.65	190.00	40.09	34.83	1.246E-06	6.799E-06	3.110E-08	3.578E-08				
Cruise/ Enroute	44	17.96%	26.25%	0.228	241.66	210.00	55.18	47.95	3.428E-06	1.501E-05	6.212E-08	7.149E-08	5.765E-06	8.713E-06	3.703E-08	4.261E-08
Descent from Cruise	14	5.71%	28.74%	0.250	241.66	210.00	60.42	52.50	1.091E-06	4.363E-06	1.805E-08	2.077E-08				
Landing Approach	55	22.45%	21.07%	0.183	161.11	140.00	29.54	25.67	4.285E-06	2.337E-05	1.451E-07	1.669E-07				
Landing	56	22.86%	0.96%	0.008	100.00	75.00	0.83	0.63	4.363E-06	5.235E-04	5.235E-06	6.980E-06	8.647E-06	4.512E-05	2.847E-07	3.289E-07
TOTAL:	245	100.00%	100.00%	0.870			188.27	163.49	1.909E-05	2.194E-05	1.014E-07	1.167E-07	1.909E-05	2.194E-05	1.014E-07	1.167E-07

Bases for Crash Rates by Flight Phase, 1986-1994 Totals:

0.87 Hours Average Flight Duration
163.1 Nmiles Average Flight Distance
12,836,398 Landings

Table 3.48
General Aviation Turbojet, Fixed Wing Crash Rates by Flight Phase

Flight Phases	No. of Accs.		Average Pct.	Average Flt. Time	Assumed Average Velocity		Calculated Average Distance		Crash Rate by Flight Phases				Crash Rate by Combined Flight Phases			
	Accs.	Pct.	Flt. Time	(hours)	Miles	Knots	Miles	Knots	Crashes /Landing	Crashes /AC Hour	Crashes /Mile	Crashes /Knot	Crashes /Landing	Crashes /AC Hour	Crashes /Mile	Crashes /Knot
Takeoff	12	14.81%	0.68%	0.008	103.57	90.00	0.86	0.75	1.305E-06	1.566E-04	1.512E-06	1.740E-06	1.849E-06	7.397E-05	3.443E-07	3.963E-07
Initial Climb	5	6.17%	1.36%	0.017	270.43	235.00	4.51	3.92	5.439E-07	3.263E-05	1.207E-07	1.389E-07				
Climb to Cruise	7	8.64%	18.97%	0.233	494.83	430.00	115.46	100.33	7.615E-07	3.263E-06	6.595E-09	7.589E-09				
Cruise/ Enroute	8	9.88%	49.86%	0.613	512.10	445.00	314.09	272.93	8.702E-07	1.419E-06	2.771E-09	3.188E-09	1.849E-06	1.825E-06	3.605E-09	4.148E-09
Descent from Cruise	2	2.47%	13.55%	0.167	500.59	435.00	83.43	72.50	2.176E-07	1.305E-06	2.608E-09	3.001E-09				
Landing Approach	19	23.46%	14.91%	0.183	270.43	235.00	49.58	43.08	2.067E-06	1.127E-05	4.169E-08	4.797E-08				
Landing	28	34.57%	0.68%	0.008	103.57	90.00	0.86	0.75	3.046E-06	3.655E-04	3.529E-06	4.061E-06	5.113E-06	2.667E-05	1.014E-07	1.166E-07
TOTAL:	81	100.00%	100.00%	1.230			568.79	494.27	8.811E-06	7.164E-06	1.549E-08	1.783E-08	8.811E-06	7.164E-06	1.549E-08	1.783E-08

Bases for Crash Rates by Flight Phase, 1986-1994 Totals:

1.23 Hours Average Flight Duration
494.4 Nmiles Average Flight Distance
9,192,926 Landings

Table 3.49
General Aviation Total Fixed Wing Crash Rates by Flight Phase

Flight Phases	No. of Accs.		Average Pct. Flt. Time		Average Average Velocity		Calculated Average Distance		Crash Rate by Flight Phases				Crash Rate by Combined Flight Phases			
	Accs.	Pct.	Flt. Time	(hours)	Miles	Knots	Miles	Knots	Crashes /Landing	Crashes /AC Hour	Crashes /Mile	Crashes /Knot	Crashes /Landing	Crashes /AC Hour	Crashes /Mile	Crashes /Knot
Takeoff	1,127	7.72%	1.16%	0.008	80.55	70.00	0.67	0.58	3.512E-06	4.214E-04	5.231E-06	6.020E-06	1.174E-05	7.043E-04	7.200E-06	8.285E-06
Initial Climb	2,640	18.08%	1.16%	0.008	115.08	100.00	0.96	0.83	8.226E-06	9.871E-04	8.578E-06	9.871E-06				
Climb to Cruise	594	4.07%	20.83%	0.150	143.85	125.00	21.58	18.75	1.851E-06	1.234E-05	8.578E-08	9.871E-08				
Cruise/ Enroute	3,053	20.91%	34.03%	0.245	166.86	145.00	40.88	35.53	9.513E-06	3.883E-05	2.327E-07	2.678E-07	1.298E-05	2.382E-05	1.514E-07	1.742E-07
Descent from Cruise	520	3.56%	20.83%	0.150	155.35	135.00	23.30	20.25	1.620E-06	1.080E-05	6.953E-08	8.001E-08				
Landing Approach	2,348	16.08%	20.83%	0.150	120.83	105.00	18.12	15.75	7.316E-06	4.877E-05	4.037E-07	4.645E-07				
Landing	4,319	29.58%	1.16%	0.008	74.80	65.00	0.62	0.54	1.346E-05	1.615E-03	2.159E-05	2.484E-05	2.077E-05	1.312E-04	1.108E-06	1.275E-06
TOTAL:	14,601	100.00%	100.00%	0.720			106.14	92.23	4.549E-05	6.319E-05	4.286E-07	4.933E-07	4.549E-05	6.319E-05	4.286E-07	4.933E-07

Bases for Crash Rates by Flight Phase, 1986-1994 Totals:

0.72 Hours Average Flight Duration
92.2 Nmiles Average Flight Distance
320,937,021 Landings

Table 3.50
General Aviation Reciprocating Engine, Rotary Wing (Helicopter) Crash Rates by Flight Phase

Flight Phases	No. of	Accs.	Average	Average	Assumed		Calculated		Crash Rate by Flight Phases				Crash Rate by Combined Flight Phases			
	Accs.	Pct.	Pct.	Flt. Time	Average	Velocity	Average	Distance	Crashes	Crashes	Crashes	Crashes	Crashes	Crashes	Crashes	Crashes
			Flt. Time	(hours)	Miles	Knots	Miles	Knots	/Landing	/AC Hour	/Mile	/Knot	/Landing	/AC Hour	/Mile	/Knot
Takeoff	59	9.15%	2.38%	0.008	57.54	50.00	0.48	0.42	3.854E-06	4.625E-04	8.037E-06	9.249E-06	1.078E-05	6.467E-04	1.070E-05	1.232E-05
Initial Climb	106	16.43%	2.38%	0.008	63.29	55.00	0.53	0.46	6.924E-06	8.309E-04	1.313E-05	1.511E-05				
Climb to Cruise	20	3.10%	23.81%	0.083	65.59	57.00	5.47	4.75	1.306E-06	1.568E-05	2.390E-07	2.750E-07				
Cruise/Enroute	201	31.16%	11.90%	0.042	69.05	60.00	2.88	2.50	1.313E-05	3.151E-04	4.564E-06	5.252E-06	1.666E-05	7.995E-05	1.182E-06	1.360E-06
Descent from Cruise	34	5.27%	23.81%	0.083	69.05	60.00	5.75	5.00	2.221E-06	2.665E-05	3.860E-07	4.442E-07				
Landing Approach	78	12.09%	33.33%	0.117	63.29	55.00	7.38	6.42	5.095E-06	4.367E-05	6.900E-07	7.940E-07				
Landing	147	22.79%	2.38%	0.008	46.03	40.00	0.38	0.33	9.602E-06	1.152E-03	2.503E-05	2.881E-05	1.470E-05	1.176E-04	1.892E-06	2.177E-06
TOTAL:	645	100.00%	100.00%	0.350			22.87	19.88	4.213E-05	1.204E-04	1.842E-06	2.120E-06	4.213E-05	1.204E-04	1.842E-06	2.120E-06

Bases for Crash Rates by Flight Phase, 1986-1994 Totals:

0.35 Hours Average Flight Duration
19.97 Nmiles Average Flight Distance
15,309,282 Landings

Table 3.51
General Aviation Turbine Engine, Rotary Wing (Helicopter) Crash Rates by Flight Phase

Flight Phases	No. of Accs.	Accs. Pct.	Average		Assumed		Calculated		Crash Rate by Flight Phases				Crash Rate by Combined Flight Phases			
			Pct.	Average Flt. Time (hours)	Average Velocity Miles	Knots	Average Distance Miles	Knots	Crashes /Landing	Crashes /AC Hour	Crashes /Mile	Crashes /Knot	Crashes /Landing	Crashes /AC Hour	Crashes /Mile	Crashes /Knot
Takeoff	26	7.85%	1.67%	0.008	63.29	55.00	0.53	0.46	1.141E-06	1.370E-04	2.164E-06	2.490E-06	3.073E-06	1.844E-04	2.739E-06	3.152E-06
Initial Climb	44	13.29%	1.67%	0.008	71.35	62.00	0.59	0.52	1.932E-06	2.318E-04	3.249E-06	3.738E-06				
Climb to Cruise	12	3.63%	23.33%	0.117	95.51	83.00	11.14	9.68	5.268E-07	4.515E-06	4.727E-08	5.440E-08				
Cruise/ Enroute	136	41.09%	31.67%	0.158	110.47	96.00	17.49	15.20	5.970E-06	3.771E-05	3.413E-07	3.928E-07	7.243E-06	1.849E-05	1.821E-07	2.095E-07
Descent from Cruise	17	5.14%	23.33%	0.117	95.51	83.00	11.14	9.68	7.463E-07	6.397E-06	6.697E-08	7.707E-08				
Landing Approach	40	12.08%	16.67%	0.083	71.35	62.00	5.95	5.17	1.756E-06	2.107E-05	2.953E-07	3.399E-07				
Landing	56	16.92%	1.67%	0.008	46.03	40.00	0.38	0.33	2.458E-06	2.950E-04	6.409E-06	7.375E-06	4.214E-06	4.597E-05	6.658E-07	7.662E-07
TOTAL:	331	100.00%	100.00%	0.500			47.23	41.04	1.453E-05	2.906E-05	3.077E-07	3.540E-07	1.453E-05	2.906E-05	3.077E-07	3.540E-07

Bases for Crash Rates by Flight Phase, 1986-1994 Totals:

0.5 Hours Average Flight Duration
41.07 Nmiles Average Flight Distance
22,779,909 Landings

Table 3.52
General Aviation Total Rotary Wing (Helicopter) Crash Rates by Flight Phase

Flight Phases	No. of Accs.		Average Pct.	Average Flt. Time	Assumed Average Velocity		Calculated Average Distance		Crash Rate by Flight Phases				Crash Rate by Combined Flight Phases			
	Accs.	Pct.	Flt. Time	(hours)	Miles	Knots	Miles	Knots	Crashes /Landing	Crashes /AC Hour	Crashes /Mile	Crashes /Knot	Crashes /Landing	Crashes /AC Hour	Crashes /Mile	Crashes /Knot
Takeoff	85	8.71%	1.85%	0.008	60.99	53.00	0.51	0.44	2.232E-06	2.678E-04	4.391E-06	5.053E-06	6.170E-06	3.702E-04	5.693E-06	6.552E-06
Initial Climb	150	15.37%	1.85%	0.008	69.05	60.00	0.58	0.50	3.938E-06	4.726E-04	6.844E-06	7.876E-06				
Climb to Cruise	32	3.28%	22.22%	0.100	89.76	78.00	8.98	7.80	8.401E-07	8.401E-06	9.360E-08	1.077E-07				
Cruise/ Enroute	337	34.53%	27.78%	0.125	104.72	91.00	13.09	11.38	8.848E-06	7.078E-05	6.759E-07	7.778E-07	1.103E-05	3.227E-05	3.389E-07	3.900E-07
Descent from Cruise	51	5.23%	25.93%	0.117	89.76	78.00	10.47	9.10	1.339E-06	1.148E-05	1.279E-07	1.471E-07				
Landing Approach	118	12.09%	18.52%	0.083	65.59	57.00	5.47	4.75	3.098E-06	3.718E-05	5.668E-07	6.522E-07				
Landing	203	20.80%	1.85%	0.008	46.03	40.00	0.38	0.33	5.330E-06	6.396E-04	1.389E-05	1.599E-05	8.428E-06	9.194E-05	1.441E-06	1.658E-06
TOTAL:	976	100.00%	100.00%	0.450			39.47	34.30	2.562E-05	5.694E-05	6.492E-07	7.471E-07	2.562E-05	5.694E-05	6.492E-07	7.471E-07

Bases for Crash Rates by Flight Phase, 1986-1994 Totals:

0.45 Hours Average Flight Duration
34.29 Nmiles Average Flight Distance
38,089,190 Landings

Table 3.53
General Aviation Total Powered Aircraft Crash Rates by Flight Phase

Flight Phases	No. of Accs.	Accs. Pct.	Average Pct. Flt. Time	Average Flt. Time (hours)	Assumed Average Velocity		Calculated Average Distance		Crash Rate by Flight Phases				Crash Rate by Combined Flight Phases			
					Miles	Knots	Miles	Knots	Crashes /Landing	Crashes /AC Hour	Crashes /Mile	Crashes /Knot	Crashes /Landing	Crashes /AC Hour	Crashes /Mile	Crashes /Knot
Takeoff	1,212	7.78%	1.23%	0.008	69.05	60.00	0.58	0.50	3.323E-06	3.988E-04	5.775E-06	6.646E-06	1.097E-05	4.389E-04	4.975E-06	5.725E-06
Initial Climb	2,790	17.91%	2.45%	0.017	97.82	85.00	1.63	1.42	7.649E-06	4.590E-04	4.692E-06	5.400E-06				
Climb to Cruise	626	4.02%	19.61%	0.133	142.70	124.00	19.03	16.53	1.716E-06	1.287E-05	9.021E-08	1.038E-07				
Cruise/ Enroute	3,390	21.76%	32.60%	0.222	163.41	142.00	36.22	31.48	9.294E-06	4.193E-05	2.566E-07	2.953E-07	1.258E-05	2.411E-05	1.554E-07	1.788E-07
Descent from Cruise	571	3.67%	24.51%	0.167	154.20	134.00	25.70	22.33	1.566E-06	9.393E-06	6.091E-08	7.010E-08				
Landing Approach	2,466	15.83%	17.16%	0.117	109.32	95.00	12.75	11.08	6.761E-06	5.795E-05	5.301E-07	6.100E-07				
Landing	4,522	29.03%	2.45%	0.017	63.29	55.00	1.05	0.92	1.240E-05	7.439E-04	1.175E-05	1.353E-05	1.916E-05	1.437E-04	1.387E-06	1.597E-06
TOTAL:	15,577	100.00%	100.00%	0.680			96.96	84.26	4.271E-05	6.281E-05	4.404E-07	5.069E-07	4.271E-05	6.281E-05	4.404E-07	5.069E-07

Bases for Crash Rates by Flight Phase, 1986-1994 Totals:

0.68 Hours Average Flight Duration
84.19 Nmiles Average Flight Distance
364,735,255 Landings

Table 3.54
Condition Probabilities of General Aviation Crash Location (/sq. mile),
Given a Crash on Takeoff
[Reference 3.3]

Y	X	(-4,-3)	(-3,-2)	(-2,-1)	(-1,0)	(0,1)	(1,2)	(2,3)	(3,4)	(4,5)	(5,6)	(6,7)	(7,8)
(3,4)					1.2E-05	1.7E-04	4.2E-04	1.7E-04	1.4E-05				
(2,3)				1.1E-05	1.5E-04	1.1E-03	2.2E-03	8.9E-04	4.0E-04	1.1E-03	6.5E-04	6.3E-05	
(1,2)			1.6E-05	5.2E-04	6.4E-03	1.3E-02	9.8E-03	4.0E-03	1.9E-03	3.2E-03	1.9E-03	2.1E-04	
(0,1)			3.4E-04	5.1E-03	1.5E-01	2.0E-01	6.9E-02	2.2E-02	5.8E-03	4.5E-03	4.5E-03	1.5E-03	4.6E-04
(-1,0)		1.1E-05	4.8E-04	6.4E-03	1.5E-01	2.0E-01	6.3E-02	2.1E-02	6.1E-03	4.3E-03	4.4E-03	1.5E-03	1.6E-04
(-2,-1)			5.9E-05	1.0E-03	7.2E-03	1.1E-02	5.7E-03	2.0E-03	5.1E-04	2.7E-04	3.8E-04	1.4E-04	1.0E-05
(-3,-2)				1.7E-05	1.0E-04	1.7E-04	4.5E-04	1.0E-03	5.1E-04	2.7E-04	3.8E-04	1.4E-04	1.0E-05
(-4,-3)						2.6E-05	4.4E-04	1.2E-03	5.7E-04	2.0E-04	3.4E-04	1.2E-04	
(-5,-4)							1.5E-05	4.2E-05	2.0E-05				

intended direction of travel is left to right
origin is center of runway
units are in miles

Table 3.55
Condition Probabilities of General Aviation Crash Location (/sq. mile), Given a Crash on Landing
[Reference 3.3]

Y \ X	(-16,-15)	(-15,-14)	(-14,-13)	(-13,-12)	(-12,-11)	(-11,-10)	(-10,-9)	(-9,-8)	(-8,-7)	(-7,-6)	(-6,-5)	(-5,-4)	(-4,-3)	(-3,-2)	(-2,-1)	(-1,0)	(0,1)	(1,2)	(2,3)	(3,4)	(4,5)	5,6)	(6,7)	(7,8)
(5,6)													1.5E-05	6.3E-05	1.9E-04	3.5E-04	3.5E-04	1.9E-04	6.2E-05	1.5E-05				
(4,5)												4.3E-05	1.9E-04	4.3E-04	6.1E-04	6.8E-04	6.0E-04	4.9E-04	3.8E-04	2.4E-04	1.7E-04	8.7E-05	2.0E-05	
(3,4)										3.3E-05	1.1E-04	2.7E-04	5.2E-04	8.3E-04	9.7E-04	7.6E-04	5.0E-04	3.9E-04	3.7E-04	4.8E-04	4.8E-04	2.3E-04	4.4E-05	
(2,3)			5.6E-05	2.0E-04	3.3E-04	2.9E-04	1.6E-04	7.1E-05	9.9E-05	3.1E-04	5.0E-04	4.5E-04	7.5E-04	1.5E-03	1.7E-03	1.1E-03	6.0E-04	4.0E-04	4.5E-04	7.1E-04	7.1E-04	3.3E-04	6.0E-05	
(1,2)		7.2E-05	2.8E-04	5.2E-04	6.1E-04	5.6E-04	4.5E-04	4.5E-04	6.5E-04	8.8E-04	8.7E-04	6.6E-04	1.1E-03	3.0E-03	5.8E-03	1.2E-02	1.1E-02	4.4E-03	1.5E-03	7.0E-04	5.3E-04	3.3E-04	8.9E-05	
(0,1)	1.2E-05	1.0E-04	3.5E-04	5.3E-04	5.0E-04	5.8E-04	7.4E-04	9.5E-04	1.6E-03	2.9E-03	4.0E-03	4.3E-03	7.2E-03	1.8E-02	3.9E-02	1.6E-01	1.6E-01	2.9E-02	1.1E-02	3.9E-03	2.6E-03	1.7E-03	5.6E-04	6.8E-05
(-1,0)		7.3E-05	3.1E-04	6.0E-04	6.3E-04	6.0E-04	6.5E-04	6.7E-04	1.1E-03	2.2E-03	3.3E-03	3.8E-03	6.8E-03	1.7E-02	3.7E-02	1.6E-01	1.6E-01	2.8E-02	1.0E-02	4.0E-03	3.0E-03	2.1E-03	6.5E-04	7.7E-05
(-2,-1)			5.8E-05	1.9E-04	3.0E-04	3.9E-04	3.7E-04	2.1E-04	2.5E-04	3.5E-04	5.1E-04	7.4E-04	1.0E-03	2.3E-03	4.9E-03	1.1E-02	1.0E-02	3.8E-03	1.6E-03	8.2E-04	6.0E-04	4.0E-04	1.2E-04	1.4E-05
(-3,-2)			4.6E-05	1.6E-04	2.1E-04	1.5E-04	1.0E-04	7.8E-05	1.9E-04	3.2E-04	3.9E-04	5.3E-04	6.8E-04	1.1E-03	1.4E-03	1.2E-03	9.4E-04	6.8E-04	4.7E-04	4.2E-04	3.7E-04	1.6E-04	2.7E-05	
(-4,-3)								5.2E-05	1.6E-04	2.0E-04	2.5E-04	6.0E-04	8.3E-04	5.8E-04	3.6E-04	3.9E-04	3.3E-04	1.4E-04	1.4E-04	2.8E-04	2.4E-04	8.1E-05		
(-5,-4)								4.8E-05	1.5E-04	1.7E-04	1.8E-04	3.5E-04	4.8E-04	3.8E-04	2.5E-04	3.3E-04	3.1E-04	1.2E-04	1.2E-04	2.6E-04	2.2E-04	6.8E-05		
(-6,-5)												1.3E-05	1.6E-05	2.5E-05	1.1E-04	3.0E-04	3.0E-04	3.5E-05	1.1E-04	5.3E-05	4.5E-05	1.4E-05		

intended direction of travel is left to right
origin is center of runway
units are in miles

Table 3.56
U.S. Air Force Crash Data and Estimates of Crash Frequencies Based on the Minuteman III Mishap Database
[Reference 3.3]

			Number of Landings	TAKEOFF				LANDING				No. of Sorties (000)	Flight Hours (000)	Avg. Flt. Hrs / Sortie	Normal Flight			Special Operations			Total No. of Crashes	
				Number of Crashes		Crash Rate/Takeoff		Number of Crashes		Crash Rate/Landing					Estimated Miles	No. of Crashes	Crash Rate/ Mile	Estimated Miles	No. of Crashes	Crash Rate/ Mile		
				On RW	Off RW	On RW	Off RW	On RW	Off RW	On RW	Off RW											
Large	Bombers (Bs)	B-1, B-52, B-57	1,072,000	3	2	2.80E-06	1.87E-06	2	6	1.87E-06	5.80E-06	343	2,177	6.35	5.00E+08	2	4.00E-09	5.00E+08	6	1.20E-08	21	
	Cargo (Cs)	C-130	6,341,000	1	2	1.58E-07	3.15E-07	8	8	1.26E-06	1.26E-06	2,669	6,343	2.38	1.50E+09	4	2.67E-09	1.50E+09	10	6.67E-09	33	
		KC-135	3,512,000	3	4	8.54E-07	1.14E-06	5	8	1.42E-06	2.28E-06	1,123	4,728	4.21	1.10E+09	1	9.09E-10	1.10E+09	0	9.09E-10	21	
		Other Large Cs	4,932,000	0	2	< 2.0 E-7	4.06E-07	11	5	2.23E-06	1.01E-06	2,333	7,738	3.32	1.80E+09	2	1.11E-09	1.80E+09	1	5.56E-10	21	
		Small Cs	1,628,000	0	0	< 6.1 E-7	< 6.1 E-7	2	1	1.23E-06	6.14E-07	821	1,535	1.87	3.50E+08	1	2.86E-09	3.50E+08	1	2.86E-09	5	
	All Cargo	16,413,000	4	8	2.44E-07	4.87E-07	26	22	1.58E-06	1.34E-06	6,948	20,344	2.93	4.75E+09	8	1.68E-09	4.75E+09	12	2.53E-09	80		
		All Large (Bs, Cs)	17,485,000	7	10	4.00E-07	5.72E-07	28	28	1.80E-06	1.60E-06	7,289	22,521	3.06	5.25E+09	10	1.90E-09	5.25E+09	18	3.43E-09	101	
Small	Attack (As)	Single Engine	A-7	940,000	2	9	2.13E-06	9.57E-06	12	5	1.28E-05	5.32E-06	925	1,387	1.50	2.40E+08	9	3.75E-08	2.80E+08	43	1.65E-07	80
			F-16	2,818,000	2	16	7.10E-07	5.68E-06	24	34	8.52E-06	1.21E-05	2,875	3,730	1.39	8.30E+08	32	3.86E-08	9.30E+08	104	1.12E-07	212
			All Single-engine	3,758,000	4	25	1.06E-06	6.65E-06	36	39	9.58E-06	1.04E-05	3,600	5,117	1.42	1.07E+09	41	3.83E-08	1.19E+09	147	1.24E-07	292
		Multiple Engine	A-10	1,738,000	0	2	< 5.8 E-7	1.15E-06	9	10	5.18E-06	5.75E-06	1,740	2,962	1.70	5.10E+08	16	3.14E-08	5.60E+08	47	8.39E-08	84
			F-4	4,462,000	7	21	1.57E-06	4.71E-06	41	24	9.19E-06	5.38E-06	3,882	5,182	1.33	1.20E+09	20	1.67E-08	1.30E+09	139	1.07E-07	252
			F-15	2,235,000	1	5	4.47E-07	2.24E-06	17	7	7.61E-06	3.13E-06	2,082	2,864	1.36	6.40E+08	4	6.25E-09	7.10E+08	60	8.45E-08	94
	Fighters (Fs)	Multiple Engine	F-111, FB-111	891,000	1	5	1.12E-06	5.61E-06	8	14	8.98E-06	1.57E-05	658	1,648	2.50	3.70E+08	9	2.43E-08	4.10E+08	40	9.76E-08	77
			All Multiple-engine	9,326,000	9	33	9.65E-07	3.54E-06	75	55	8.04E-06	5.90E-06	8,382	12,636	1.51	2.72E+09	49	1.80E-08	2.98E+09	286	9.60E-08	507
			Other As, Fs	1,677,000	5	12	2.98E-06	7.16E-06	23	26	1.37E-05	1.55E-05	1,530	2,079	1.36	4.50E+08	12	2.67E-08	5.00E+09	73	1.46E-08	151
		Trainers (Ts)	All As, Fs	14,781,000	18	70	1.22E-06	4.74E-06	134	120	9.08E-06	8.13E-06	13,492	19,832	1.47	4.24E+09	102	2.41E-08	9.17E+09	506	5.52E-08	950
			Subsonic: T-37	14,147,000	1	4	7.07E-08	2.83E-07	2	6	1.41E-07	4.24E-07	4,154	5,212	1.25	7.00E+08	4	5.71E-09	7.80E+08	11	1.41E-08	26
			Supersonic: T-38	15,118,000	6	9	3.97E-07	5.95E-07	17	20	1.12E-06	1.32E-06	5,109	6,038	1.18	1.20E+09	11	9.17E-09	1.40E+09	27	1.93E-08	90
		Other Ts	2,896,000	3	3	1.04E-06	1.04E-06	4	8	1.38E-06	2.76E-06	1,347	2,254	1.67	3.90E+08	3	7.69E-09	4.30E+08	7	1.63E-08	28	
		All Ts	32,161,000	10	16	3.11E-07	4.97E-07	23	34	7.15E-07	1.06E-06	10,610	13,504	1.27	2.29E+09	18	7.86E-09	2.61E+09	45	1.72E-08	146	
			All Small (As, Fs, Ts)	46,922,000	28	86	5.97E-07	1.83E-06	157	154	3.35E-06	3.28E-06	24,102	33,336	1.38	6.53E+09	120	1.84E-08	1.18E+10	551	4.68E-08	1096
	Helicopter			3,507,000	2	3	5.70E-07	8.55E-07	2	10	5.70E-07	2.85E-06	1,028	1,449	1.41	8.30E+07	17	2.05E-07	9.30E+07	9	9.66E-08	43
All Military Aircraft			67,914,000	37	99	5.45E-07	1.46E-06	187	192	2.75E-06	2.83E-06	32,419	57,306	1.77	1.19E+10	147	1.24E-08	1.71E+10	578	3.38E-08	1240	

Table 3.57
Conditional Probabilities of Small Military Aircraft Crash Location (/sq. mile),
Given a Crash on Takeoff
[Reference 3.3]

X (ml)	Y(ml)												
	-2	-1	0	1	2	3	4	5	6	7	8	9	10
0	0.00527	0.01480	0.02204	0.01798	0.00924	0.00390	0.00166	0.00111	0.00107	0.00102	0.00127	0.00129	0.00071
1	0.00735	0.02132	0.03286	0.02815	0.01564	0.00723	0.00325	0.00214	0.00205	0.00198	0.00228	0.00212	0.00112
2	0.00776	0.02294	0.03631	0.03246	0.01924	0.00950	0.00452	0.00300	0.00282	0.00280	0.00297	0.00244	0.00118
3	0.00669	0.01955	0.03145	0.02927	0.01816	0.00933	0.00493	0.00357	0.00313	0.00298	0.00289	0.00204	0.00087
4	0.00545	0.01491	0.02402	0.02315	0.01462	0.00770	0.00510	0.00439	0.00336	0.00256	0.00211	0.00127	0.00046
5	0.00491	0.01186	0.01832	0.01769	0.01103	0.00623	0.00562	0.00548	0.00371	0.00200	0.00119	0.00060	0.00018
6	0.00455	0.00975	0.01385	0.01280	0.00782	0.00510	0.00578	0.00581	0.00366	0.00151	0.00056	0.00021	5.40E-05
7	0.00350	0.00708	0.00947	0.00844	0.00518	0.00383	0.00470	0.00460	0.00277	0.00100	0.00025	5.90E-05	1.20E-05
8	0.00197	0.00411	0.00577	0.00551	0.00361	0.00262	0.00289	0.00260	0.00148	0.00050	0.00010	1.50E-05	2.00E-06
9	0.00081	0.00201	0.00358	0.00424	0.00326	0.00223	0.00176	0.00119	0.00057	0.00018	3.30E-05	3.60E-06	3.00E-07
10	0.00030	0.00110	0.00271	0.00396	0.00375	0.00295	0.00188	0.00080	0.00023	5.00E-05	7.70E-06	7.30E-07	4.20E-08

intended direction of travel is left to right
origin is center of runway
units are in miles

Table 3.58
Conditional Probabilities of Small Military Aircraft Crash Location (/sq. mile),
Given a Crash on Landing
[Reference 3.3]

X (ml)	Y(ml)															
	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
-2	3.00E-07	1.00E-05	1.00E-04	0.002	0.011	0.022	0.013	0.003	8.00E-04	2.00E-04	1.00E-05	2.00E-07	2.00E-08	4.00E-08	4.00E-08	1.00E-08
-1	9.00E-07	3.00E-05	4.00E-04	0.003	0.021	0.045	0.027	0.006	0.001	3.00E-04	2.00E-05	1.00E-06	3.00E-07	6.00E-07	6.00E-07	2.00E-07
0	2.00E-06	6.00E-05	6.00E-04	0.005	0.031	0.065	0.039	0.008	0.002	4.00E-04	6.00E-05	7.00E-06	3.00E-06	6.00E-06	6.00E-06	2.00E-06
1	2.00E-06	7.00E-05	7.00E-04	0.005	0.032	0.069	0.042	0.009	0.002	0.001	2.00E-04	4.00E-05	2.00E-05	4.00E-05	4.00E-05	2.00E-05
2	2.00E-06	6.00E-05	6.00E-04	0.004	0.025	0.055	0.034	0.008	0.002	0.001	4.00E-04	2.00E-04	8.00E-05	2.00E-04	2.00E-04	9.00E-05
3	8.00E-06	4.00E-05	4.00E-04	0.003	0.016	0.035	0.022	0.006	0.002	0.002	0.001	5.00E-04	2.00E-04	5.00E-04	6.00E-04	3.00E-04
4	5.00E-05	5.00E-05	4.00E-04	0.002	0.010	0.020	0.013	0.004	0.002	0.002	0.002	0.001	5.00E-04	0.001	0.001	8.00E-04
5	2.00E-04	1.00E-04	4.00E-04	0.002	0.007	0.012	0.008	0.003	0.001	0.002	0.002	0.002	6.00E-04	0.001	0.002	0.001
6	6.00E-04	4.00E-04	5.00E-04	0.002	0.005	0.008	0.006	0.002	8.00E-04	0.001	0.002	0.001	6.00E-04	0.001	0.002	0.001
7	0.001	7.00E-04	6.00E-04	0.002	0.005	0.007	0.005	0.002	4.00E-04	8.00E-04	0.002	0.001	4.00E-04	6.00E-04	0.001	1.00E-03
8	0.001	8.00E-04	6.00E-04	0.002	0.004	0.006	0.005	0.002	3.00E-04	4.00E-04	0.001	0.001	4.00E-04	2.00E-04	4.00E-04	5.00E-04
9	0.001	6.00E-04	5.00E-04	0.002	0.003	0.005	0.005	0.002	2.00E-04	3.00E-04	0.001	0.001	4.00E-04	9.00E-05	1.00E-04	2.00E-04
10	6.00E-04	3.00E-04	2.00E-04	9.00E-04	0.002	0.005	0.005	0.002	2.00E-04	2.00E-04	9.00E-04	0.001	4.00E-04	4.00E-05	2.00E-05	4.00E-05
11	2.00E-04	1.00E-04	8.00E-05	4.00E-04	0.002	0.005	0.005	0.002	2.00E-04	1.00E-04	6.00E-04	7.00E-04	2.00E-04	2.00E-05	4.00E-06	5.00E-06
12	5.00E-05	3.00E-05	2.00E-05	3.00E-04	0.002	0.005	0.004	0.001	1.00E-04	5.00E-05	2.00E-04	3.00E-04	1.00E-04	8.00E-06	5.00E-07	5.00E-07
13	7.00E-06	4.00E-06	8.00E-06	2.00E-04	0.001	0.003	0.002	7.00E-04	8.00E-05	2.00E-05	7.00E-05	9.00E-05	3.00E-05	2.00E-06	6.00E-08	3.00E-08

intended direction of travel is left to right
origin is center of runway
units are in miles

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4. MMA FACILITIES AIRCRAFT CRASH HIT FREQUENCY

4.1 INTRODUCTION

The LLNL Materials Management Area (MMA) is the designation for the area, which is under the oversight of the Materials Management Section of the Applied Research Engineering Division (ARED) of the Mechanical Engineering Department. It consists of three facilities, the Building 231 Vault, the Building 232 Fenced Compound, and the Building 233 Vault. [Ref. 4.1] Because this Aircraft Crash Hit Analysis is being done in support of the MMA Facilities Safety Analysis Report (SAR), only that part of Building 231 (the vault), Building 232 (the northern fenced compound portion), and Building 233 (the vault) that is covered by the SAR is considered within the scope of this analysis. The MMA facilities are located within a secured area in the southwest quadrant of the LLNL Site 200, 1150 feet from the southern boundary and 2300 feet from the western boundary. Figure 4.1 shows the layout of LLNL Site 200 and the location of the MMA Facilities. Figure 4.2 shows the layout of the MMA Facilities.

The Building 231 Vault is a reinforced concrete block structure built in 1956 as an addition to the Building 231 Complex. Only the vault addition is considered in the MMA Facilities SAR and in this aircraft crash hit analysis. The Building 231 Vault currently functions as an inspection, shipping, and storage facility for controlled materials. These parts may be composed of hazardous and/or radioactive materials. Based on the hazard analysis discussed in Chapter 3 of the MMA SAR, the Building 231 Vault is classified as a Low Hazard Category 3 Nuclear Facility [Ref. 4.1]. The Building 231 Vault is approximately 40 feet wide and 75 feet long with the longer dimension oriented East-West. It is a one story building topped by a mechanical equipment room and an exhaust stack that is 34 feet in height.

The Building 232 Fenced Compound is an open, metal frame structure added to the north end of Building 232 in 1966. Only the fenced area, currently used for storage and inspection of controlled and nuclear material, is considered in the SAR and in this aircraft crash hit analysis. Based on the hazard analysis discussed in Chapter 3 of the MMA SAR, the Building 232 Fenced Compound is classified as a radiological facility [Ref. 4.1]. The Building 232 Fenced Compound is 31.5 feet wide, and 38.2 feet long with the longer dimension oriented North-South. It is 15.3 feet in height at its highest point.

The Building 233 Vault is a reinforced concrete structure built in 1958 as a long-term storage area for classified and controlled parts and material. In 1966, an office area was built at the north end of the vault, but is not included in the MMA SAR or in the aircraft crash hit analysis. Based on the hazard analysis discussed in Chapter 3 of the MMA SAR, the Building 233 Vault is classified as a radiological facility [Ref. 4.1]. The Building 233 Vault is 36 feet wide, and 50 feet long with the longer dimension oriented East-West. The building is 15 feet in height.

4.2 MMA FACILITIES AREA CALCULATION

Because of the closeness of adjacent buildings to the MMA facilities as shown in Figure 4.1, there is insufficient room for an aircraft to skid into a building of the MMA. Neighboring buildings act as shields and would serve to deflect or absorb the impact of all but the largest General Aviation (GA) aircraft. Therefore, for the MMA facilities, only direct impact or "fly-in" is considered, with "skid-in" discounted.

The three buildings which make up the MMA facilities, the Building 231 Vault (only), the Building 232 Fenced Compound, and the Building 233 Vault (only) are considered together along with the spaces between these facilities. The logic for this modeling decision is that the space between the MMA facilities is smaller than the wingspan of even the smallest General Aviation aircraft and so even if an aircraft were to crash between the buildings which make up the MMA facilities, its wing would probably still hit one or more of the buildings. The location of the various buildings which make up the MMA Facilities were adjusted for ease of modeling. A distance of 30 feet was assumed between the Building 231 Vault and the Building 232 Fenced Compound. A distance of 50 feet was assumed between the Building 232 Fenced Compound and the Building 233 Vault. The physical area of the MMA facilities was modeled as rectangle 40 feet wide and 240 feet long. A border area 10 feet wide was added to outside of the physical area of the MMA facilities to approximate the spacing between the MMA facilities and adjacent buildings. This increases the area of the MMA facilities to include the area around the buildings in which an aircraft could land outside of the MMA facilities and yet still hit a structure. Thus, the effective area of the MMA facilities, A_t , is modeled as a rectangle 60 feet wide and 260 feet long giving a total effective area of 15,600 ft.² or 5.6 E-4 mi.². This facility effective target area A_t is used in all subsequent calculations. Figure 4.3 shows the MMA Facilities as modeled for the Aircraft Crash Hit Analysis.

4.3 MMA FACILITIES AIR CARRIER AIRCRAFT CRASH HIT FREQUENCY ESTIMATE

4.3.1 Air Carrier Aircraft Crash Hit Frequency from Livermore Municipal Airport Operations

From Table 2.1, it was found that for Fiscal Years 1995, 1993-95, and 1991-95, there were no aircraft flying under 14 CFR 121 (Air Carriers) which performed any operation from the Livermore Municipal Airport (LVK). Only for the Fiscal Year 1986-95 time period were any Air Carrier operations were performed at the Livermore Municipal Airport. A total of two Air Carrier operations were performed at the Livermore Municipal Airport (one landing and one takeoff) for this ten year period for an average number of Air Carrier operations per year of 0.1. All Air Carrier takeoff operations were assumed to the East towards LLNL, and all Air Carrier landing operations were assumed to the West approaching over LLNL.

From Table 3.9, the crash rates for 14 CFR 121 Air Carriers for the 1973-94 time period for accidents which resulted in the destruction or major damage/write-off of the airframe were 3.65 E-7/landing, and 2.86 E-7/takeoff.

From Table 3.11, the crash location probability for Air Carriers at 5-6 miles from the runway on the runway centerline while on approach was found to be 1.72 E-2. From Table 3.10, the crash location probability for Air Carriers at 5-6 miles from the runway on the runway centerline while on departure was found to be 3.95 E-3.

The aircraft crash hit frequency for Air Carrier aircraft operations from the Livermore Municipal Airport for the Fiscal Year 1986-95 time period is then:

$$F = N * P * f(x,y) * A_t$$

$$\begin{aligned} F &= (0.1) * (3.65 \text{ E-}7) * (1.72 \text{ E-}2) * (5.6 \text{ E-}4) \text{ for landing} \\ &= 3.51 \text{ E-}13/\text{yr.} \end{aligned}$$

$$\begin{aligned} F &= (0.1) * (2.86 \text{ E-}7) * (3.95 \text{ E-}3) * (5.6 \text{ E-}4) \text{ for takeoff} \\ &= 6.32 \text{ E-}14/\text{yr.} \end{aligned}$$

The total aircraft crash hit frequency, F, for Air Carriers due to aircraft operations from the Livermore Municipal Airport for the Fiscal Year 1986-95 time period is 4.15 E-13/yr.

4.3.2 Air Carrier Aircraft Crash Hit Frequency from Bay TRACON Aircraft Operations

From Table 2.2, it was found that for Fiscal Year 1995, a total of 501,976 Air Carrier instrument operations were performed by the Bay TRACON. From Table 2.3, Oakland International Airport performed a total of 164,384 Air Carrier instrument operations for Fiscal Year 1995. From Table 2.4, San Francisco International Airport performed a total of 299,444 Air Carrier instrument operations for Fiscal Year 1995. Combining Oakland and San Francisco airport Air Carrier instrument operations yields 463,828. Subtracting 5% of this total for international air carrier flights yields 440,637. Assume 75% of this total are Air Carrier approaches and departures from the Southeast, East, and Northeast yields 330,477 of which half or 165,329 are approaches over Livermore, and half or 165,329 are departures over Livermore.

Similarly, for the Fiscal Year 1993-95 time period, from Tables 2.2, 2.3, and 2.4, 153,383 Air Carrier approaches and 153,383 Air Carrier departures were performed over Livermore per year.

For the Fiscal Year 1991-95 time period, from Tables 2.2, 2.3, and 2.4, 150,673 Air Carrier approaches and 150,673 Air Carrier departures were performed over Livermore per year.

For the Fiscal Year 1986-95 time period, from Tables 2.2, 2.3, and 2.4, 145,896 Air Carrier approaches and 145,896 Air Carrier departures were performed over Livermore per year.

From Table 3.9, the crash rates for 14 CFR 121 Air Carriers for the 1973-94 time period for accidents which resulted in the destruction or major damage/write-off of the airframe were 2.06 E-9/mile (where the airport approach flight phase was used for the TRACON approach operation), and 5.50 E-10/mile (where the climb to cruise flight phase was used for the TRACON departure operation).

The radius of the potential area affected by a distressed aircraft, R_p , was set equal to the glide ratio of the aircraft, g , times the height (altitude), h , of the aircraft when the initiating event occurred. For the Madwin3 arrival approach procedure for the San Francisco Bay area [Ref. 4.2], the assigned altitude is no greater than 11,000 feet. A glide ratio of 15 was assume to be the maximum glide ratio for 14 CFR 121 Air Carrier Aircraft [Ref. 4.3] so. R_p is 15 x 11,000 feet or 165,000 feet or 31.25 miles.

The aircraft crash hit frequency for Air Carrier aircraft operations in the Bay TRACON flight environment for the 1995 Fiscal Year is then:

$$F = N * CR * (4/\pi^2) * (1/R_p) * A_t$$

$$F = (165,239) * (2.06 \text{ E-9}) * (0.405) * (1/31.25) * (5.6 \text{ E-4}) \text{ for landing approaches}$$

$$= 2.47 \text{ E-9/yr.}$$

$$F = (165,239) * (5.50 \text{ E-10}) * (0.405) * (1/31.25) * (5.6 \text{ E-4}) \text{ for departures}$$

$$= 6.60 \text{ E-10/yr.}$$

The total aircraft crash hit frequency, F , for Air Carriers due to aircraft operations in the Bay TRACON for Fiscal Year 1995 is 3.13 E-9/yr.

Similarly, for the Fiscal Year 1993-95 time period:

$$F = (153,383) * (2.06 \text{ E-9}) * (0.405) * (1/31.25) * (5.6 \text{ E-4}) \text{ for landing approaches}$$

$$= 2.30 \text{ E-9/yr.}$$

$$F = (153,383) * (5.50 \text{ E-10}) * (0.405) * (1/31.25) * (5.6 \text{ E-4}) \text{ for departures}$$

$$= 6.13 \text{ E-10/yr.}$$

The total aircraft crash hit frequency, F , for Air Carriers due to aircraft operations in the Bay TRACON for Fiscal Years 1993-95 is 2.91 E-9/yr.

For the Fiscal Year 1991-95 time period:

$$F = (150,673) * (2.06 \text{ E-9}) * (0.405) * (1/31.25) * (5.6 \text{ E-4}) \text{ for landing approaches}$$

$$= 2.26 \text{ E-9/yr.}$$

$$F = (150,673) * (5.50 \text{ E-10}) * (0.405) * (1/31.25) * (5.6 \text{ E-4}) \text{ for departures}$$

$$= 6.02 \text{ E-10/yr.}$$

The total aircraft crash hit frequency, F , for Air Carriers due to aircraft operations in the Bay TRACON for Fiscal Years 1991-95 is 2.86 E-9 yr.

For the Fiscal Year 1986-95 time period:

$$F = (145,896) * (2.06 \text{ E-9}) * (0.405) * (1/31.25) * (5.6 \text{ E-4}) \text{ for landing approaches}$$

$$= 2.18 \text{ E-9/yr.}$$

$$F = (145,896) * (5.50 \text{ E-}10) * (0.405) * (1/31.25) * (5.6 \text{ E-}4) \text{ for departures}$$

$$= 5.83 \text{ E-}10/\text{yr.}$$

The total aircraft crash hit frequency, F, for Air Carriers due to aircraft operations in the Bay TRACON for Fiscal years 1986-95 is $2.77 \text{ E-}9/\text{yr.}$

4.3.3 Air Carrier Aircraft Crash Hit Frequency from Oakland ARTCC Aircraft Handled

From Table 2.7, 961,986 Air Carrier aircraft were handled per year by the Oakland ARTCC in Fiscal Year 1995. For the Fiscal Year 1993-95 time period, an average of 905,884 Air Carrier aircraft were handled per year by the Oakland ARTCC. For the Fiscal Year 1991-95 time period, an average of 886,927 Air Carrier aircraft were handled per year by the Oakland ARTCC. For the Fiscal Year 1986-95 time period, an average of 843,660 Air Carrier aircraft were handled per year by the Oakland ARTCC.

From Table 3.9, the crash rates for 14 CFR 121 Air Carriers for the 1973-94 time period for accidents which resulted in the destruction or major damage/write-off of the airframe was $1.21 \text{ E-}7/\text{aircraft}$ handled based on the combination of 17 Air Carrier crashes during the climb to cruise, cruise/enroute, and initial descent flight phases and on the total of 139,934,558 departures during this time period.

The area of the airspace controlled by the Oakland ARTCC has been determined in Ref. 4.4 to be $100,478 \text{ mile}^2$.

The aircraft crash hit frequency for Air Carrier aircraft operations in the Oakland ARTCC flight environment for the 1995 Fiscal Year is then:

$$F = N_c * P_c * (1/A_c) * A_t$$

$$F = (961,986) * (1.21 \text{ E-}7) * (1/100,478) * (5.6 \text{ E-}4)$$

$$= 6.51 \text{ E-}10/\text{yr.}$$

Similarly, for the Fiscal Year 1993-95 time period:

$$F = (905,884) * (1.21 \text{ E-}7) * (1/100,478) * (5.6 \text{ E-}4)$$

$$= 6.13 \text{ E-}10/\text{yr.}$$

For the Fiscal Year 1991-95 time period:

$$F = (886,927) * (1.21 \text{ E-}7) * (1/100,478) * (5.6 \text{ E-}4)$$

$$= 6.00 \text{ E-}10/\text{yr.}$$

For the Fiscal Year 1986-95 time period:

$$F = (843,660) * (1.21 \text{ E-}7) * (1/100,478) * (5.6 \text{ E-}4)$$

$$= 5.71 \text{ E-}10/\text{yr.}$$

4.3.4 Air Carriers Crash Hit Frequency, Total for All Flight Environments

The total Air Carriers Crash Hit Frequency for all flight environments is the sum of the Air Carriers aircraft crash hit frequency due to airport operations, TRACON operations, and ARTCC operations.

For the 1995 Fiscal Year, the total aircraft crash hit frequency for Air Carriers in all flight environments is:

$$F_{\text{total}} = (0) + (3.13 \text{ E-9}) + (6.51 \text{ E-10}) = 3.78 \text{ E-9/yr.}$$

Similarly, for Fiscal Years 1993-95, $F_{\text{total}} = (0) + (2.91 \text{ E-9}) + (6.13 \text{ E-10}) = 3.52 \text{ E-9/yr.}$

For Fiscal Years 1991-95, $F_{\text{total}} = (0) + (2.86 \text{ E-9}) + (6.00 \text{ E-10}) = 3.46 \text{ E-9/yr.}$

For Fiscal Years 1986-95, $F_{\text{total}} = (4.15 \text{ E-13}) + (2.77 \text{ E-9}) + (5.71 \text{ E-10}) = 3.34 \text{ E-9/yr.}$

4.4 MMA FACILITIES AIR TAXI AIRCRAFT CRASH HIT FREQUENCY ESTIMATE

4.4.1 Air Taxi Aircraft Crash Hit Frequency from Livermore Municipal Airport Operations

From Table 2.1, there were 127 Air Taxi itinerant operations for Fiscal Year 1995 at the Livermore Municipal Airport of which 64 were landings and 64 were takeoffs. For Fiscal Years 1993-95, there were an average of 292 Air Taxi itinerant operations at Livermore of which 146 were landings, and 146 were takeoffs. For Fiscal Years 1991-95, there were an average of 406 Air Taxi itinerant operations at Livermore of which 203 were landings, and 203 were takeoffs. For Fiscal years 1986-95, there were an average of 410 Air Taxi itinerant operations at Livermore of which 205 were landings, and 205 were takeoffs. . All Air Taxi takeoff operations were assumed to the East towards LLNL, and all Air Taxi landing operations were assumed to the West approaching over LLNL.

From Table 3.53, a crash rate for Air Taxis during landings of 1.92 E-5/landing was taken from the crash rates for General Aviation Total Powered Aircraft for the 1986-94 time period. A crash rate for Air Taxis during takeoffs of 1.10 E-5/takeoff was also taken from the crash rates for General Aviation Total Powered Aircraft for the 1986-94 time period. The crash rates for General Aviation Total Powered Aircraft were used for Air Taxis because of the similarity of General Aviation Total Powered Aircraft operations and Nonscheduled Air Taxi aircraft operations which is predominant at the Livermore Municipal Airport.

From Table 3.55, the crash location probability for Air Taxis at 5-6 miles from the runway on the runway centerline while on approach was found to be 4.0 E-3 . From Table 3.54, the crash location probability for Air Taxis at 5-6 miles from the runway on the runway centerline while on departure was found to be 4.5 E-3 . Again, the crash location probability for General Aviation was used for Air Taxis because of the similarity of General Aviation aircraft operations and Nonscheduled Air Taxi aircraft operations which is predominant at the Livermore Municipal Airport.

The aircraft crash hit frequency for Air Taxi aircraft operations from the Livermore Municipal Airport for the 1995 Fiscal Year is:

$$F = N * P * f(x,y) * A_t$$

$$\begin{aligned} F &= (64) * (1.92 \text{ E-5}) * (4.0 \text{ E-3}) * (5.6 \text{ E-4}) \text{ for landing} \\ &= 2.73 \text{ E-9/yr.} \end{aligned}$$

$$\begin{aligned} F &= (64) * (1.10 \text{ E-5}) * (4.5 \text{ E-3}) * (5.6 \text{ E-4}) \text{ for takeoff} \\ &= 1.76 \text{ E-9/yr.} \end{aligned}$$

The total aircraft crash hit frequency, F , due to Air Taxi aircraft operations from the Livermore Municipal Airport for the 1995 Fiscal Year is 4.49 E-9/yr.

Similarly, for the Fiscal Year 1993-95 time period:

$$\begin{aligned} F &= (146) * (1.92 \text{ E-5}) * (4.0 \text{ E-3}) * (5.6 \text{ E-4}) \text{ for landing} \\ &= 6.27 \text{ E-9/yr.} \end{aligned}$$

$$\begin{aligned} F &= (146) * (1.10 \text{ E-5}) * (4.5 \text{ E-3}) * (5.6 \text{ E-4}) \text{ for takeoff} \\ &= 4.04 \text{ E-9/yr.} \end{aligned}$$

The total aircraft crash hit frequency, F , due to Air Taxi aircraft operations from the Livermore Municipal Airport for Fiscal Years 1993-95 is 1.03 E-8/yr.

For the Fiscal Year 1991-95 time period:

$$\begin{aligned} F &= (203) * (1.92 \text{ E-}5) * (4.0 \text{ E-}3) * (5.6 \text{ E-}4) \text{ for landing} \\ &= 8.72 \text{ E-}9/\text{yr.} \end{aligned}$$

$$\begin{aligned} F &= (203) * (1.10 \text{ E-}5) * (4.5 \text{ E-}3) * (5.6 \text{ E-}4) \text{ for takeoff} \\ &= 5.62 \text{ E-}9/\text{yr.} \end{aligned}$$

The total aircraft crash hit frequency, F, due to Air Taxi aircraft operations from the Livermore Municipal Airport for Fiscal Years 1991-95 is $1.43 \text{ E-}8/\text{yr.}$

For the Fiscal year 1986-95 time period:

$$\begin{aligned} F &= (205) * (1.92 \text{ E-}5) * (4.0 \text{ E-}3) * (5.6 \text{ E-}4) \text{ for landing} \\ &= 8.81 \text{ E-}9/\text{yr.} \end{aligned}$$

$$\begin{aligned} F &= (205) * (1.10 \text{ E-}5) * (4.5 \text{ E-}3) * (5.6 \text{ E-}4) \text{ for takeoff} \\ &= 5.68 \text{ E-}9/\text{yr.} \end{aligned}$$

The total aircraft crash hit frequency, F, due to Air Taxi aircraft operations from the Livermore Municipal Airport for Fiscal Years 1986-95 is $1.45 \text{ E-}8/\text{yr.}$

4.4.2 Air Taxi Aircraft Crash Hit Frequency from Bay TRACON Aircraft Operations

From Table 2.2, it was found that for Fiscal Year 1995, a total of 216,973 Air Taxi instrument operations were performed by the Bay TRACON. From Table 2.3, Oakland International Airport performed a total of 52,554 Air Taxi instrument operations for Fiscal Year 1995. From Table 2.4, San Francisco International Airport performed a total of 96,937 Air Taxi instrument operations for Fiscal Year 1995. Combining Oakland and San Francisco airport Air Taxi instrument operations yields 149,491. Assume 75% of this total are Air Taxi approaches and departures from the Southeast, East, and Northeast yields 112,118 of which half or 56,059 are approaches over Livermore, and half or 56,059 are departures over Livermore.

Similarly, for the Fiscal Year 1993-95 time period, from Tables 2.2, 2.3, and 2.4, 58,809 Air Taxi approaches and 58,809 Air Taxi departures were performed over Livermore per year.

For the Fiscal Year 1991-95 time period, from Tables 2.2, 2.3, and 2.4, 56,445 Air Taxi approaches and 56,445 Air Taxi departures were performed over Livermore per year.

For the Fiscal year 1986-95 time period, from Tables 2.2, 2.3, and 2.4, 52,404 Air Taxi approaches and 52,404 Air Taxi departures were performed over Livermore per year.

From Table 3.16, a crash rate for Air Taxis during landings of $9.54 \text{ E-}8/\text{mile}$ was taken from the crash rates for Scheduled 14 CFR 135 Air Taxis for the 1980-94 time period using the landing approach flight phase for TRACON landing approaches. A crash rate for Air Taxis during takeoffs of $1.06 \text{ E-}8/\text{mile}$ was also taken from the crash rates for Scheduled 14 CFR 135 Air Taxis for the 1980-94 time period using the climb to cruise flight phase for TRACON departures.

The radius of the potential area affected by a distressed aircraft, R_p , was set equal to the glide ratio of the aircraft, g, times the height (altitude), h, of the aircraft when the initiating event occurred. For the Madwin3 arrival approach procedure for the San Francisco Bay area [Ref. 4.2], the assigned altitude is no greater than 11,000 feet. A glide ratio of 10 was assume to be the maximum glide ratio for 14 CFR 135 Air Taxi Aircraft [Ref. 4.3] so, R_p is $10 \times 11,000$ feet or 110,000 feet or 20.83 miles.

The aircraft crash hit frequency for Air Taxi aircraft operations in the Bay TRACON flight environment for the 1995 Fiscal Year is then:

$$F = N * CR * (4/\pi^2) * (1/R_p) * A_t$$

$$F = (56,059) * (9.54 \text{ E-}8) * (0.405) * (1/20.83) * (5.6 \text{ E-}4) \text{ for landing approaches}$$

$$= 1.44 \text{ E-}7/\text{yr.}$$

$$F = (56,059) * (1.06 \text{ E-}8) * (0.405) * (1/20.83) * (5.6 \text{ E-}4) \text{ for departures}$$

$$= 1.60 \text{ E-}8/\text{yr.}$$

The total aircraft crash hit frequency, F, due to Air Taxi aircraft operations in the Bay TRACON for Fiscal Year 1995 is 1.60 E-7/yr.

Similarly, for the Fiscal Year 1993-95 time period:

$$F = (58,809) * (9.54 \text{ E-}8) * (0.405) * (1/20.83) * (5.6 \text{ E-}4) \text{ for landing approaches}$$

$$= 1.51 \text{ E-}7/\text{yr.}$$

$$F = (58,809) * (1.06 \text{ E-}8) * (0.405) * (1/20.83) * (5.6 \text{ E-}4) \text{ for departures}$$

$$= 1.68 \text{ E-}8/\text{yr.}$$

The total aircraft crash hit frequency, F, due to Air Taxi aircraft operations in the Bay TRACON for Fiscal Years 1993-95 is 1.67 E-7/yr.

For the Fiscal Year 1991-95 time period:

$$F = (56,445) * (9.54 \text{ E-}8) * (0.405) * (1/20.83) * (5.6 \text{ E-}4) \text{ for landing approaches}$$

$$= 1.45 \text{ E-}7/\text{yr.}$$

$$F = (56,445) * (1.06 \text{ E-}8) * (0.405) * (1/20.83) * (5.6 \text{ E-}4) \text{ for departures}$$

$$= 1.61 \text{ E-}8/\text{yr.}$$

The total aircraft crash hit frequency, F, due to Air Taxi aircraft operations in the Bay TRACON for Fiscal Years 1991-95 is 1.61 E-7 yr.

For the Fiscal Year 1986-95 time period:

$$F = (52,404) * (9.54 \text{ E-}8) * (0.405) * (1/20.83) * (5.6 \text{ E-}4) \text{ for landing approaches}$$

$$= 1.34 \text{ E-}7/\text{yr.}$$

$$F = (52,404) * (1.06 \text{ E-}8) * (0.405) * (1/20.83) * (5.6 \text{ E-}4) \text{ for departures}$$

$$= 1.49 \text{ E-}8/\text{yr.}$$

The total aircraft crash hit frequency, F, due to Air Taxi aircraft operations in the Bay TRACON for Fiscal years 1986-95 is 1.49 E-7/yr.

4.4.3 Air Taxi Aircraft Crash Hit Frequency from Oakland ARTCC Aircraft Handled

From Table 2.7, 210,332 Air Taxi IFR aircraft were handled by the Oakland ARTCC in Fiscal Year 1995. For the Fiscal Year 1993-95 time period, an average of 217,531 Air Taxi aircraft were handled per year by the Oakland ARTCC. For the Fiscal Year 1991-95 time period, an average of 217,680 Air Taxi aircraft were handled per year by the Oakland ARTCC. For the Fiscal Year 1986-95 time period, an average of 210,548 Air Taxi aircraft were handled per year by the Oakland ARTCC.

From Table 3.16, the crash rates for Scheduled 14 CFR 135 Air Carriers for the 1980-94 time period was 1.56 E-6/aircraft handled based on the combination of 64 Air Taxi crashes during the climb to cruise, cruise/enroute, and initial descent flight phases and on the total of 41,089,306 departures during this time period.

The area of the airspace controlled by the Oakland ARTCC has been determined in Ref. 4.4 to be 100,478 mile².

The aircraft crash hit frequency for Air Taxi aircraft operations in the Oakland ARTCC flight environment for the 1995 Fiscal Year is then:

$$F = N_c * P_c * (1/A_c) * A_t$$

$$\begin{aligned} F &= (210,332) * (1.56 \text{ E-6}) * (1/100,478) * (5.6 \text{ E-4}) \\ &= 1.82 \text{ E-9/yr.} \end{aligned}$$

Similarly, for the Fiscal Year 1993-95 time period:

$$\begin{aligned} F &= (217,531) * (1.56 \text{ E-6}) * (1/100,478) * (5.6 \text{ E-4}) \\ &= 1.89 \text{ E-9/yr.} \end{aligned}$$

For the Fiscal Year 1991-95 time period:

$$\begin{aligned} F &= (217,860) * (1.56 \text{ E-6}) * (1/100,478) * (5.6 \text{ E-4}) \\ &= 1.89 \text{ E-9/yr.} \end{aligned}$$

For the Fiscal Year 1986-95 time period:

$$\begin{aligned} F &= (210,548) * (1.56 \text{ E-6}) * (1/100,478) * (5.6 \text{ E-4}) \\ &= 1.83 \text{ E-9/yr.} \end{aligned}$$

4.4.4 Air Taxi Crash Hit Frequency, Total for All Flight Environments

The total Air Taxis Crash Hit Frequency for all flight environments is the sum of the Air Taxis aircraft crash hit frequency due to airport operations, TRACON operations, and ARTCC operations.

For the 1995 Fiscal Year, the total aircraft crash hit frequency for Air Taxis in all flight environments is:

$$F_{\text{total}} = (4.49 \text{ E-9}) + (1.60 \text{ E-7}) + (1.82 \text{ E-9}) = 1.66 \text{ E-7/yr.}$$

Similarly, for Fiscal Years 1993-95, $F_{\text{total}} = (1.03 \text{ E-8}) + (1.67 \text{ E-7}) + (1.89 \text{ E-9}) = 1.80 \text{ E-7/yr.}$

For Fiscal Years 1991-95, $F_{\text{total}} = (1.43 \text{ E-8}) + (1.61 \text{ E-7}) + (1.89 \text{ E-9}) = 1.77 \text{ E-7/yr.}$

For Fiscal Years 1986-95, $F_{\text{total}} = (1.45 \text{ E-8}) + (1.49 \text{ E-7}) + (1.83 \text{ E-9}) = 1.66 \text{ E-7/yr.}$

4.5 MMA FACILITIES GENERAL AVIATION (GA) AIRCRAFT CRASH HIT FREQUENCY ESTIMATE

4.5.1 GA Aircraft Crash Hit Frequency from Livermore Municipal Airport Operations

From Table 2.1, there 225,730 General Aviation airport operations at the Livermore Municipal Airport for Fiscal Year 1995. Of these, 146,406 were local operations and 79,324 were itinerant operations. Only itinerant operations at the Livermore Municipal Airport will be considered in the aircraft crash hit analysis. Half of these itinerant operations are considered landings (39,662) and half are considered takeoffs (39,662). All General Aviation itinerant takeoff operations were assumed to the East towards LLNL, and all General Aviation itinerant landing operations were assumed to the West approaching over LLNL. Applying the percentages of General Aviation flights for the FAA Western Pacific Region for calendar year 1994 to the FY1995 itinerant operations at the Livermore Municipal Airport yields:

<u>GA Aircraft Subcategory</u>	<u>Landings</u>	<u>Takeoffs</u>
Single-eng. piston	27,065	27,065
Multi-eng. piston	2,705	2,705
Turboprop	930	930
Turbojet	558	558
Helicopter	8,404	8,404
Total	39,662	39,662

Similarly, for the Fiscal Year 1993-95 time period, from Table 2.1:

<u>GA Aircraft Subcategory</u>	<u>Landings</u>	<u>Takeoffs</u>
Single-eng. piston	31,304	31,304
Multi-eng. piston	3,129	3,129
Turboprop	1,076	1,076
Turbojet	645	645
Helicopter	9,720	9,720
Total	45,875	45,875

For Fiscal year 1991-95 time period, from Table 2.1:

<u>GA Aircraft Subcategory</u>	<u>Landings</u>	<u>Takeoffs</u>
Single-eng. piston	32,109	32,109
Multi-eng. piston	3,210	3,210
Turboprop	1,104	1,104
Turbojet	662	662
Helicopter	9,970	9,970
Total	47,054	47,054

For Fiscal year 1986-95 time period, from Table 2.1:

<u>GA Aircraft Subcategory</u>	<u>Landings</u>	<u>Takeoffs</u>
Single-eng. piston	32,089	32,089
Multi-eng. piston	3,208	3,208
Turboprop	1,103	1,103
Turbojet	662	662
Helicopter	9,964	9,964
Total	47,026	47,026

Crash rates were taken from Tables 3.45, 3.46, 3.47, 3.48 and 3.52 for General Aviation for the 1986-94 time period for airport landings, and for airport takeoffs.

<u>GA Aircraft Subcategory</u>	<u>Landings</u>	<u>Takeoffs</u>
Single-eng. piston	Table 3.45, 2.15 E-5	Table 3.45, 1.25 E-5
Multi-eng. piston	Table 3.46, 2.46 E-5	Table 3.46, 1.06 E-5
Turboprop	Table 3.47, 8.65 E-6	Table 3.47, 4.67 E-6
Turbojet	Table 3.48, 5.11 E-6	Table 3.48, 1.85 E-6
Helicopter	Table 3.52, 8.43 E-6	Table 3.52, 6.17 E-6

Crash location probability for General Aviation at 5-6 miles from the runway on the runway centerline while on approach was found to be 4.0 E-3 from Table 3.55. The crash location probability for General Aviation at 5-6 miles from the runway on the runway centerline while on departure was found to be 4.5 E-4 from Table 3.54.

The aircraft crash hit frequencies for General Aviation operations from the Livermore Municipal Airport for the 1995 Fiscal Year are:

$$F = N * P * f(x,y) * A_t$$

For landings

Single-Engine Piston	F =	27065 * (2.15 E-5) * (4.0 E-3) * (5.6 E-4) = 1.30 E-6/yr.
Multi-Engine Piston	F =	2705 * (2.46 E-5) * (4.0 E-3) * (5.6 E-4) = 1.49 E-7/yr.
Turboprop	F =	930 * (8.65 E-6) * (4.0 E-3) * (5.6 E-4) = 1.80 E-8/yr.
Turbojet	F =	558 * (5.11 E-6) * (4.0 E-3) * (5.6 E-4) = 6.38 E-9/yr.
Helicopters	F =	8404 * (8.43 E-6) * (4.0 E-3) * (5.6 E-4) = 1.59 E-7/yr.

For takeoffs

Single-Engine Piston	F =	27065 * (1.25 E-5) * (4.5 E-3) * (5.6 E-4) = 8.52 E-7/yr.
Multi-Engine Piston	F =	2705 * (1.06 E-5) * (4.5 E-3) * (5.6 E-4) = 7.22 E-8/yr.
Turboprop	F =	930 * (4.67 E-6) * (4.5 E-3) * (5.6 E-4) = 1.09 E-8/yr.
Turbojet	F =	558 * (1.85 E-6) * (4.5 E-3) * (5.6 E-4) = 2.60 E-9/yr.
Helicopters	F =	8404 * (6.17 E-6) * (4.5 E-3) * (5.6 E-4) = 1.31 E-7/yr.

The combined (takeoffs and landings) General Aviation aircraft crash hit frequencies for Fiscal Year 1995 are:

Single-Engine Piston	F =	2.15 E-6/yr.
Multi-Engine Piston	F =	2.21 E-7/yr.
Turboprop	F =	2.89 E-8/yr.
Turbojet	F =	8.98 E-9/yr.
Helicopters	F =	2.89 E-7/yr.

The combined (takeoffs and landings) fixed wing aircraft (summation of single-engine piston, multi-engine piston, turboprop, and turbojet) General Aviation aircraft crash hit frequency for Fiscal Year 1995 is 2.41 E-6/yr.

The combined (takeoffs and landings) total General Aviation aircraft (fixed wing and helicopter) crash hit frequency for Fiscal Year 1995 is 2.70 E-6/yr.

Similarly, the aircraft crash hit frequencies for General Aviation operations from the Livermore Municipal Airport for the Fiscal Year 1993-95 time period are:

For landings

Single-Engine Piston	F =	31304 * (2.15 E-5) * (4.0 E-3) * (5.6 E-4) = 1.51 E-6/yr.
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Multi-Engine Piston	F =	$3129 * (2.46 \text{ E-}5) * (4.0 \text{ E-}3) * (5.6 \text{ E-}4) = 1.72 \text{ E-}7/\text{yr.}$
Turboprop	F =	$1076 * (8.65 \text{ E-}6) * (4.0 \text{ E-}3) * (5.6 \text{ E-}4) = 2.08 \text{ E-}8/\text{yr.}$
Turbojet	F =	$645 * (5.11 \text{ E-}6) * (4.0 \text{ E-}3) * (5.6 \text{ E-}4) = 7.38 \text{ E-}9/\text{yr.}$
Helicopters	F =	$9720 * (8.43 \text{ E-}6) * (4.0 \text{ E-}3) * (5.6 \text{ E-}4) = 1.83 \text{ E-}7/\text{yr.}$

For takeoffs

Single-Engine Piston	F =	$31304 * (1.25 \text{ E-}5) * (4.5 \text{ E-}3) * (5.6 \text{ E-}4) = 9.85 \text{ E-}7/\text{yr.}$
Multi-Engine Piston	F =	$3129 * (1.06 \text{ E-}5) * (4.5 \text{ E-}3) * (5.6 \text{ E-}4) = 8.35 \text{ E-}8/\text{yr.}$
Turboprop	F =	$1076 * (4.67 \text{ E-}6) * (4.5 \text{ E-}3) * (5.6 \text{ E-}4) = 1.27 \text{ E-}8/\text{yr.}$
Turbojet	F =	$645 * (1.85 \text{ E-}6) * (4.5 \text{ E-}3) * (5.6 \text{ E-}4) = 3.01 \text{ E-}9/\text{yr.}$
Helicopters	F =	$9720 * (6.17 \text{ E-}6) * (4.5 \text{ E-}3) * (5.6 \text{ E-}4) = 1.51 \text{ E-}7/\text{yr.}$

The combined (takeoffs and landings) General Aviation aircraft crash hit frequencies for Fiscal Years 1993-95 are:

Single-Engine Piston	F =	$2.49 \text{ E-}6/\text{yr.}$
Multi-Engine Piston	F =	$2.56 \text{ E-}7/\text{yr.}$
Turboprop	F =	$3.35 \text{ E-}8/\text{yr.}$
Turbojet	F =	$1.04 \text{ E-}8/\text{yr.}$
Helicopters	F =	$3.34 \text{ E-}7/\text{yr.}$

The combined (takeoffs and landings) fixed wing aircraft (summation of single-engine piston, multi-engine piston, turboprop, and turbojet) General Aviation aircraft crash hit frequency for Fiscal Years 1993-95 is $2.79 \text{ E-}6/\text{yr.}$

The combined (takeoffs and landings) total General Aviation aircraft (fixed wing and helicopter) crash hit frequency for Fiscal Years 1993-95 is $3.13 \text{ E-}6/\text{yr.}$

The aircraft crash hit frequencies for General Aviation operations from the Livermore Municipal Airport for the Fiscal Year 1991-95 time period are:

For landings

Single-Engine Piston	F =	$32109 * (2.15 \text{ E-}5) * (4.0 \text{ E-}3) * (5.6 \text{ E-}4) = 1.55 \text{ E-}6/\text{yr.}$
Multi-Engine Piston	F =	$3210 * (2.46 \text{ E-}5) * (4.0 \text{ E-}3) * (5.6 \text{ E-}4) = 1.77 \text{ E-}7/\text{yr.}$
Turboprop	F =	$1104 * (8.65 \text{ E-}6) * (4.0 \text{ E-}3) * (5.6 \text{ E-}4) = 2.14 \text{ E-}8/\text{yr.}$
Turbojet	F =	$662 * (5.11 \text{ E-}6) * (4.0 \text{ E-}3) * (5.6 \text{ E-}4) = 7.57 \text{ E-}9/\text{yr.}$
Helicopters	F =	$9970 * (8.43 \text{ E-}6) * (4.0 \text{ E-}3) * (5.6 \text{ E-}4) = 1.88 \text{ E-}7/\text{yr.}$

For takeoffs

Single-Engine Piston	F =	$32109 * (1.25 \text{ E-}5) * (4.5 \text{ E-}3) * (5.6 \text{ E-}4) = 1.01 \text{ E-}6/\text{yr.}$
Multi-Engine Piston	F =	$3210 * (1.06 \text{ E-}5) * (4.5 \text{ E-}3) * (5.6 \text{ E-}4) = 8.57 \text{ E-}8/\text{yr.}$
Turboprop	F =	$1104 * (4.67 \text{ E-}6) * (4.5 \text{ E-}3) * (5.6 \text{ E-}4) = 1.30 \text{ E-}8/\text{yr.}$
Turbojet	F =	$662 * (1.85 \text{ E-}6) * (4.5 \text{ E-}3) * (5.6 \text{ E-}4) = 3.08 \text{ E-}9/\text{yr.}$
Helicopters	F =	$9970 * (6.17 \text{ E-}6) * (4.5 \text{ E-}3) * (5.6 \text{ E-}4) = 1.55 \text{ E-}7/\text{yr.}$

The combined (takeoffs and landings) General Aviation aircraft crash hit frequencies for Fiscal Years 1991-95 are:

Single-Engine Piston	F =	$2.56 \text{ E-}6/\text{yr.}$
Multi-Engine Piston	F =	$2.62 \text{ E-}7/\text{yr.}$
Turboprop	F =	$3.43 \text{ E-}8/\text{yr.}$
Turbojet	F =	$1.07 \text{ E-}8/\text{yr.}$
Helicopters	F =	$3.43 \text{ E-}7/\text{yr.}$

The combined (takeoffs and landings) fixed wing aircraft (summation of single-engine piston, multi-engine piston, turboprop, and turbojet) General Aviation aircraft crash hit frequency for Fiscal Years 1991-95 is 2.86 E-6/yr.

The combined (takeoffs and landings) total General Aviation aircraft (fixed wing and helicopter) crash hit frequency for Fiscal Years 1991-95 is 3.21 E-6/yr.

The aircraft crash hit frequencies for General Aviation operations from the Livermore Municipal Airport for the 1986-95 time period are:

For landings

Single-Engine Piston	F =	$32089 * (2.15 \text{ E-}5) * (4.0 \text{ E-}3) * (5.6 \text{ E-}4) = 1.54 \text{ E-}6/\text{yr.}$
Multi-Engine Piston	F =	$3208 * (2.46 \text{ E-}5) * (4.0 \text{ E-}3) * (5.6 \text{ E-}4) = 1.77 \text{ E-}7/\text{yr.}$
Turboprop	F =	$1103 * (8.65 \text{ E-}6) * (4.0 \text{ E-}3) * (5.6 \text{ E-}4) = 2.14 \text{ E-}8/\text{yr.}$
Turbojet	F =	$662 * (5.11 \text{ E-}6) * (4.0 \text{ E-}3) * (5.6 \text{ E-}4) = 7.57 \text{ E-}9/\text{yr.}$
Helicopters	F =	$9964 * (8.43 \text{ E-}6) * (4.0 \text{ E-}3) * (5.6 \text{ E-}4) = 1.88 \text{ E-}7/\text{yr.}$

For takeoffs

Single-Engine Piston	F =	$32089 * (1.25 \text{ E-}5) * (4.5 \text{ E-}3) * (5.6 \text{ E-}4) = 1.01 \text{ E-}6/\text{yr.}$
Multi-Engine Piston	F =	$3208 * (1.06 \text{ E-}5) * (4.5 \text{ E-}3) * (5.6 \text{ E-}4) = 8.56 \text{ E-}8/\text{yr.}$
Turboprop	F =	$1103 * (4.67 \text{ E-}6) * (4.5 \text{ E-}3) * (5.6 \text{ E-}4) = 1.30 \text{ E-}8/\text{yr.}$
Turbojet	F =	$662 * (1.85 \text{ E-}6) * (4.5 \text{ E-}3) * (5.6 \text{ E-}4) = 3.08 \text{ E-}9/\text{yr.}$
Helicopters	F =	$9964 * (6.17 \text{ E-}6) * (4.5 \text{ E-}3) * (5.6 \text{ E-}4) = 1.55 \text{ E-}7/\text{yr.}$

The combined (takeoffs and landings) General Aviation aircraft crash hit frequencies for Fiscal Years 1986-95 are:

Single-Engine Piston	F =	2.55 E-6/yr.
Multi-Engine Piston	F =	2.62 E-7/yr.
Turboprop	F =	3.43 E-8/yr.
Turbojet	F =	1.06 E-8/yr.
Helicopters	F =	3.43 E-7/yr.

The combined (takeoffs and landings) fixed wing aircraft (summation of single-engine piston, multi-engine piston, turboprop, and turbojet) General Aviation aircraft crash hit frequency for Fiscal Years 1986-95 is 2.86 E-6/yr.

The combined (takeoffs and landings) total General Aviation aircraft (fixed wing and helicopter) crash hit frequency for Fiscal Years 1986-95 is 3.20 E-6/yr.

4.5.2 GA Aircraft Crash Hit Frequency from Bay TRACON Aircraft Operations and Oakland ARTCC Aircraft Handled

A SAIC developed computer program called SHARK.EXE [Ref. 4.4] is used to determine the non-airport (in-flight) environment aircraft crash frequency. For the LLNL site, located at 37° 41' North latitude, 121° 42' West longitude, SHARK.EXE determines that the non-airport aircraft crash frequency is 1.33 E-4/mi.² for GA fixed wing aircraft, and 3.11 E-5/mi.² for GA helicopters. Multiplying by the MMA facilities target area of 5.6 E-4 mi.² gives an aircraft crash frequency for nonairport GA aircraft operations of 7.44 E-8/yr. for GA fixed wing aircraft and 1.74 E-8/yr. for GA helicopters.

4.5.3 GA Crash Hit Frequency. Total for All Flight Environments

The total General Aviation Aircraft Crash Hit Frequency for all flight environments is the sum of the General Aviation aircraft crash hit frequency due to airport operations and nonairport operations (TRACON and ARTCC). The SHARK.EXE code calculates aircraft crash frequency for fixed wing

aircraft and helicopters separately, so the total General Aviation Aircraft Crash Hit Frequency is the sum of the aircraft crash hit frequencies for fixed wing aircraft and helicopters summed over the airport and nonairport flight environments.

$$F_{\text{total}} = [F_{\text{fixed wing/airport}} + F_{\text{fixed wing/nonairport}}] + [F_{\text{helicopter/airport}} + F_{\text{helicopter/nonairport}}]$$

For the 1995 Fiscal Year, the total aircraft crash hit frequency for General Aviation in all flight environments is:

$$F_{\text{total}} = [(2.41 \text{ E-6}) + (7.44 \text{ E-8})] + [(2.89 \text{ E-7}) + (1.74 \text{ E-8})] = 2.79 \text{ E-6/yr.}$$

Similarly, for 1993-95, $F_{\text{total}} = [(2.79 \text{ E-6}) + (7.44 \text{ E-8})] + [(3.34 \text{ E-7}) + (1.74 \text{ E-8})] = 3.22 \text{ E-6/yr.}$

For 1991-95, $F_{\text{total}} = [(2.86 \text{ E-6}) + (7.44 \text{ E-8})] + [(3.43 \text{ E-7}) + (1.74 \text{ E-8})] = 3.30 \text{ E-6/yr.}$

For 1986-95, $F_{\text{total}} = [(2.86 \text{ E-6}) + (7.44 \text{ E-8})] + [(3.43 \text{ E-7}) + (1.74 \text{ E-8})] = 3.30 \text{ E-6/yr.}$

4.6 MMA FACILITIES MILITARY AVIATION (MA) AIRCRAFT CRASH HIT FREQUENCY ESTIMATE

4.6.1 MA Aircraft Crash Hit Frequency from Livermore Municipal Airport Operations

From Table 2.1, there were 434 Military Aviation itinerant operations for Fiscal Year 1995 at the Livermore Municipal Airport of which 217 were landings and 217 were takeoffs. For Fiscal Years 1993-95, there were an average of 598 MA itinerant operations per year at Livermore of which 299 were landings, and 299 were takeoffs. For Fiscal Years 1991-95, there were an average of 624 MA itinerant operations at Livermore of which 312 were landings, and 312 were takeoffs. For Fiscal years 1986-95, there were an average of 522 MA itinerant operations at Livermore of which 261 were landings, and 261 were takeoffs. All Military Aviation itinerant takeoff operations were assumed to the East towards LLNL, and all Military Aviation itinerant landing operations were assumed to the West approaching over LLNL.

The crash rate for small military aircraft operations at the Livermore Municipal Airport was taken from Table 3.53, General Aviation Total Powered Aircraft Crash Rates by Flight Phase. The reason for using General Aviation crash rates for small Military Aviation aircraft operations is that the length of the longest runway (7Left/25Right, 5255 ft.) and the lack of suitable ground facilities at the Livermore Municipal Airport precludes operation of small high performance military aircraft except under special circumstances. Small military aircraft which would use the Livermore Municipal Airport would tend to be similar to General Aviation aircraft. A crash rate of 1.92 E-5/landing is used for small military aircraft during landings. A crash rate during takeoffs of 1.10 E-5/takeoff is used for small military aircraft during takeoffs.

The crash location probability for General Aviation was used for Military Aviation again because of the similarity of Military Aviation aircraft operations and General Aviation aircraft operations at the Livermore Municipal Airport. From Table 3.55, the crash location probability for Military Aviation at 5-6 miles from the runway on the runway centerline while on approach was found to be 4.0 E-3. From Table 3.54, the crash location probability for Military Aviation at 5-6 miles from the runway on the runway centerline while on departure was found to be 4.5 E-3.

The aircraft crash hit frequency for Military Aviation aircraft operations from the Livermore Municipal Airport for the 1995 Fiscal Year is:

$$F = N * P * f(x,y) * A_t$$

$$\begin{aligned} F &= (217) * (1.92 \text{ E-}5) * (4.0 \text{ E-}3) * (5.6 \text{ E-}4) \text{ for landing} \\ &= 9.33 \text{ E-}9/\text{yr.} \end{aligned}$$

$$\begin{aligned} F &= (217) * (1.10 \text{ E-}5) * (4.5 \text{ E-}3) * (5.6 \text{ E-}4) \text{ for takeoff} \\ &= 6.01 \text{ E-}9/\text{yr.} \end{aligned}$$

The total aircraft crash hit frequency, F, due to Military Aviation aircraft operations from the Livermore Municipal Airport for the 1995 Fiscal Year is 1.53 E-8/yr.

Similarly, for the Fiscal Year 1993-95 time period:

$$\begin{aligned} F &= (299) * (1.92 \text{ E-}5) * (4.0 \text{ E-}3) * (5.6 \text{ E-}4) \text{ for landing} \\ &= 1.28 \text{ E-}8/\text{yr.} \end{aligned}$$

$$\begin{aligned} F &= (299) * (1.10 \text{ E-}5) * (4.5 \text{ E-}3) * (5.6 \text{ E-}4) \text{ for takeoff} \\ &= 8.28 \text{ E-}9/\text{yr.} \end{aligned}$$

The total aircraft crash hit frequency, F, due to Military Aviation aircraft operations from the Livermore Municipal Airport for Fiscal Years 1993-95 is 2.11 E-8/yr.

For the Fiscal Year 1991-95 time period:

$$\begin{aligned} F &= (312) * (1.92 \text{ E-5}) * (4.0 \text{ E-3}) * (5.6 \text{ E-4}) \text{ for landing} \\ &= 1.34 \text{ E-8/yr.} \end{aligned}$$

$$\begin{aligned} F &= (312) * (1.10 \text{ E-5}) * (4.5 \text{ E-3}) * (5.6 \text{ E-4}) \text{ for takeoff} \\ &= 8.64 \text{ E-9/yr.} \end{aligned}$$

The total aircraft crash hit frequency, F, due to Military Aviation aircraft operations from the Livermore Municipal Airport for Fiscal Years 1991-95 is 2.21 E-8/yr.

For the Fiscal year 1986-95 time period:

$$\begin{aligned} F &= (261) * (1.92 \text{ E-5}) * (4.0 \text{ E-3}) * (5.6 \text{ E-4}) \text{ for landing} \\ &= 1.12 \text{ E-8/yr.} \end{aligned}$$

$$\begin{aligned} F &= (261) * (1.10 \text{ E-5}) * (4.5 \text{ E-3}) * (5.6 \text{ E-4}) \text{ for takeoff} \\ &= 7.23 \text{ E-9/yr.} \end{aligned}$$

The total aircraft crash hit frequency, F, due to Military Aviation aircraft operations from the Livermore Municipal Airport for Fiscal Years 1986-95 is 1.84 E-8/yr.

4.6.2 MA Aircraft Crash Hit Frequency from Bay TRACON Aircraft Operations

From Table 2.2, it was found that for Fiscal Year 1995, a total of 22,255 Military Aviation instrument operations were performed by the Bay TRACON. Since no military air units are assigned at the Oakland International Airport and the San Francisco International Airport, a survey of the Military Aviation airport operations at OAK and SFO is not done. Assuming 75% of the FY1995 total are MA approaches and departures from the Southeast, East, and Northeast yields 16,691 of which half or 8,346 are approaches over Livermore, and half or 8,346 are departures over Livermore. Because of the recent shutdown of the Moffet Naval Air Station (NAS) (which formerly based patrol squadrons for the U.S. Navy) and the Alameda NAS (which formerly based carrier air wings for the U.S. Navy), and Fort Ord, the number of large military aircraft, small high performance aircraft and military helicopters which were handled by the Bay TRACON in 1995 has been reduced. Therefore, 30% of the total military instrument operations performed by the Bay TRACON were assumed to be small low performance military aircraft, 30% were assumed to be small high performance military aircraft, 30% were assumed to be large military aircraft, and 10% were assumed to be military helicopters.

Similarly, for the Fiscal Year 1993-95 time period, from Tables 2.2, 10,698 MA approaches and 10,698 MA departures were performed over Livermore per year. During this time period, Moffet NAS, Alameda NAS and Ford Ord were in the process of closing. Therefore, 10% of the total military instrument operations performed by the Bay TRACON were assumed to be small low performance military aircraft, 40% were assumed to be small high performance military aircraft, 30% were assumed to be large military aircraft, and 20% were military helicopters.

For the Fiscal Year 1991-95 time period, from Tables 2.2, 12,264 MA approaches and 12,264 MA departures were performed over Livermore per year. The distribution of military aircraft subcategories was assumed to be similar as for the 1993-95 time period.

For the Fiscal year 1986-95 time period, from Tables 2.2, 21,265 MA approaches and 21,265 MA departures were performed over Livermore per year. The distribution of military aircraft subcategories was assumed to be similar as for the 1993-95 time period.

The crash rates for Military Aviation were calculated from data taken from Table 3.56. The crash rates are calculated in Section 3.5.1. The crash rates for small low performance military aircraft are 9.95 E-8/mile for landing, and 3.32 E-8/mile for takeoff. The crash rates for small high performance military aircraft are 1.66 E-7/mile for landing, and 9.43 E-8/mile for takeoff. The crash rates for large military aircraft are 8.51 E-8/mile for landing, and 3.15 E-8/mile for takeoff. The crash rates for military helicopter are 1.43 E-7/mile for land, and 4.28 E-8/mile for takeoff. Again, a distance of 20 statute miles was assumed for the distance traveled on each approach and departure.

The radius of the potential area affected by a distressed aircraft, R_p , was set equal to glide ratio of the aircraft, g , times the height of aircraft when the initiating event occurred. For the Madwin3 arrival approach procedure for the San Francisco Bay area [Ref. 4.2], the assigned altitude is no greater than 11,000 feet. A glide ratio of 15 was assume to be the maximum glide ratio for Military Aviation aircraft [Ref. 4.3] so, R_p is $15 \times 11,000$ feet or 165,000 feet or 31.25 miles.

The aircraft crash hit frequencies for Military Aviation aircraft operations in the Bay TRACON flight environment for the 1995 Fiscal Year are:

$$F = N * CR * (4/\pi^2) * (1/R_p) * A_t$$

For landing approaches

$$\text{Small, low perf. AC} \quad F = 2504 * (9.95 \text{ E-8}) * (4/\pi^2) * (1/31.25) * (0.00056) = 1.81 \text{ E-9/yr.}$$

$$\text{Small, high perf. AC} \quad F = 2504 * (1.66 \text{ E-7}) * (4/\pi^2) * (1/31.25) * (0.00056) = 3.02 \text{ E-9/yr.}$$

$$\text{Large AC} \quad F = 2504 * (8.51 \text{ E-8}) * (4/\pi^2) * (1/31.25) * (0.00056) = 1.55 \text{ E-9/yr.}$$

$$\text{Helicopter} \quad F = 835 * (1.43 \text{ E-7}) * (4/\pi^2) * (1/31.25) * (0.00056) = 8.66 \text{ E-10/yr.}$$

The total military aircraft crash hit frequency for landing approaches for 1995 is 7.24 E-9/yr.

For departures

$$\text{Small, low perf. AC} \quad F = 2504 * (3.32 \text{ E-8}) * (4/\pi^2) * (1/31.25) * (0.00056) = 6.03 \text{ E-10/yr.}$$

$$\text{Small, high perf. AC} \quad F = 2504 * (9.43 \text{ E-8}) * (4/\pi^2) * (1/31.25) * (0.00056) = 1.71 \text{ E-9/yr.}$$

$$\text{Large AC} \quad F = 2504 * (3.15 \text{ E-8}) * (4/\pi^2) * (1/31.25) * (0.00056) = 5.72 \text{ E-10/yr.}$$

$$\text{Helicopter} \quad F = 835 * (4.28 \text{ E-8}) * (4/\pi^2) * (1/31.25) * (0.00056) = 2.59 \text{ E-10/yr.}$$

The total military aircraft crash hit frequency for departures for 1995 is 3.15 E-9/yr.

The total military aircraft crash hit frequency for 1995 is 1.04 E-8/yr.

The aircraft crash hit frequencies for Military Aviation aircraft operations in the Bay TRACON flight environment for the 1993-95 Fiscal Years are:

$$F = N * CR * (4/\pi^2) * (1/R_p) * A_t$$

For landing approaches

$$\text{Small, low perf. AC} \quad F = 1070 * (9.95 \text{ E-8}) * (4/\pi^2) * (1/31.25) * (0.00056) = 7.73 \text{ E-10/yr.}$$

Small, high perf. AC	F=	$4279 * (1.66 \text{ E-}7) * (4/\pi^2) * (1/31.25) * (0.00056) = 5.16 \text{ E-}9/\text{yr.}$
Large AC	F=	$3210 * (8.51 \text{ E-}8) * (4/\pi^2) * (1/31.25) * (0.00056) = 1.98 \text{ E-}9/\text{yr.}$
Helicopter	F=	$2140 * (1.43 \text{ E-}7) * (4/\pi^2) * (1/31.25) * (0.00056) = 2.22 \text{ E-}9/\text{yr.}$

The total military aircraft crash hit frequency for landing approaches for 1993-95 is 1.01 E-8/yr.

For departures

Small, low perf. AC	F=	$1070 * (3.32 \text{ E-}8) * (4/\pi^2) * (1/31.25) * (0.00056) = 2.58 \text{ E-}10/\text{yr.}$
Small, high perf. AC	F=	$4279 * (9.43 \text{ E-}8) * (4/\pi^2) * (1/31.25) * (0.00056) = 2.93 \text{ E-}9/\text{yr.}$
Large AC	F=	$3210 * (3.15 \text{ E-}8) * (4/\pi^2) * (1/31.25) * (0.00056) = 7.34 \text{ E-}10/\text{yr.}$
Helicopter	F=	$2140 * (4.28 \text{ E-}8) * (4/\pi^2) * (1/31.25) * (0.00056) = 6.65 \text{ E-}10/\text{yr.}$

The total military aircraft crash hit frequency for departures for 1993-95 is 4.58 E-9/yr.

The total military aircraft crash hit frequency for 1993-95 is 1.47 E-8/yr.

The aircraft crash hit frequencies for Military Aviation aircraft operations in the Bay TRACON flight environment for the 1991-95 Fiscal Years are:

$$F = N * CR * (4/\pi^2) * (1/R_p) * A_t$$

For landing approaches

Small, low perf. AC	F=	$1226 * (9.95 \text{ E-}8) * (4/\pi^2) * (1/31.25) * (0.00056) = 8.86 \text{ E-}10/\text{yr.}$
Small, high perf. AC	F=	$4906 * (1.66 \text{ E-}7) * (4/\pi^2) * (1/31.25) * (0.00056) = 5.91 \text{ E-}9/\text{yr.}$
Large AC	F=	$3679 * (8.51 \text{ E-}8) * (4/\pi^2) * (1/31.25) * (0.00056) = 2.27 \text{ E-}9/\text{yr.}$
Helicopter	F=	$2453 * (1.43 \text{ E-}7) * (4/\pi^2) * (1/31.25) * (0.00056) = 2.55 \text{ E-}9/\text{yr.}$

The total military aircraft crash hit frequency for landing approaches for 1991-95 is 1.16 E-8/yr.

For departures

Small, low perf. AC	F=	$1226 * (3.32 \text{ E-}8) * (4/\pi^2) * (1/31.25) * (0.00056) = 2.95 \text{ E-}10/\text{yr.}$
Small, high perf. AC	F=	$4906 * (9.43 \text{ E-}8) * (4/\pi^2) * (1/31.25) * (0.00056) = 3.36 \text{ E-}9/\text{yr.}$
Large AC	F=	$3679 * (3.15 \text{ E-}8) * (4/\pi^2) * (1/31.25) * (0.00056) = 8.41 \text{ E-}10/\text{yr.}$
Helicopter	F=	$2453 * (4.28 \text{ E-}8) * (4/\pi^2) * (1/31.25) * (0.00056) = 7.62 \text{ E-}10/\text{yr.}$

The total military aircraft crash hit frequency for departures for 1991-95 is 5.26 E-9/yr.

The total military aircraft crash hit frequency for 1991-95 is 1.69 E-8/yr.

The aircraft crash hit frequencies for Military Aviation aircraft operations in the Bay TRACON flight environment for the 1986-95 Fiscal Years are:

$$F = N * CR * (4/\pi^2) * (1/R_p) * A_t$$

For landing approaches

Small, low perf. AC	F=	$2127 * (9.95 \text{ E-}8) * (4/\pi^2) * (1/31.25) * (0.00056) = 1.54 \text{ E-}9/\text{yr.}$
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Small, high perf. AC	F=	$8506 * (1.66 \text{ E-}7) * (4/\pi^2) * (1/31.25) * (0.00056) = 1.02 \text{ E-}8/\text{yr.}$
Large AC	F=	$6380 * (8.51 \text{ E-}8) * (4/\pi^2) * (1/31.25) * (0.00056) = 3.94 \text{ E-}9/\text{yr.}$
Helicopter	F=	$4253 * (1.43 \text{ E-}7) * (4/\pi^2) * (1/31.25) * (0.00056) = 4.41 \text{ E-}9/\text{yr.}$

The total military aircraft crash hit frequency for landing approaches for 1986-95 is 2.01 E-8/yr.

For departures

Small, low perf. AC	F=	$2127 * (3.32 \text{ E-}8) * (4/\pi^2) * (1/31.25) * (0.00056) = 5.12 \text{ E-}10/\text{yr.}$
Small, high perf. AC	F=	$8506 * (9.43 \text{ E-}8) * (4/\pi^2) * (1/31.25) * (0.00056) = 5.82 \text{ E-}9/\text{yr.}$
Large AC	F=	$6380 * (3.15 \text{ E-}8) * (4/\pi^2) * (1/31.25) * (0.00056) = 1.46 \text{ E-}9/\text{yr.}$
Helicopter	F=	$4253 * (4.28 \text{ E-}8) * (4/\pi^2) * (1/31.25) * (0.00056) = 1.32 \text{ E-}9/\text{yr.}$

The total military aircraft crash hit frequency for departures for 1986-95 is 9.11 E-9/yr.

The total military aircraft crash hit frequency for 1986-95 is 2.92 E-8/yr.

4.6.3 MA Aircraft Crash Hit Frequency from Oakland ARTCC Aircraft Handled

From Table 2.7, 195,476 Military Aviation IFR aircraft were handled by the Oakland ARTCC in Fiscal Year 1995. For the Fiscal Year 1993-95 time period, an average of 207,251 MA aircraft were handled per year by the Oakland ARTCC. For the Fiscal Year 1991-95 time period, an average of 273,821 MA aircraft were handled per year by the Oakland ARTCC. For the Fiscal Year 1986-95 time period, an average of 322,092 MA aircraft were handled per year by the Oakland ARTCC. The distribution of high altitude overflights by military aircraft were assumed to be 5% small low performance military aircraft, 55% small high performance military aircraft, and 40% large military aircraft. It is also assumed that few, if any military helicopters are able to operate in ARTCC airspace.

From Ref. 5.5 and Table 3.56, the crash rate for small military aircraft was 4.36 E-6/aircraft handled based on 105 accidents and 24,102,000 sorties for the 1976-93 time period. The crash rate for large military aircraft was 1.23 E-6/aircraft handled based on 9 accidents and 7,289,000 sorties for the 1976-93 time period. The crash rates for military aircraft in ARTCC airspace are expected to be conservatively high because all military aircraft accidents during the 1976-93 time period were included, not just those accidents which occurred while in ARTCC airspace.

The area of the airspace controlled by the Oakland ARTCC has been determined in Ref. 4.4 to be 100,478 mile².

The aircraft crash hit frequencies for Military Aviation aircraft operations in the Oakland ARTCC flight environment for the 1995 Fiscal Year are:

$$F = N_c * P_c * (1/A_c) * A_t$$

Small, low perf. AC	F=	$9774 * (4.36 \text{ E-}6) * (1/100478) * (0.00056) = 2.37 \text{ E-}10/\text{yr.}$
Small, high perf. AC	F=	$107512 * (4.36 \text{ E-}6) * (1/100478) * (0.00056) = 2.61 \text{ E-}9/\text{yr.}$
Large AC	F=	$78190 * (1.23 \text{ E-}6) * (1/100478) * (0.00056) = 5.38 \text{ E-}10/\text{yr.}$

The total military aircraft crash hit frequency for 1995 is 3.38 E-9/yr.

The aircraft crash hit frequencies for Military Aviation aircraft operations in the Oakland ARTCC flight environment for the 1993-95 Fiscal Years are:

$$F = N_c * P_c * (1/A_c) * A_t$$

Small, low perf. AC	F=	10363 * (4.36 E-6) * (1/100478) * (0.00056) = 2.51 E-10/yr.
Small, high perf. AC	F=	113988 * (4.36 E-6) * (1/100478) * (0.00056) = 2.77 E-9/yr.
Large AC	F=	82900 * (1.23 E-6) * (1/100478) * (0.00056) = 5.70 E-10/yr.

The total military aircraft crash hit frequency for 1993-95 is 3.59 E-9/yr.

The aircraft crash hit frequencies for Military Aviation aircraft operations in the Oakland ARTCC flight environment for the 1991-95 Fiscal Years are:

$$F = N_c * P_c * (1/A_c) * A_t$$

Small, low perf. AC	F=	13691 * (4.36 E-6) * (1/100478) * (0.00056) = 3.32 E-10/yr.
Small, high perf. AC	F=	150602 * (4.36 E-6) * (1/100478) * (0.00056) = 3.65 E-9/yr.
Large AC	F=	109528 * (1.23 E-6) * (1/100478) * (0.00056) = 7.53 E-10/yr.

The total military aircraft crash hit frequency for 1991-95 is 4.74 E-9/yr.

The aircraft crash hit frequencies for Military Aviation aircraft operations in the Oakland ARTCC flight environment for the 1986-95 Fiscal Years are:

$$F = N_c * P_c * (1/A_c) * A_t$$

Small, low perf. AC	F=	16105 * (4.36 E-6) * (1/100478) * (0.00056) = 3.91 E-10/yr.
Small, high perf. AC	F=	177151 * (4.36 E-6) * (1/100478) * (0.00056) = 4.30 E-9/yr.
Large AC	F=	128837 * (1.23 E-6) * (1/100478) * (0.00056) = 8.86 E-10/yr.

The total military aircraft crash hit frequency for 1986-95 is 5.57 E-9/yr.

4.6.4 MA Crash Hit Frequency, Total for All Flight Environments

The total Military Aviation Crash Hit Frequency for all flight environments is the sum of the Military Aviation aircraft crash hit frequency due to airport operations, TRACON operations, and ARTCC operations.

For the 1995 Fiscal Year, the total aircraft crash hit frequency for Military Aviation in all flight environments is:

$$F_{total} = (1.53 \text{ E-8}) + (1.04 \text{ E-8}) + (3.38 \text{ E-9}) = 2.91 \text{ E-8/yr.}$$

Similarly, for Fiscal Years 1993-95, $F_{total} = (2.11 \text{ E-8}) + (1.47 \text{ E-8}) + (3.59 \text{ E-9}) = 3.94 \text{ E-8/yr.}$

For Fiscal Years 1991-95, $F_{total} = (2.21 \text{ E-8}) + (1.69 \text{ E-8}) + (4.74 \text{ E-9}) = 4.37 \text{ E-8/yr.}$

For Fiscal Years 1986-95, $F_{total} = (1.84 \text{ E-8}) + (2.92 \text{ E-8}) + (5.57 \text{ E-9}) = 5.33 \text{ E-8/yr.}$

4.7 MMA FACILITIES TOTAL AIRCRAFT CRASH HIT FREQUENCY ESTIMATE

The total aircraft crash hit frequencies for the MMA facilities due to all aircraft operations in all flight environments is the sum of the aircraft crash hit frequencies for Air Carriers, Air Taxis, General Aviation and Military Aviation. The results for Fiscal Year 1995, Fiscal Years 1993-95, 1991-95 and 1986-95 are presented below.

	AIR CARRIERS	AIR TAXIS	GENERAL AVIATION	MILITARY AVIATION	TOTAL
1995	3.78 E-9/yr. Sec. 4.3.4	1.66 E-7/yr. Sec. 4.4.4	2.79 E-6/yr. Sec. 4.5.3	2.91 E-8/yr. Sec. 4.6.4	2.99 E-6/yr.
1993-95 Average	3.52 E-9/yr. Sec. 4.3.4	1.80 E-7/yr. Sec. 4.4.4	3.22 E-6/yr. Sec. 4.5.3	3.94 E-8/yr. Sec. 4.6.4	3.44 E-6/yr.
1991-95 Average	3.46 E-9/yr. Sec. 4.3.4	1.77 E-7/yr. Sec. 4.4.4	3.30 E-6/yr. Sec. 4.5.3	4.37 E-8/yr. Sec. 4.6.4	3.52 E-6/yr.
1986-95 Average	3.34 E-9/yr. Sec. 4.3.4	1.66 E-7/yr. Sec. 4.4.4	3.30 E-6/yr. Sec. 4.5.3	5.33 E-8/yr. Sec. 4.6.4	3.52 E-6/yr.

As can be seen by the numbers presented above, the aircraft crash hit frequency for the MMA facilities is dominated by General Aviation, constituting about 94% of the total frequency. Air Taxis represent the next most important component of the aircraft crash hit frequency for the MMA facilities, constituting about 5% of the total frequency. Air Carriers and Military Aviation constitute only a minor part of the total frequency. In terms of the flight environment, about 91% of the total aircraft crash hit frequency is due to aircraft operations at the Livermore Municipal Airport. The Bay TRACON aircraft operations represent about 5% of the total frequency. The Oakland ARTCC aircraft operations represent about 3% of the total aircraft crash hit frequency.

Figure 4.1

Layout of LLNL Site 200 Showing Location of MMA Facilities

Figure 4.2
Layout of MMA Facilities

Figure 4.3

MMA Facilities as Modeled for Aircraft Crash Hit Analysis

4.8 REFERENCES

- [4.1] Safety Analysis Report for Building 231 Vault, and Building 233 Vault and Building 232 Fenced Compound, UCRL-AR-118884, Engineering Directorate, Lawrence Livermore National Laboratory, Livermore, CA, Rev. 0, December 1996.
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- [4.3] Quest for Performance, the Evolution of Modern Aircraft, NASA SP-468, Laurence K. Loftin, Jr., National Aeronautics and Space Administration, Scientific and Technical Information Branch, Washington, DC, 1985.
- [4.4] Data Development Technical Support Document for the Aircraft Crash Risk Analysis Methodology (ACRAM) Standard, UCRL-ID-124837, Rev. 1, Chris Y. Kimura, Ronald E. Glaser, Richard W. Mensing, Tom Lin, Timothy A. Haley, Andrew B. Barto, and Martin A. Stutzke, Lawrence Livermore National Laboratory, Livermore, CA, September 26, 1996.

Appendix to Section 4

A4.1 MMA Facilities Aircraft Crash Hit Frequency Calculation Spreadsheet

AIR CARRIERS

Livermore Municipal Airport (LVK) ATCT

Operations, N		Crash Rate, CR	Crash Location	Facility Area, At mi.^2	Facility Crash Hit Frequency
1995	0	/Landing 3.85E-07	1.72E-02	0.00056	0
	0	/Takeoff 2.86E-07	3.95E-03	0.00056	0
1993-95 Average	0	/Landing 3.85E-07	1.72E-02	0.00056	0
	0	/Takeoff 2.86E-07	3.95E-03	0.00056	0
1991-95 Average	0	/Landing 3.85E-07	1.72E-02	0.00056	0
	0	/Takeoff 2.86E-07	3.95E-03	0.00056	0
1986-95 Average	0.1	/Landing 3.85E-07	1.72E-02	0.00056	3.51E-13
	0.1	/Takeoff 2.86E-07	3.95E-03	0.00056	6.32E-14
				Total:	4.15E-13

Bay TRACON (O90)

$$FP = N \cdot CR \cdot (4/\pi^2) \cdot (1/Rp) \cdot At$$

IFR Aircraft OAK Inst. SFO Inst. OAK+SFO					Crash Rate, CR			Facility Area, At	Facility Crash Hit
Handled	Operations	Operations	Inst. Ops.		(/mi.)	(4/pi^2)	(1/Rp)	mi.^2	Frequency
1995	501,978	164,384	299,444	463,828					
-Intr'l Air Carrier Flights (assume 5% of total)				440,837	No. of Approaches				
Assume 75% of flts app. & dep. from SE, E, NE				330,477	165,239	2.06E-09	0.4052847	0.032	0.00056
					No. of Departures				
					165,239	5.50E-10	0.4052847	0.032	0.00056
									6.80E-10
									3.13E-09
									Total:
93-95 Avg.	476,782	139,020	291,530	430,550					
-Intr'l Air Carrier Flights (assume 5% of total)				409,023	No. of Approaches				
Assume 75% of flts app. & dep. from SE, E, NE				306,767	153,383	2.06E-09	0.4052847	0.032	0.00056
					No. of Departures				
					153,383	5.50E-10	0.4052847	0.032	0.00056
									6.13E-10
									2.91E-09
									Total:
91-95 Avg.	473,854	128,841	296,301	422,942					
-Intr'l Air Carrier Flights (assume 5% of total)				401,795	No. of Approaches				
Assume 75% of flts app. & dep. from SE, E, NE				301,346	150,673	2.06E-09	0.4052847	0.032	0.00056
					No. of Departures				
					150,673	5.50E-10	0.4052847	0.032	0.00056
									6.02E-10
									2.86E-09
									Total:
86-95 Avg.	481,715	102,880	306,853	409,533					
-Intr'l Air Carrier Flights (assume 5% of total)				389,056	No. of Approaches				
Assume 75% of flts app. & dep. from SE, E, NE				291,792	145,896	2.06E-09	0.4052847	0.032	0.00056
					No. of Departures				
					145,896	5.50E-10	0.4052847	0.032	0.00056
									5.83E-10
									2.77E-09
									Total:

NOTES

Table 3.9, Crash rate for 14 CFR 121 flight operations for 1973-1994, accidents with destroyed or major damage to airframe, runway approach flight phase for airport landing operations

Table 3.9, Crash rate for 14 CFR 121 flight operations for 1973-1994, accidents with destroyed or major damage to airframe initial climb flight phase for airport takeoff operations

Table 3.11, Crash location for Air Carriers at 5miles from runway centerline for landings

Table 3.10, Crash location for Air Carriers at 5 miles from runway centerline for takeoffs

Facility Area At determined in General Aviation calculations

NOTES

Table 3.9, Crash rate for 14 CFR 121 flight operations for 1973-1994, accidents with destroyed or major damage to airframe, airport approach flight phase for TRACON operations

Table 3.9, Crash rate for 14 CFR 121 flight operations for 1973-1994, accidents with destroyed or major damage to airframe, climb to cruise flight phase for TRACON operations

Rp = Potential Area radius = g * h
g = glide ratio, for commercial aircraft, assume 15
h = assigned height, for Madwin 3 arrival assume 11000'
Rp = 15 * 11000' = 165000' = 31.25 mi.

Facility Area At determined in General Aviation calculations

Oakland ARTCC (ZOA)
 FP = $N_c \cdot P_c \cdot (1/A_c) \cdot A_t$

IFR Aircraft Handled, Nc		In-Flight Crash Rate (/AC handled)	Oakland ARTCC Area, Ac mi.^2	1/Ac	Facility Area, At mi.^2	Facility Crash Hit Frequency	NOTES
1995	961,986	1.21E-07	100,478	9.952E-06	0.00056	6.51E-10	
1993-95 Average	905,684	1.21E-07	100,478	9.952E-06	0.00056	6.13E-10	
1991-95 Average	886,927	1.21E-07	100,478	9.952E-06	0.00056	6.00E-10	
1986-95 Average	843,660	1.21E-07	100,478	9.952E-06	0.00056	5.71E-10	
							Crash rate for 14 CFR 121 flight operations for 1973-1994 aircraft handled, accidents with destroyed or major damage to airframe, climb to cruise, cruise/enroute, initial descent flight phases combined for ARTCC operations, departures assumed equal to ARTCC aircraft handled,
							Facility Area At determined in General Aviation calculations

TOTAL AIR CARRIER
 Facility Crash Hit Frequency

1995	3.78E-09
1993-95 Average	3.52E-09
1991-95 Average	3.46E-09
1986-95 Average	3.34E-09

AIR TAXIS

Livermore Municipal Airport (LVK) ATCT

All Air Taxi flight operations are itinerant operations.

Itinerant Operations		Itinerant Landings	Crash Rate, CR /Landing	Crash Location /Takeoff	Facility Area, At mi. ²	Facility Crash Hit Frequency
1995	127	64	1.92E-05	4.00E-03	0.00056	2.73E-09
		Takeoffs 64	1.10E-05	4.50E-03	0.00056	1.76E-09
						Total: 4.49E-09
1993-95 Average	292	146	1.92E-05	4.00E-03	0.00056	6.27E-09
		Takeoffs 146	1.10E-05	4.50E-03	0.00056	4.04E-09
						Total: 1.03E-08
1991-95 Average	408	203	1.92E-05	4.00E-03	0.00056	8.72E-09
		Takeoffs 203	1.10E-05	4.50E-03	0.00056	5.62E-09
						Total: 1.43E-08
1986-95 Average	410	205	1.92E-05	4.00E-03	0.00056	6.81E-09
		Takeoffs 205	1.10E-05	4.50E-03	0.00056	5.68E-09
						Total: 1.45E-08

Bay TRACON (O90)

$$FP = N \cdot CR \cdot (4/\pi^2) \cdot (1/R_p) \cdot A_t$$

IFR Aircraft Handled Operations					OAK Inst. Operations	SFO Inst. Operations	OAK+SFO Inst. Ops.	Crash Rate, CR (/mi.)	(4/pi ²)	(1/Rp)	Facility Area, At mi. ²	Facility Crash Hit Frequency
1995	216,973	52,554	96,937	149,491	No. of Approaches	112,118	58,059	9.54E-08	0.4052847	0.0480	0.00056	1.44E-07
Assume 75% of flts app. & dep. from SE, E, NE					No. of Departures		58,059	1.06E-08	0.4052847	0.0480	0.00056	1.60E-08
								Total: 1.60E-07				
93-95 Avg.	205,965	55,344	101,479	156,823	No. of Approaches	117,617	58,809	9.54E-08	0.4052847	0.0480	0.00056	1.51E-07
Assume 75% of flts app. & dep. from SE, E, NE					No. of Departures		58,809	1.06E-08	0.4052847	0.0480	0.00056	1.68E-08
								Total: 1.67E-07				
91-95 Avg.	209,122	53,889	98,651	150,520	No. of Approaches	112,890	58,445	9.54E-08	0.4052847	0.0480	0.00056	1.45E-07
Assume 75% of flts app. & dep. from SE, E, NE					No. of Departures		58,445	1.06E-08	0.4052847	0.0480	0.00056	1.61E-08
								Total: 1.61E-07				
86-95 Avg.	179,939	49,474	90,270	139,744	No. of Approaches	104,808	52,404	9.54E-08	0.4052847	0.0480	0.00056	1.34E-07
Assume 75% of flts app. & dep. from SE, E, NE					No. of Departures		52,404	1.06E-08	0.4052847	0.0480	0.00056	1.49E-08
								Total: 1.49E-07				

NOTES

Table 3.53, Crash rate for 14 CFR 91 flight operations for 1986-1994 General Aviation Total Powered Aircraft, landing approach flight phase for airport landing operations

Table 3.53, Crash rate for 14 CFR 91 flight operations for 1986-1994, General Aviation Total Powered Aircraft, initial climb and climb to cruise flight phases for airport takeoff operations

Table 3.55, Crash Location for General Aviation at 5miles from runway centerline for landings

Table 3.54, Crash Location for Air Carriers at 5 miles from runway centerline for takeoffs

Facility Area At determined in General Aviation calculations

NOTES

Table 3.16, Crash Rate for Scheduled 14 CFR 135 flight operations for 1980-1994, landing approach flight phase used for TRACON landing approach operations

Table 3.16, Crash Rate for Scheduled 14 CFR 135 flight operations for 1980-1994, climb to cruise flight phase used for TRACON departure operations

Rp = Potential Area radius = g * h
g = glide ratio, for nonscheduled 14 CFR 135 aircraft, similar to General Aviation aircraft, assume = 10
h = assigned height, for Madwin 3 arrival assume 11000'
Rp = 10 * 11000' = 110000' = 20.83 mi.

Facility Area At determined in General Aviation calculations

Oakland ARTCC (ZOA)
 FP = $N_c * P_c * (1/A_c) * A_t$

IFR Aircraft Handled		In-Flight Crash Rate (/AC handled)	Oakland ARTCC Area, Ac mi.^2	1/Ac	Facility Area, At mi.^2	Facility Crash Hit Frequency
1996	210,332	1.56E-06	100,478	9.952E-06	0.00056	1.82E-09
1993-95 Average	217,531	1.56E-06	100,478	9.952E-06	0.00056	1.89E-09
1991-95 Average	217,680	1.56E-06	100,478	9.952E-06	0.00056	1.89E-09
1986-95 Average	210,548	1.56E-06	100,478	9.952E-06	0.00056	1.83E-09

NOTES

Table 3.16 Crash Rate for Scheduled 14 CFR 135 flight operations for 1980-1994, climb to cruise, cruise/enroute, initial descent, and flight phases combined for ARTCC operations, landings assumed equal to aircraft handled

Facility Area At determined in General Aviation calculations

**TOTAL AIR TAXI
Facility Crash Hit Frequency**

1996	1.66E-07
1993-95 Average	1.80E-07
1991-95 Average	1.77E-07
1986-95 Average	1.66E-07

GENERAL AVIATION

Livermore Municipal Airport (LVK) ATCT

1995	Airport Operations			Itinerant Landings	Subcategory Operations	Crash Rate /Landing	LLNL Crash Location	Facility Area, At mi.^2	Facility Crash Hit Frequency
	Total	Local	Itinerant						
	225,730	146,406	79,324	39,662					
1-Eng. Piston					27,065	2.15E-05	4.00E-03	0.00056	1.30E-08
Multi-Eng. Piston					2,705	2.46E-05	4.00E-03	0.00056	1.49E-07
Turboprop					930	8.65E-06	4.00E-03	0.00056	1.80E-08
Turbojet					558	5.11E-06	4.00E-03	0.00056	6.38E-09
Helicopter					8,404	8.43E-06	4.00E-03	0.00056	1.59E-07
				Takeoffs 39,662		/Takeoff			
1-Eng. Piston					27,065	1.25E-05	4.50E-03	0.00056	8.52E-07
Multi-Eng. Piston					2,705	1.06E-05	4.50E-03	0.00056	7.22E-08
Turboprop					930	4.67E-06	4.50E-03	0.00056	1.09E-08
Turbojet					558	1.85E-06	4.50E-03	0.00056	2.60E-09
Helicopter					8,404	6.17E-06	4.50E-03	0.00056	1.31E-07
								Total:	2.70E-08

1993-95 Average	Airport Operations			Itinerant Landings	Subcategory Operations	Crash Rate /Landing	LLNL Crash Location	Facility Area, At mi.^2	Facility Crash Hit Frequency
	Total	Local	Itinerant						
	252,192	160,442	91,750	45,875					
1-Eng. Piston					31,304	2.15E-05	4.00E-03	0.00056	1.51E-08
Multi-Eng. Piston					3,129	2.46E-05	4.00E-03	0.00056	1.72E-07
Turboprop					1,076	8.65E-06	4.00E-03	0.00056	2.08E-08
Turbojet					645	5.11E-06	4.00E-03	0.00056	7.38E-09
Helicopter					9,720	8.43E-06	4.00E-03	0.00056	1.83E-07
				Takeoffs 45,875		/Takeoff			
1-Eng. Piston					31,304	1.25E-05	4.50E-03	0.00056	9.65E-07
Multi-Eng. Piston					3,129	1.06E-05	4.50E-03	0.00056	8.35E-08
Turboprop					1,076	4.67E-06	4.50E-03	0.00056	1.27E-08
Turbojet					645	1.85E-06	4.50E-03	0.00056	3.01E-09
Helicopter					9,720	6.17E-06	4.50E-03	0.00056	1.51E-07
								Total:	3.13E-08

1991-95 Average	Airport Operations			Itinerant Landings	Subcategory Operations	Crash Rate /Landing	LLNL Crash Location	Facility Area, At mi.^2	Facility Crash Hit Frequency
	Total	Local	Itinerant						
	246,184	152,076	94,108	47,054					
1-Eng. Piston					32,109	2.15E-05	4.00E-03	0.00056	1.55E-08
Multi-Eng. Piston					3,210	2.46E-05	4.00E-03	0.00056	1.77E-07
Turboprop					1,104	8.65E-06	4.00E-03	0.00056	2.14E-08
Turbojet					662	5.11E-06	4.00E-03	0.00056	7.57E-09
Helicopter					9,970	8.43E-06	4.00E-03	0.00056	1.88E-07
				Takeoffs 47,054		/Takeoff			
1-Eng. Piston					32,109	1.25E-05	4.50E-03	0.00056	1.01E-08
Multi-Eng. Piston					3,210	1.06E-05	4.50E-03	0.00056	8.57E-08
Turboprop					1,104	4.67E-06	4.50E-03	0.00056	1.30E-08
Turbojet					662	1.85E-06	4.50E-03	0.00056	3.08E-09
Helicopter					9,970	6.17E-06	4.50E-03	0.00056	1.55E-07
								Total:	3.21E-08

NOTES

General Aviation Subcategory Distribution Adjustment Calculation

	FAA Region			
	Western-Pacific			
	Total No. of Landings	Pct.	Adjusted No. of Landings	Adjusted Pct.
	(Table 2.5)	(Calculated)	(Calculated)	(Calculated)
1-Eng. Piston	4,260,364	66.14%	4,385,050	68.24%
Multi-Eng. Piston	425,870	6.61%	438,334	6.62%
Turboprop	146,419	2.27%	150,704	2.35%
Turbojet	87,844	1.36%	90,415	1.41%
Helicopter	1,322,882	20.54%	1,361,598	21.19%
Gliders	130,283	2.02%	134,075	
Balloons	68,274	1.06%	70,272	
Subtotal:	6,441,916	100.00%	6,630,448	
Exp./Home Built	122,287			
Exp./Exhibition	17,389			
Exp./Other	48,856			
Subtotal:	188,532			
Total	6,630,448			

Table 3.45, GA Single-Eng. Crash Rate, landing approach flight phase for airport landings
 Table 3.45, GA Single-Eng. Crash Rate, initial climb, climb to cruise flight phases for airport takeoffs
 Table 3.46, GA Multi-Eng. Crash Rate, landing approach flight phase for airport landings
 Table 3.46, GA Multi-Eng. Crash Rate, initial climb, climb to cruise flight phases for airport takeoffs
 Table 3.47, GA Turboprop Crash Rate, landing approach flight phase for airport landings
 Table 3.47, GA Turboprop Crash Rate, initial climb, climb to cruise flight phases for airport takeoffs
 Table 3.48, GA Turbojet Crash Rate, landing approach flight phase for airport landings
 Table 3.48, GA Turbojet Crash Rate, initial climb, climb to cruise flight phases for airport takeoffs
 Table 3.52, GA Helicopter Crash Rate, landing approach flight phase for airport landings
 Table 3.52, GA Helicopter Crash Rate, initial climb, climb to cruise flight phases for airport takeoffs

Table 3.55 Crash Location for GA at 5 miles from runway centerline for landings

Table 3.54 Crash Location for GA at 5 miles from runway centerline for takeoffs

231, 232, 233 Facility Area

L = facility length (ft.) = 260
 W = facility width (ft.) = 60
 H = facility height (ft.) = 20

Because of closeness of adjacent facilities, consider no skid-in area because of shielding
 Skid-In Area = 0

Fly-In Area = (L*W)
 for GA 1-eng. piston (ft.) = 15800.00 0.00056
 for GA multi-eng. piston (ft.) = 15800.00 0.00056
 for GA turboprop (ft.) = 15800.00 0.00056
 for GA turbojet (ft.) = 15800.00 0.00056
 for GA helicopters (ft.) = 15800.00 0.00056

Facility Area = Skid-In Area + Fly-In Area
 for GA 1-eng. piston (ft.) = 15800.00 0.00056
 for GA multi-eng. piston (ft.) = 15800.00 0.00056
 for GA turboprop (ft.) = 15800.00 0.00056
 for GA turbojet (ft.) = 15800.00 0.00056
 for GA helicopters (ft.) = 15800.00 0.00056

Airport Operations				Subcategory	Crash Rate /Landing	LLNL Crash Location	Facility Area, At mi. ²	Facility Crash Hit Frequency
Total	Local	Itinerant	Itinerant Landings					
1986-95	223,288	129,237	94,051	47,026				
Average	1-Eng. Piston			32,069	2.15E-05	4.00E-03	0.00056	1.54E-06
	Multi-Eng. Piston			3,206	2.46E-05	4.00E-03	0.00056	1.77E-07
	Turboprop			1,103	8.65E-06	4.00E-03	0.00056	2.14E-06
	Turbojet			662	5.11E-06	4.00E-03	0.00056	7.57E-09
	Helicopter			9,964	8.43E-06	4.00E-03	0.00056	1.88E-07
			Takeoffs		/Takeoff			
			47,026					
	1-Eng. Piston			32,069	1.25E-05	4.50E-03	0.00056	1.01E-06
	Multi-Eng. Piston			3,206	1.06E-05	4.50E-03	0.00056	8.56E-06
	Turboprop			1,103	4.67E-06	4.50E-03	0.00056	1.30E-06
	Turbojet			662	1.85E-06	4.50E-03	0.00056	3.08E-09
	Helicopter			9,964	6.17E-06	4.50E-03	0.00056	1.56E-07
							Total:	3.20E-06

All General Aviation flight operations outside of Livermore Airport Control Zone (non-airport environment) considered by SAIC SHARK.EXE Program

In-Flight (Non-Airport) Crash Frequency using SAIC SHARK.EXE Program for 37o 41' N, 121o 42' W	General Aviation Helicopters	/mi ² /yr	Facility Area, At mi. ²	Facility Crash Hit Frequency
	General Aviation	1.33E-04	0.00056	7.44E-06
	Helicopters	3.11E-05	0.00056	1.74E-06
			Total:	9.18E-06

TOTAL GENERAL AVIATION			
Facility Crash Hit Frequency			
LVK Airport	+Non-Airport-	Total	
1995	1-Eng. Piston	2.15E-06	
	Multi-Eng. Piston	2.21E-07	
	Turboprop	2.89E-06	
	Turbojet	8.98E-09	
	Total Fixed Wing	2.41E-06	7.44E-06
	Helicopter	2.89E-07	1.74E-06
	Total General Aviation	2.70E-06	2.49E-06
1993-95 Average	1-Eng. Piston	2.49E-06	
	Multi-Eng. Piston	2.66E-07	
	Turboprop	3.35E-06	
	Turbojet	1.04E-06	
	Total Fixed Wing	2.79E-06	7.44E-06
	Helicopter	3.34E-07	1.74E-06
	Total General Aviation	3.13E-06	2.87E-06
1991-95 Average	1-Eng. Piston	2.56E-06	
	Multi-Eng. Piston	2.62E-07	
	Turboprop	3.43E-06	
	Turbojet	1.07E-06	
	Total Fixed Wing	2.86E-06	7.44E-06
	Helicopter	3.43E-07	1.74E-06
	Total General Aviation	3.21E-06	2.94E-06
1986-95 Average	1-Eng. Piston	2.55E-06	
	Multi-Eng. Piston	2.62E-07	
	Turboprop	3.43E-06	
	Turbojet	1.08E-06	
	Total Fixed Wing	2.86E-06	7.44E-06
	Helicopter	3.43E-07	1.74E-06
	Total General Aviation	3.20E-06	2.94E-06

MILITARY AVIATION

Livermore Municipal Airport (LVK) ATCT

	Airport Operations			Itinerant Landings
	Total	Local	Itinerant	
1995	1,098	664	434	217
				Takeoffs
				217

Crash Rate, CR	Crash Location
/Landing	1.92E-05
/Takeoff	1.10E-05
	4.50E-03

Facility Area, At	Facility Crash Hit Frequency
mi. ²	0.00056
	9.33E-09
	0.00056
	6.01E-09
Total:	1.53E-08

	Airport Operations			Itinerant Landings
	Total	Local	Itinerant	
1993-95	859	261	598	299
Average				Takeoffs
				299

Crash Rate, CR	Crash Location
/Landing	1.92E-05
/Takeoff	1.10E-05
	4.50E-03

Facility Area, At	Facility Crash Hit Frequency
mi. ²	0.00056
	1.28E-08
	0.00056
	8.28E-09
Total:	2.11E-08

	Airport Operations			Itinerant Landings
	Total	Local	Itinerant	
1991-95	854	230	624	312
Average				Takeoffs
				312

Crash Rate, CR	Crash Location
/Landing	1.92E-05
/Takeoff	1.10E-05
	4.50E-03

Facility Area, At	Facility Crash Hit Frequency
mi. ²	0.00056
	1.34E-08
	0.00056
	8.64E-09
Total:	2.21E-08

	Airport Operations			Itinerant Landings
	Total	Local	Itinerant	
1986-95	694	171	522	261
Average				Takeoffs
				261

Crash Rate, CR	Crash Location
/Landing	1.92E-05
/Takeoff	1.10E-05
	4.50E-03

Facility Area, At	Facility Crash Hit Frequency
mi. ²	0.00056
	1.12E-08
	0.00056
	7.23E-09
Total:	1.84E-08

Bay TRACON (O80)

$$FP = N \cdot CR \cdot (4\pi r^2) \cdot (1/Rp) \cdot At$$

	IFR Aircraft Handled	SE, E, NE flts.	No. of Approaches	Aircraft Subcategory
1995	22,255	16,891	8,346	Small/Low
				Small/High
				Large
				Helicopter
			No. of Departures	
			8,346	Small/Low
				Small/High
				Large
				Helicopter

Crash Rate, CR	/mi.	(4 π r ²)	(1/Rp)
2,504	9.95E-08	0.4052847	0.032
2,504	1.66E-07	0.4052847	0.032
2,504	8.51E-08	0.4052847	0.032
835	1.43E-07	0.4052847	0.032
2,504	3.32E-08	0.4052847	0.032
2,504	9.43E-08	0.4052847	0.032
2,504	3.15E-08	0.4052847	0.032
835	4.28E-08	0.4052847	0.032

Facility Area, At	Facility Crash Hit Frequency
mi. ²	0.00056
	1.81E-09
	0.00056
	3.02E-09
	0.00056
	1.56E-09
	0.00056
	8.66E-10
Total Landing	7.24E-09
	0.00056
	8.03E-10
	0.00056
	1.71E-09
	0.00056
	5.72E-10
	0.00056
	2.59E-10
Total Takeoff	3.15E-09
1995 Total	1.04E-08

NOTES

Table 3.56, Crash Rate for small military aircraft, Class A and B mishaps, landing and runway approach flight phases combined for airport landing operations

Table 3.56, Crash Rate for small military aircraft, Class A and B mishaps, off airport events, takeoff and initial climb flight phases combined for airport takeoff operations

Crash location based on General Aviation accident distributions (most Military Aviation flights into Livermore similar to General Aviation flts.)

Facility Area At determined in General Aviation calculations

NOTES

Table 2.2, assume 75% of Military Aircraft handled by Bay TRACON approach and depart from San Francisco Bay Region from/to Southeast, East, and Northeast.

Assume all approaches and departures divided as 30% small low performance military aircraft, 30% small high performance military aircraft, 30% large military aircraft, and 10% military helicopter for 1995.

Assume all approaches and departures divided as 10% small low performance military aircraft, 40% small high performance military aircraft, 30% large military aircraft, and 20% military helicopter for 1993-95, 1991-95, and 1986-95.

Table 3.56, Crash Rate for military aircraft, Class A and B mishaps, off airport events, landing and runway approach flight phases combined for TRACON operations, assumed 20 mi. for distance traveled on approach.

Table 3.56, Crash Rate for small military aircraft, Class A and B mishaps, off airport events, takeoff and initial climb flight phases combined for TRACON operations, assumed 20 mi. for distance traveled on departure.

Assume small Cs, and other Ts from Table 3.56 for small low performance military aircraft.

Assume all As, and Fs, and T-37 and T-38 from Table 3.56 for small high performance military aircraft.

Assume all Bs, and all Cs except small Cs from Table 3.56 for large military aircraft.

IFR Aircraft Handled	SE, E, NE fts.	No. of Approaches	Aircraft Subcategory	Crash Rate, CR			(1/Rp)	Facility Area, At mi. ²	Facility Crash Hit Frequency
				/mi.	(4/pi*2)				
1993-95 Average	28,529	21,397	10,698 Small/Low	1,070	9.95E-08	0.4052847	0.032	0.00056	7.73E-10
			Small/High	4,279	1.66E-07	0.4052847	0.032	0.00056	5.16E-09
			Large	3,210	8.51E-08	0.4052847	0.032	0.00056	1.98E-09
			Helicopter	2,140	1.43E-07	0.4052847	0.032	0.00056	2.22E-09
		No. of Departures						Total Landing	1.01E-08
		10,698	Small/Low	1,070	3.32E-08	0.4052847	0.032	0.00056	2.58E-10
			Small/High	4,279	9.43E-08	0.4052847	0.032	0.00056	2.93E-09
			Large	3,210	3.15E-08	0.4052847	0.032	0.00056	7.34E-10
			Helicopter	2,140	4.26E-08	0.4052847	0.032	0.00056	6.65E-10
								Total Takeoff	4.58E-09
								1993-95 Average Total	1.47E-08

IFR Aircraft Handled	SE, E, NE fts.	No. of Approaches	Aircraft Subcategory	Crash Rate, CR			(1/Rp)	Facility Area, At mi. ²	Facility Crash Hit Frequency
				/mi.	(4/pi*2)				
1991-95 Average	32,704	24,526	12,264 Small/Low	1,226	9.95E-08	0.4052847	0.032	0.00056	8.66E-10
			Small/High	4,906	1.66E-07	0.4052847	0.032	0.00056	5.91E-09
			Large	3,679	8.51E-08	0.4052847	0.032	0.00056	2.27E-09
			Helicopter	2,453	1.43E-07	0.4052847	0.032	0.00056	2.55E-09
		No. of Departures						Total Landing	1.16E-08
		12,264	Small/Low	1,226	3.32E-08	0.4052847	0.032	0.00056	2.95E-10
			Small/High	4,906	9.43E-08	0.4052847	0.032	0.00056	3.36E-09
			Large	3,679	3.15E-08	0.4052847	0.032	0.00056	8.41E-10
			Helicopter	2,453	4.26E-08	0.4052847	0.032	0.00056	7.62E-10
								Total Takeoff	5.26E-09
								1991-95 Average Total	1.69E-08

IFR Aircraft Handled	SE, E, NE fts.	No. of Approaches	Aircraft Subcategory	Crash Rate, CR			(1/Rp)	Facility Area, At mi. ²	Facility Crash Hit Frequency
				/mi.	(4/pi*2)				
1986-95 Average	56,707	42,530	21,265 Small/Low	2,127	9.95E-08	0.4052847	0.032	0.00056	1.54E-09
			Small/High	8,506	1.66E-07	0.4052847	0.032	0.00056	1.02E-08
			Large	6,380	8.51E-08	0.4052847	0.032	0.00056	3.94E-09
			Helicopter	4,253	1.43E-07	0.4052847	0.032	0.00056	4.41E-09
		No. of Departures						Total Landing	2.01E-08
		21,265	Small/Low	2,127	3.32E-08	0.4052847	0.032	0.00056	5.12E-10
			Small/High	8,506	9.43E-08	0.4052847	0.032	0.00056	5.62E-09
			Large	6,380	3.15E-08	0.4052847	0.032	0.00056	1.46E-09
			Helicopter	4,253	4.26E-08	0.4052847	0.032	0.00056	1.32E-09
								Total Takeoff	9.11E-09
								1986-95 Average Total	2.92E-08

Rp = Potential Area radius = $g \cdot h$
g = glide ratio, for military aircraft, assume 15
h = assigned height, for Madwin 3 arrival assume 11000'
Rp = $15 \cdot 11000' = 165000' = 31.25$ mi.

Facility Area At determined in General Aviation calculations

Oakland ARTCC (ZOA)
 FP = $N_c \cdot P_c \cdot (1/A_c) \cdot A_t$

IFR Aircraft Handled		Aircraft Subcategory	IFR AC Handled by Subcategory	In-Flight Crash Rate (/AC handled)	ARTCC Area, Ac mi.^2	1/Ac	Facility Area, At mi.^2	Facility Crash Hit Frequency
1995	195,476	Small/Low	9,774	4.36E-06	100,478	9.952E-06	0.00056	2.37E-10
		Small/High	107,512	4.36E-06	100,478	9.952E-06	0.00056	2.61E-09
		Large	78,190	1.23E-06	100,478	9.952E-06	0.00056	5.38E-10
							1995 Total	3.38E-09
IFR Aircraft Handled		Aircraft Subcategory	IFR AC Handled by Subcategory					
1993-95 Average	207,251	Small/Low	10,363	4.36E-06	100,478	9.952E-06	0.00056	2.51E-10
		Small/High	113,968	4.36E-06	100,478	9.952E-06	0.00056	2.77E-09
		Large	82,900	1.23E-06	100,478	9.952E-06	0.00056	5.70E-10
							1993-95 Average Total	3.59E-09
IFR Aircraft Handled		Aircraft Subcategory	IFR AC Handled by Subcategory					
1991-95 Average	273,821	Small/Low	13,691	4.36E-06	100,478	9.952E-06	0.00056	3.32E-10
		Small/High	150,802	4.36E-06	100,478	9.952E-06	0.00056	3.65E-09
		Large	109,528	1.23E-06	100,478	9.952E-06	0.00056	7.53E-10
							1991-95 Average Total	4.74E-09
IFR Aircraft Handled		Aircraft Subcategory	IFR AC Handled by Subcategory					
1986-95 Average	322,062	Small/Low	16,105	4.36E-06	100,478	9.952E-06	0.00056	3.91E-10
		Small/High	177,151	4.36E-06	100,478	9.952E-06	0.00056	4.30E-09
		Large	128,837	1.23E-06	100,478	9.952E-06	0.00056	8.86E-10
							1986-95 Average Total	5.57E-09

NOTES

Assume all high altitude overflights divided as 5% small low performance military aircraft, 55% small high performance military aircraft and 40% large military aircraft.

In-flight crash rate for small military aircraft based on 105 accidents for 1973-1993, 24,102,000 small military aircraft sorties for 1976-1993.

In-flight crash rate for large military aircraft based on 9 accidents for 1976-1993, 7,289,000 large military aircraft sorties for 1976-1993.

Facility Area At taken to be larger of landing or takeoff effective area

TOTAL MILITARY AVIATION Facility Crash Hit Frequency

1995	2.91E-08
1993-95 Average	3.94E-08
1991-95 Average	4.37E-08
1986-95 Average	5.33E-08

Facility 231/232/233 Aircraft Crash Hit Frequency

	AIR CARRIERS		AIR TAXIS		GENERAL AVIATION		MILITARY AVIATION		ALL AVIATION CATEGORIES TOTAL	Pct.
1995 Total	3.78E-09	0.13%	1.66E-07	5.54%	2.79E-06	93.36%	2.91E-08	0.97%	2.99E-06	
Livermore ATCT	0.00E+00		4.49E-09		2.70E-06		1.53E-08		2.72E-06	90.95%
Bay TRACON	3.13E-09		1.60E-07				1.04E-08		1.73E-07	5.78%
Oakland ARTCC	6.51E-10		1.62E-09		9.18E-08		3.38E-09		9.77E-08	3.26%
1993-95 Average	3.52E-09	0.10%	1.60E-07	5.22%	3.22E-06	93.63%	3.94E-08	1.15%	3.44E-06	
Livermore ATCT	0.00E+00		1.03E-08		3.13E-06		2.11E-08		3.16E-06	91.77%
Bay TRACON	2.91E-09		1.67E-07				1.47E-08		1.65E-07	5.38%
Oakland ARTCC	6.13E-10		1.89E-09		9.18E-06		3.59E-09		9.79E-08	2.85%
1991-95 Average	3.46E-09	0.10%	1.77E-07	5.02%	3.30E-06	93.64%	4.37E-08	1.24%	3.52E-06	
Livermore ATCT	0.00E+00		1.43E-08		3.21E-06		2.21E-08		3.24E-06	92.06%
Bay TRACON	2.86E-09		1.61E-07				1.69E-08		1.80E-07	5.12%
Oakland ARTCC	6.00E-10		1.89E-09		9.18E-06		4.74E-09		9.91E-08	2.81%
1986-95 Average	3.34E-09	0.09%	1.66E-07	4.70%	3.30E-06	93.69%	5.33E-08	1.51%	3.52E-06	
Livermore ATCT	4.15E-13		1.45E-08		3.20E-06		1.84E-08		3.24E-06	92.01%
Bay TRACON	2.77E-09		1.49E-07				2.92E-08		1.81E-07	5.15%
Oakland ARTCC	5.71E-10		1.83E-09		9.18E-06		5.57E-09		9.98E-08	2.84%

5. NIF AIRCRAFT CRASH HIT FREQUENCY ESTIMATE

5.1 INTRODUCTION

The National Ignition Facility (NIF) will be a newly constructed experimental fusion facility that will include the Laser and Target Area Building (LTAB), the Optics Assembly Building (OAB) and a mixture of existing support facilities to provide functions such as optics processing, machine shops, and emergency services. Because this Aircraft Crash Hit Analysis is being done in support of the NIF Preliminary Safety Analysis Report (PSAR) [Ref. 5.1], only the Laser and Target Area Building (LTAB) is considered within the scope of this analysis. NIF will be located in the northeast quadrant of the LLNL Site 200. Figure 5.1 shows the layout of LLNL Site 200 and the location of the NIF [Ref. 5.1]. Figure 5.2 shows the proposed location for the NIF at the LLNL Site 200 [Ref 5.1].

The Laser and Target Area Building (LTAB) will consist of two laser bays, four capacitor bays, two optical switchyards, a target bay, and a diagnostics building. The LTAB is 656 feet long and 410 feet wide with the longer dimension oriented Northeast-Southwest. It is a two story building that is 50 feet high. Figure 5.3 shows the layout of the LTAB [Ref. 5.1]. Figure 5.4 shows the LTAB floor plan [Ref. 5.1]. Figure 5.5 shows the LTAB cross-sectional view [Ref. 5.1].

Because of the open area surrounding the LTAB, the skid-in area must be considered in the facility effective target area, A_t , calculations. The skid-in area as well as the fly-in area are both related to aviation category specific parameters, i.e. aircraft wing span, aircraft skid length, and aircraft impact angle so the facility effective target area will be done by aviation category.

5.2 NIF AIR CARRIER AIRCRAFT CRASH HIT FREQUENCY ESTIMATE

5.2.1 Air Carrier Aircraft Crash Hit Frequency from Livermore Municipal Airport Operations

From Table 2.1, it was found that for Fiscal Years 1995, 1993-95, and 1991-95, there were no aircraft flying under 14 CFR 121 (Air Carriers) which performed any operation from the Livermore Municipal Airport (LVK). Only for the Fiscal Year 1986-95 time period were any Air Carrier operations performed at the Livermore Municipal Airport. A total of two Air Carrier operations were performed at the Livermore Municipal Airport (one landing and one takeoff) for this ten year period for an average number of Air Carrier operations per year of 0.1. All Air Carrier takeoff operations were assumed to the East towards LLNL, and all Air Carrier landing operations were assumed to the West approaching over LLNL.

From Table 3.9, the crash rates for 14 CFR 121 Air Carriers for the 1973-94 time period for accidents which resulted in the destruction or major damage/write-off of the airframe were 3.75 E-7/landing, and 2.86 E-7/takeoff.

From Table 3.11, the crash location probability for Air Carriers at 5-6 miles from the runway on the runway centerline while on approach was found to be 1.72 E-2. From Table 3.10, the crash location probability for Air Carriers at 5-6 miles from the runway on the runway centerline while on departure was found to be 3.95 E-3.

From Ref. 5.2, the NIF facility effective target area, A_t , is equal to the fly-in area, A_f , and the skid-in area, A_s .

$$A_t = A_f + A_s$$

where

$$A_f = [(WS + R) * H * \cot \phi] + [(2 * L * W * WS)/R] + (L * W)$$

$$A_s = (WS + R) * S$$

WS = aircraft wingspan, for 14 CFR 121 Air Carriers = 100 ft. [Ref. 5.2]

L = facility length, for NIF = 656 ft. [Ref. 5.1]

W = facility width, for NIF = 410 ft. [Ref. 5.1]

R = diagonal dimension of the facility = $(L^2 + W^2)^{1/2} = 773.59$ ft.

H = facility height, for NIF = 50 ft. [Ref. 5.1]

$\cot \phi$ = mean cotangent of aircraft impact angle, for 14 CFR 121 Air Carriers = 10.2 [Ref. 5.2]

S = mean aircraft skid length, for 14 CFR 121 Air Carriers = 1440 ft. [Ref. 5.2]

$$\begin{aligned} A_f &= [(100 + 773.59) * 50 * 10.2] + [(2 * 656 * 410 * 100)/773.59] + (656 * 410) \\ &= 784,025 \text{ ft}^2 = 0.02812 \text{ mi}^2. \end{aligned}$$

$$A_s = (100 + 773.59) * 1440 = 1,257,965 \text{ ft}^2 = 0.04512 \text{ mi}^2.$$

$$A_t = 0.02812 \text{ mi}^2 + 0.04512 \text{ mi}^2 = 0.07325 \text{ mi}^2.$$

The aircraft crash hit frequency for Air Carrier aircraft operations from the Livermore Municipal Airport for the Fiscal Year 1986-95 time period is then:

$$F = N * P * f(x,y) * A_t$$

$$F = (0.1) * (3.65 \text{ E-}7) * (1.72 \text{ E-}2) * (0.07325) \text{ for landing} \\ = 4.60 \text{ E-}11/\text{yr.}$$

$$F = (0.1) * (2.86 \text{ E-}7) * (3.95 \text{ E-}3) * (0.07325) \text{ for takeoff} \\ = 8.27 \text{ E-}12/\text{yr.}$$

The total aircraft crash hit frequency, F, for Air Carriers due to aircraft operations from the Livermore Municipal Airport for the Fiscal Year 1986-95 time period is 5.43 E-11/yr.

5.2.2 Air Carrier Aircraft Crash Hit Frequency from Bay TRACON Aircraft Operations

From Table 2.2, it was found that for Fiscal Year 1995, a total of 501,976 Air Carrier instrument operations were performed by the Bay TRACON. From Table 2.3, Oakland International Airport performed a total of 164,384 Air Carrier instrument operations for Fiscal Year 1995. From Table 2.4, San Francisco International Airport performed a total of 299,444 Air Carrier instrument operations for Fiscal Year 1995. Combining Oakland and San Francisco airport Air Carrier instrument operations yields 463,828. Subtracting 5% of this total for international air carrier flights yields 440,637. Assume 75% of this total are Air Carrier approaches and departures from the Southeast, East, and Northeast yields 330,477 of which half or 165,329 are approaches over Livermore, and half or 165,329 are departures over Livermore.

Similarly, for the Fiscal Year 1993-95 time period, from Tables 2.2, 2.3, and 2.4, 153,383 Air Carrier approaches and 153,383 Air Carrier departures were performed over Livermore per year.

For the Fiscal Year 1991-95 time period, from Tables 2.2, 2.3, and 2.4, 150,673 Air Carrier approaches and 150,673 Air Carrier departures were performed over Livermore per year.

For the Fiscal Year 1986-95 time period, from Tables 2.2, 2.3, and 2.4, 145,896 Air Carrier approaches and 145,896 Air Carrier departures were performed over Livermore per year.

From Table 3.9, the crash rates for 14 CFR 121 Air Carriers for the 1973-94 time period for accidents which resulted in the destruction or major damage/write-off of the airframe were 2.06 E-9/mile (where the airport approach flight phase was used for the TRACON approach operation), and 5.50 E-10/mile (where the climb to cruise flight phase was used for the TRACON departure operation).

The radius of the potential area affected by a distressed aircraft, R_p , was set equal to the glide ratio of the aircraft, g, times the height of the aircraft when the initiating event occurred. For the Madwin3 arrival approach procedure for the San Francisco Bay area [Ref. 5.3], the assigned altitude is no greater than 11,000 feet. A glide ratio of 15 was assume to be the maximum glide ratio for 14 CFR 121 Air Carrier Aircraft [Ref. 5.4] so, R_p is 15 x 11,000 feet or 165,000 feet or 31.25 miles.

The NIF facility effective target area is as determined in Section 5.2.1 above.

The aircraft crash hit frequency for Air Carrier aircraft operations in the Bay TRACON flight environment for the 1995 Fiscal Year is then:

$$F = N * CR * (4/\pi^2) * (1/R_p) * A_t$$

$$F = (165,239) * (2.06 \text{ E-}9) * (0.405) * (1/31.25) * (0.07325) \text{ for landing approaches} \\ = 3.24 \text{ E-}7/\text{yr.}$$

$$F = (165,239) * (5.50 \text{ E-}10) * (0.405) * (1/31.25) * (0.07325) \text{ for departures}$$

$$= 8.64 \text{ E-8/yr.}$$

The total aircraft crash hit frequency, F, for Air Carriers due to aircraft operations in the Bay TRACON for Fiscal Year 1995 is 4.10 E-7/yr.

Similarly, for the Fiscal Year 1993-95 time period:

$$\begin{aligned} F &= (153,383) * (2.06 \text{ E-9}) * (0.405) * (1/31.25) * (0.07325) \text{ for landing approaches} \\ &= 3.01 \text{ E-7/yr.} \\ F &= (153,383) * (5.50 \text{ E-10}) * (0.405) * (1/31.25) * (0.07325) \text{ for departures} \\ &= 8.02 \text{ E-8/yr.} \end{aligned}$$

The total aircraft crash hit frequency, F, for Air Carriers due to aircraft operations in the Bay TRACON for Fiscal Years 1993-95 is 3.81 E-7/yr.

For the Fiscal Year 1991-95 time period:

$$\begin{aligned} F &= (150,673) * (2.06 \text{ E-9}) * (0.405) * (1/31.25) * (0.07325) \text{ for landing approaches} \\ &= 2.95 \text{ E-7/yr.} \\ F &= (150,673) * (5.50 \text{ E-10}) * (0.405) * (1/31.25) * (0.07325) \text{ for departures} \\ &= 7.88 \text{ E-8/yr.} \end{aligned}$$

The total aircraft crash hit frequency, F, for Air Carriers due to aircraft operations in the Bay TRACON for Fiscal Years 1991-95 is 3.74 E-7 yr.

For the Fiscal Year 1986-95 time period:

$$\begin{aligned} F &= (145,896) * (2.06 \text{ E-9}) * (0.405) * (1/31.25) * (0.07325) \text{ for landing approaches} \\ &= 2.86 \text{ E-7/yr.} \\ F &= (145,896) * (5.50 \text{ E-10}) * (0.405) * (1/31.25) * (0.07325) \text{ for departures} \\ &= 7.63 \text{ E-8/yr.} \end{aligned}$$

The total aircraft crash hit frequency, F, for Air Carriers due to aircraft operations in the Bay TRACON for Fiscal years 1986-95 is 3.62 E-7/yr.

5.2.3 Air Carrier Aircraft Crash Hit Frequency from Oakland ARTCC Aircraft Handled

From Table 2.7, 961,986 Air Carrier aircraft were handled per year by the Oakland ARTCC in Fiscal Year 1995. For the Fiscal Year 1993-95 time period, an average of 905,884 Air Carrier aircraft were handled per year by the Oakland ARTCC. For the Fiscal Year 1991-95 time period, an average of 886,927 Air Carrier aircraft were handled per year by the Oakland ARTCC. For the Fiscal Year 1986-95 time period, an average of 843,660 Air Carrier aircraft were handled per year by the Oakland ARTCC.

From Table 3.9, the crash rates for 14 CFR 121 Air Carriers for the 1973-94 time period for accidents which resulted in the destruction or major damage/write-off of the airframe was 1.21 E-7/aircraft handled based on the combination of 17 Air Carrier crashes during the climb to cruise, cruise/enroute, and initial descent flight phases and on the total of 139,934,558 departures during this time period.

The area of the airspace controlled by the Oakland ARTCC has been determined in Ref. 5.5 to be 100,478 mile².

The NIF facility effective target area is as determined in Section 5.2.1 above.

The aircraft crash hit frequency for Air Carrier aircraft operations in the Oakland ARTCC flight environment for the 1995 Fiscal Year is then:

$$F = N_c * P_c * (1/A_c) * A_t$$

$$\begin{aligned} F &= (961,986) * (1.21 \text{ E-}7) * (1/100,478) * (0.07325) \\ &= 8.52 \text{ E-}8/\text{yr.} \end{aligned}$$

Similarly, for the Fiscal Year 1993-95 time period:

$$\begin{aligned} F &= (905,884) * (1.21 \text{ E-}7) * (1/100,478) * (0.07325) \\ &= 8.02 \text{ E-}8/\text{yr.} \end{aligned}$$

For the Fiscal Year 1991-95 time period:

$$\begin{aligned} F &= (886,927) * (1.21 \text{ E-}7) * (1/100,478) * (0.07325) \\ &= 7.85 \text{ E-}8/\text{yr.} \end{aligned}$$

For the Fiscal Year 1986-95 time period:

$$\begin{aligned} F &= (843,660) * (1.21 \text{ E-}7) * (1/100,478) * (0.07325) \\ &= 7.47 \text{ E-}8/\text{yr.} \end{aligned}$$

5.2.4 Air Carriers Crash Hit Frequency, Total for All Flight Environments

The total Air Carriers Crash Hit Frequency for all flight environments is the sum of the Air Carriers aircraft crash hit frequency due to airport operations, TRACON operations, and ARTCC operations.

For the 1995 Fiscal Year, the total aircraft crash hit frequency for Air Carriers in all flight environments is:

$$F_{\text{total}} = (0) + (4.10 \text{ E-}7) + (8.52 \text{ E-}8) = 4.95 \text{ E-}7/\text{yr.}$$

Similarly, for Fiscal Years 1993-95, $F_{\text{total}} = (0) + (3.81 \text{ E-}7) + (8.02 \text{ E-}8) = 4.61 \text{ E-}7/\text{yr.}$

For Fiscal Years 1991-95, $F_{\text{total}} = (0) + (3.74 \text{ E-}7) + (7.85 \text{ E-}8) = 4.53 \text{ E-}7/\text{yr.}$

For Fiscal Years 1986-95, $F_{\text{total}} = (5.43 \text{ E-}11) + (3.62 \text{ E-}7) + (7.47 \text{ E-}8) = 4.37 \text{ E-}7/\text{yr.}$

5.3 NIF AIR TAXI AIRCRAFT CRASH HIT FREQUENCY ESTIMATE

5.3.1 Air Taxi Aircraft Crash Hit Frequency from Livermore Municipal Airport Operations

From Table 2.1, there were 127 Air Taxi itinerant operations for Fiscal Year 1995 at the Livermore Municipal Airport of which 64 were landings and 64 were takeoffs. For Fiscal Years 1993-95, there were an average of 292 Air Taxi itinerant operations at Livermore of which 146 were landings, and 146 were takeoffs. For Fiscal Years 1991-95, there were an average of 406 Air Taxi itinerant operations at Livermore of which 203 were landings, and 203 were takeoffs. For Fiscal years 1986-95, there were an average of 410 Air Taxi itinerant operations at Livermore of which 205 were landings, and 205 were takeoffs. All Air Taxi takeoff operations were assumed to the East towards LLNL, and all Air Taxi landing operations were assumed to the West approaching over LLNL.

From Table 3.53, a crash rate for Air Taxis during landings of 1.92 E-5/landing was taken from the crash rates for General Aviation Total Powered Aircraft for the 1986-94 time period. A crash rate for Air Taxis during takeoffs of 1.10 E-5/takeoff was also taken from the crash rates for General Aviation Total Powered Aircraft for the 1986-94 time period. The crash rates for General Aviation Total Powered Aircraft were used for Air Taxis because of the similarity of General Aviation Total Powered Aircraft operations and Nonscheduled Air Taxi aircraft operations which is predominant at the Livermore Municipal Airport.

From Table 3.55, the crash location probability for Air Taxis at 5-6 miles from the runway on the runway centerline while on approach was found to be 4.0 E-3 . From Table 3.54, the crash location probability for Air Taxis at 5-6 miles from the runway on the runway centerline while on departure was found to be 4.5 E-3 . Again, the crash location probability for General Aviation was used for Air Taxis because of the similarity of General Aviation aircraft operations and Nonscheduled Air Taxi aircraft operations which is predominant at the Livermore Municipal Airport.

From Ref. 5.2, the NIF facility effective target area, A_t , is equal to the fly-in area, A_f , and the skid-in area, A_s .

$$A_t = A_s + A_f$$

where

$$A_s = (WS + R) * S$$

$$A_f = [(WS + R) * H * \cot \phi] + [(2 * L * W * WS)/R] + (L * W)$$

WS = aircraft wingspan, for 14 CFR 135 Air Taxis = 60 ft. [Ref. 5.2]

L = facility length, for NIF = 656 ft. [Ref. 5.1]

W = facility width, for NIF = 410 ft. [Ref. 5.1]

R = diagonal dimension of the facility = $(L^2 + W^2)^{1/2} = 773.59 \text{ ft.}$

H = facility height, for NIF = 50 ft. [Ref. 5.1]

$\cot \phi$ = mean cotangent of aircraft impact angle, for General Aviation = 8.2 [Ref. 5.2]

S = mean aircraft skid length, for General Aviation = 60 ft. [Ref. 5.2]

$$A_s = (60 + 773.59) * 60 = 50,115 \text{ ft}^2 = 0.00179 \text{ mi}^2.$$

$$\begin{aligned} A_f &= [(60 + 773.59) * 50 * 8.2] + [(2 * 656 * 410 * 60)/773.59] + (656 * 410) \\ &= 652,452 \text{ ft}^2 = 0.02340 \text{ mi}^2. \end{aligned}$$

$$A_t = 0.00179 \text{ mi}^2 + 0.02340 \text{ mi}^2 = 0.02520 \text{ mi}^2.$$

The aircraft crash hit frequency for Air Taxi aircraft operations from the Livermore Municipal Airport for the 1995 Fiscal Year is:

$$F = N * P * f(x,y) * A_t$$

$$\begin{aligned} F &= (64) * (1.92 \text{ E-}5) * (4.0 \text{ E-}3) * (0.02520) \text{ for landing} \\ &= 1.23 \text{ E-}7/\text{yr.} \end{aligned}$$

$$\begin{aligned} F &= (64) * (1.10 \text{ E-}5) * (4.5 \text{ E-}3) * (0.02520) \text{ for takeoff} \\ &= 7.92 \text{ E-}8/\text{yr.} \end{aligned}$$

The total aircraft crash hit frequency, F, due to Air Taxi aircraft operations from the Livermore Municipal Airport for the 1995 Fiscal Year is 2.02 E-7/yr.

Similarly, for the Fiscal Year 1993-95 time period:

$$\begin{aligned} F &= (146) * (1.92 \text{ E-}5) * (4.0 \text{ E-}3) * (0.02520) \text{ for landing} \\ &= 2.83 \text{ E-}7/\text{yr.} \end{aligned}$$

$$\begin{aligned} F &= (146) * (1.10 \text{ E-}5) * (4.5 \text{ E-}3) * (0.02520) \text{ for takeoff} \\ &= 1.82 \text{ E-}7/\text{yr.} \end{aligned}$$

The total aircraft crash hit frequency, F, due to Air Taxi aircraft operations from the Livermore Municipal Airport for Fiscal Years 1993-95 is 4.65 E-7/yr.

For the Fiscal Year 1991-95 time period:

$$\begin{aligned} F &= (203) * (1.92 \text{ E-}5) * (4.0 \text{ E-}3) * (0.02520) \text{ for landing} \\ &= 3.93 \text{ E-}7/\text{yr.} \end{aligned}$$

$$\begin{aligned} F &= (203) * (1.10 \text{ E-}5) * (4.5 \text{ E-}3) * (0.02520) \text{ for takeoff} \\ &= 2.53 \text{ E-}7/\text{yr.} \end{aligned}$$

The total aircraft crash hit frequency, F, due to Air Taxi aircraft operations from the Livermore Municipal Airport for Fiscal Years 1991-95 is 6.86 E-7/yr.

For the Fiscal year 1986-95 time period:

$$\begin{aligned} F &= (205) * (1.92 \text{ E-}5) * (4.0 \text{ E-}3) * (0.02520) \text{ for landing} \\ &= 3.97 \text{ E-}7/\text{yr.} \end{aligned}$$

$$\begin{aligned} F &= (205) * (1.10 \text{ E-}5) * (4.5 \text{ E-}3) * (0.02520) \text{ for takeoff} \\ &= 2.56 \text{ E-}7/\text{yr.} \end{aligned}$$

The total aircraft crash hit frequency, F, due to Air Taxi aircraft operations from the Livermore Municipal Airport for Fiscal Years 1986-95 is 6.52 E-7/yr.

5.3.2 Air Taxi Aircraft Crash Hit Frequency from Bay TRACON Aircraft Operations

From Table 2.2, it was found that for Fiscal Year 1995, a total of 216,973 Air Taxi instrument operations were performed by the Bay TRACON. From Table 2.3, Oakland International Airport performed a total of 52,554 Air Taxi instrument operations for Fiscal Year 1995. From Table 2.4, San Francisco International Airport performed a total of 96,937 Air Taxi instrument operations for Fiscal Year 1995. Combining Oakland and San Francisco airport Air Taxi instrument operations yields 149,491. Assume 75% of this total are Air Taxi approaches and departures from the Southeast, East, and Northeast yields 112,118 of which half or 56,059 are approaches over Livermore, and half or 56,059 are departures over Livermore.

Similarly, for the Fiscal Year 1993-95 time period, from Tables 2.2, 2.3, and 2.4, 58,809 Air Taxi approaches and 58,809 Air Taxi departures were performed over Livermore per year.

For the Fiscal Year 1991-95 time period, from Tables 2.2, 2.3, and 2.4, 56,445 Air Taxi approaches and 56,445 Air Taxi departures were performed over Livermore per year.

For the Fiscal year 1986-95 time period, from Tables 2.2, 2.3, and 2.4, 52,404 Air Taxi approaches and 52,404 Air Taxi departures were performed over Livermore per year.

From Table 3.16, a crash rate for Air Taxis during landings of 9.54 E-8/mile was taken from the crash rates for Scheduled 14 CFR 135 Air Taxis for the 1980-94 time period using the landing approach flight phase for TRACON landing approaches. A crash rate for Air Taxis during takeoffs of 1.06 E-8/mile was also taken from the crash rates for Scheduled 14 CFR 135 Air Taxis for the 1980-94 time period using the climb to cruise flight phase for TRACON departures.

The radius of the potential area affected by a distressed aircraft, R_p , was set equal to the glide ratio of the aircraft, g , times the height of the aircraft when the initiating event occurred. For the Madwin3 arrival approach procedure for the San Francisco Bay area [Ref. 5.3], the assigned altitude is no greater than 11,000 feet. A glide ratio of 10 was assume to be the maximum glide ratio for 14 CFR 135 Air Taxi Aircraft [Ref. 5.4] so, R_p is $10 \times 11,000$ feet or 110,000 feet or 20.83 miles.

Because the types of Air Taxi aircraft handled by the Bay TRACON and the Oakland ARTCC are a mixture of scheduled and nonscheduled air taxi aircraft, and since no values are provided in Ref. 5.2 for Air Taxi aircraft for the cotangent of the impact angle and the skid distance, a mixture of values for Air Carrier and General Aviation aircrafts are used to determine the NIF facility effect target area for Bay TRACON and Oakland ARTCC aircraft operations. From Ref. 5.2, the NIF facility effective target area, A_t , is equal to the fly-in area, A_f , and the skid-in area, A_s .

$$A_t = A_s + A_f$$

where

$$A_s = (WS + R) * S$$

$$A_f = [(WS + R) * H * \cot \phi] + [(2 * L * W * WS)/R] + (L * W)$$

WS = aircraft wingspan, for 14 CFR 135 Air Taxis = 60 ft. [Ref. 5.2]

L = facility length, for NIF = 656 ft. [Ref. 5.1]

W = facility width, for NIF = 410 ft. [Ref. 5.1]

R = diagonal dimension of the facility = $(L^2 + W^2)^{1/2} = 773.59$ ft.

H = facility height, for NIF = 50 ft. [Ref. 5.1]

$\cot \phi$ = mean cotangent of aircraft impact angle, for Air Carriers = 10.2 [Ref. 5.2]

S = mean aircraft skid length, for General Aviation = 230 ft. [Ref. 5.2]

based on the 90 percentile skid distance for General Aviation

$$A_g = (60 + 773.59) * 230 = 191,725 \text{ ft}^2 = 0.00688 \text{ mi}^2.$$

$$\begin{aligned} A_f &= [(60 + 773.59) * 50 * 10.2] + [(2 * 656 * 410 * 60) / 773.59] + (656 * 410) \\ &= 735,811 \text{ ft}^2 = 0.02639 \text{ mi}^2. \end{aligned}$$

$$A_t = 0.00688 \text{ mi}^2 + 0.02639 \text{ mi}^2 = 0.03327 \text{ mi}^2.$$

The aircraft crash hit frequency for Air Taxi aircraft operations in the Bay TRACON flight environment for the 1995 Fiscal Year is then:

$$F = N * CR * (4/\pi^2) * (1/R_p) * A_t$$

$$\begin{aligned} F &= (56,059) * (9.54 \text{ E-}8) * (0.405) * (1/20.83) * (0.03327) \text{ for landing approaches} \\ &= 8.54 \text{ E-}6/\text{yr}. \end{aligned}$$

$$\begin{aligned} F &= (56,059) * (1.06 \text{ E-}8) * (0.405) * (1/20.83) * (0.03327) \text{ for departures} \\ &= 9.50 \text{ E-}7/\text{yr}. \end{aligned}$$

The total aircraft crash hit frequency, F , due to Air Taxi aircraft operations in the Bay TRACON for Fiscal Year 1995 is 9.49 E-6/yr.

Similarly, for the Fiscal Year 1993-95 time period:

$$\begin{aligned} F &= (58,809) * (9.54 \text{ E-}8) * (0.405) * (1/20.83) * (0.03327) \text{ for landing approaches} \\ &= 8.96 \text{ E-}6/\text{yr}. \end{aligned}$$

$$\begin{aligned} F &= (58,809) * (1.06 \text{ E-}8) * (0.405) * (1/20.83) * (0.03327) \text{ for departures} \\ &= 9.96 \text{ E-}7/\text{yr}. \end{aligned}$$

The total aircraft crash hit frequency, F , due to Air Taxi aircraft operations in the Bay TRACON for Fiscal Years 1993-95 is 9.96 E-6/yr.

For the Fiscal Year 1991-95 time period:

$$\begin{aligned} F &= (56,445) * (9.54 \text{ E-}8) * (0.405) * (1/20.83) * (0.03327) \text{ for landing approaches} \\ &= 8.60 \text{ E-}6/\text{yr}. \end{aligned}$$

$$\begin{aligned} F &= (56,445) * (1.06 \text{ E-}8) * (0.405) * (1/20.83) * (0.03327) \text{ for departures} \\ &= 9.56 \text{ E-}7/\text{yr}. \end{aligned}$$

The total aircraft crash hit frequency, F , due to Air Taxi aircraft operations in the Bay TRACON for Fiscal Years 1991-95 is 9.56 E-6/yr.

For the Fiscal Year 1986-95 time period:

$$\begin{aligned} F &= (52,404) * (9.54 \text{ E-}8) * (0.405) * (1/20.83) * (0.03327) \text{ for landing approaches} \\ &= 7.98 \text{ E-}6/\text{yr}. \end{aligned}$$

$$\begin{aligned} F &= (52,404) * (1.06 \text{ E-}8) * (0.405) * (1/20.83) * (0.03327) \text{ for departures} \\ &= 8.88 \text{ E-}7/\text{yr}. \end{aligned}$$

The total aircraft crash hit frequency, F , due to Air Taxi aircraft operations in the Bay TRACON for Fiscal years 1986-95 is 8.87 E-6/yr.

5.3.3 Air Taxi Aircraft Crash Hit Frequency from Oakland ARTCC Aircraft Handled

From Table 2.7, 210,332 Air Taxi IFR aircraft were handled by the Oakland ARTCC in Fiscal Year 1995. For the Fiscal Year 1993-95 time period, an average of 217,531 Air Taxi aircraft were handled per year by the Oakland ARTCC. For the Fiscal Year 1991-95 time period, an average of 217,680 Air Taxi aircraft were handled per year by the Oakland ARTCC. For the Fiscal Year 1986-95 time period, an average of 210,548 Air Taxi aircraft were handled per year by the Oakland ARTCC.

From Table 3.16, the crash rates for Scheduled 14 CFR 135 Air Carriers for the 1980-94 time period was 1.56 E-6/aircraft handled based on the combination of 64 Air Taxi crashes during the climb to cruise, cruise/enroute, and initial descent flight phases and on the total of 41,089,306 departures during this time period.

The area of the airspace controlled by the Oakland ARTCC has been determined in Ref. 5.5 to be 100,478 mile².

The NIF facility effective target area is as determined in Section 5.3.2 above.

The aircraft crash hit frequency for Air Taxi aircraft operations in the Oakland ARTCC flight environment for the 1995 Fiscal Year is then:

$$F = N_c * P_c * (1/A_c) * A_t$$

$$\begin{aligned} F &= (210,332) * (1.56 \text{ E-}6) * (1/100,478) * (0.03327) \\ &= 1.08 \text{ E-}7/\text{yr.} \end{aligned}$$

Similarly, for the Fiscal Year 1993-95 time period:

$$\begin{aligned} F &= (217,531) * (1.56 \text{ E-}6) * (1/100,478) * (0.03327) \\ &= 1.12 \text{ E-}7/\text{yr.} \end{aligned}$$

For the Fiscal Year 1991-95 time period:

$$\begin{aligned} F &= (217,680) * (1.56 \text{ E-}6) * (1/100,478) * (0.03327) \\ &= 1.12 \text{ E-}7/\text{yr.} \end{aligned}$$

For the Fiscal Year 1986-95 time period:

$$\begin{aligned} F &= (210,548) * (1.56 \text{ E-}6) * (1/100,478) * (0.03327) \\ &= 1.09 \text{ E-}7/\text{yr.} \end{aligned}$$

5.3.4 Air Taxi Crash Hit Frequency, Total for All Flight Environments

The total Air Taxicrash Hit Frequency for all flight environments is the sum of the Air Taxicrash hit frequency due to airport operations, TRACON operations, and ARTCC operations.

For the 1995 Fiscal Year, the total aircraft crash hit frequency for Air Taxicrash in all flight environments is:

$$F_{\text{total}} = (2.02 \text{ E-}7) + (9.49 \text{ E-}6) + (1.08 \text{ E-}7) = 9.80 \text{ E-}6/\text{yr.}$$

Similarly, for Fiscal Years 1993-95, $F_{\text{total}} = (4.65 \text{ E-7}) + (9.96 \text{ E-6}) + (1.12 \text{ E-7}) = 1.05 \text{ E-5/yr.}$

For Fiscal Years 1991-95, $F_{\text{total}} = (6.86 \text{ E-7}) + (9.56 \text{ E-6}) + (1.12 \text{ E-7}) = 1.03 \text{ E-5/yr.}$

For Fiscal Years 1986-95, $F_{\text{total}} = (6.52 \text{ E-7}) + (8.87 \text{ E-6}) + (1.09 \text{ E-7}) = 9.63 \text{ E-6/yr.}$

5.4 NIF GENERAL AVIATION (GA) AIRCRAFT CRASH HIT FREQUENCY ESTIMATE

5.4.1 GA Aircraft Crash Hit Frequency from Livermore Municipal Airport Operations

From Table 2.1, there 225,730 General Aviation airport operations at the Livermore Municipal Airport for Fiscal Year 1995. Of these, 146,406 were local operations and 79,324 were itinerant operations. Only itinerant operations at the Livermore Municipal Airport will be considered in the aircraft crash hit analysis. Half of these itinerant operations are considered landings (39,662) and half are considered takeoffs (39,662). All General Aviation itinerant takeoff operations were assumed to the East towards LLNL, and all General Aviation itinerant landing operations were assumed to the West approaching over LLNL. Applying the percentages of General Aviation flights for the FAA Western Pacific Region for calendar year 1994 to the FY1995 itinerant operations at the Livermore Municipal Airport yields:

<u>GA Aircraft Subcategory</u>	<u>Landings</u>	<u>Takeoffs</u>
Single-eng. piston	27,065	27,065
Multi-eng. piston	2,705	2,705
Turboprop	930	930
Turbojet	558	558
Helicopter	8,404	8,404
Total	39,662	39,662

Similarly, for the Fiscal Year 1993-95 time period, from Table 2.1:

<u>GA Aircraft Subcategory</u>	<u>Landings</u>	<u>Takeoffs</u>
Single-eng. piston	31,304	31,304
Multi-eng. piston	3,129	3,129
Turboprop	1,076	1,076
Turbojet	645	645
Helicopter	9,720	9,720
Total	45,875	45,875

For Fiscal year 1991-95 time period, from Table 2.1:

<u>GA Aircraft Subcategory</u>	<u>Landings</u>	<u>Takeoffs</u>
Single-eng. piston	32,109	32,109
Multi-eng. piston	3,210	3,210
Turboprop	1,104	1,104
Turbojet	662	662
Helicopter	9,970	9,970
Total	47,054	47,054

For Fiscal year 1986-95 time period, from Table 2.1:

<u>GA Aircraft Subcategory</u>	<u>Landings</u>	<u>Takeoffs</u>
Single-eng. piston	32,089	32,089
Multi-eng. piston	3,208	3,208
Turboprop	1,103	1,103
Turbojet	662	662
Helicopter	9,964	9,964
Total	47,026	47,026

Crash rates were taken from Tables 3.45, 3.46, 3.47, 3.48 and 3.52 for General Aviation for the 1986-94 time period for airport landings, and for airport takeoffs.

<u>GA Aircraft Subcategory</u>	<u>Landings</u>	<u>Takeoffs</u>
Single-eng. piston	Table 3.45, 2.15 E-5	Table 3.45, 1.25 E-5
Multi-eng. piston	Table 3.46, 2.46 E-5	Table 3.46, 1.06 E-5
Turboprop	Table 3.47, 8.65 E-6	Table 3.47, 4.67 E-6
Turbojet	Table 3.48, 5.11 E-6	Table 3.48, 1.85 E-6
Helicopter	Table 3.52, 8.43 E-6	Table 3.52, 6.17 E-6

Crash location probability for General Aviation at 5-6 miles from the runway on the runway centerline while on approach was found to be 4.0 E-3 from Table 3.55. The crash location probability for General Aviation at 5-6 miles from the runway on the runway centerline while on departure was found to be 4.5 E-4 from Table 3.54.

From Ref. 5.2, the NIF facility effective target area, A_t , is equal to the fly-in area, A_f , and the skid-in area, A_s .

$$A_t = A_f + A_s$$

where

$$A_s = (WS + R) * S$$

$$A_f = [(WS + R) * H * \cot \phi] + [(2 * L * W * WS)/R] + (L * W)$$

WS = aircraft wingspan,

for GA single-eng. piston aircraft = 50 ft. [Ref. 5.2]

for GA multi-eng. piston aircraft = 60 ft. [Ref. 5.2]

for GA turboprop aircraft = 72.5 ft. [Ref. 5.2]

for GA turbojet aircraft = 50 ft. [Ref. 5.2]

for GA helicopters (main rotor diameter) = 50 ft. [Ref. 5.2]

L = facility length, for NIF = 656 ft. [Ref. 5.1]

W = facility width, for NIF = 410 ft. [Ref. 5.1]

R = diagonal dimension of the facility = $(L^2 + W^2)^{1/2} = 773.59$ ft.

H = facility height, for NIF = 50 ft. [Ref. 5.1]

$\cot \phi$ = mean cotangent of aircraft impact angle, for 14 CFR 121 Air Carriers = 10.2 [Ref. 5.2]

S = mean aircraft skid length,

for GA fixed wing aircraft = 60 ft. [Ref. 5.2]

for GA helicopters = 0 ft. [Ref. 5.2]

Skid-in area

for GA single-eng. piston aircraft

$$A_s = (50 + 773.59) * 60 = 49,415 \text{ ft}^2 = 0.00177 \text{ mi}^2.$$

for GA multi-eng. piston aircraft

$$A_s = (60 + 773.59) * 60 = 50,015 \text{ ft}^2 = 0.00179 \text{ mi}^2.$$

for GA turboprop aircraft

$$A_s = (72.5 + 773.59) * 60 = 50,765 \text{ ft}^2 = 0.00182 \text{ mi}^2.$$

for GA turbojet aircraft

$$A_s = (50 + 773.59) * 60 = 49,415 \text{ ft}^2 = 0.00177 \text{ mi}^2.$$

for GA helicopters

$$A_s = (50 + 773.59) * 0 = 0 \text{ ft}^2 = 0 \text{ mi}^2.$$

Fly-in area

for GA single-eng. piston aircraft

$$A_f = [(50 + 773.59) * 50 * 10.2] + [(2 * 656 * 410 * 50) / 773.59] + (656 * 410) \\ = 641,398 \text{ ft}^2 = 0.02301 \text{ mi}^2.$$

for GA multi-eng. piston aircraft

$$A_f = [(60 + 773.59) * 60 * 10.2] + [(2 * 656 * 410 * 50) / 773.59] + (656 * 410) \\ = 652,452 \text{ ft}^2 = 0.02340 \text{ mi}^2.$$

for GA turboprop aircraft

$$A_f = [(72.5 + 773.59) * 60 * 10.2] + [(2 * 656 * 410 * 72.5) / 773.59] + (656 * 410) \\ = 666,269 \text{ ft}^2 = 0.02390 \text{ mi}^2.$$

for GA turbojet aircraft

$$A_f = [(50 + 773.59) * 60 * 10.2] + [(2 * 656 * 410 * 50) / 773.59] + (656 * 410) \\ = 641,398 \text{ ft}^2 = 0.02301 \text{ mi}^2.$$

for GA multi-eng. helicopters

$$A_f = [(50 + 773.59) * 60 * 10.2] + [(2 * 656 * 410 * 50) / 773.59] + (656 * 410) \\ = 641,398 \text{ ft}^2 = 0.02301 \text{ mi}^2.$$

Total facility effective target area

for GA single-eng. piston aircraft

$$A_t = 0.02301 \text{ mi}^2 + 0.00177 \text{ mi}^2 = 0.02478 \text{ mi}^2.$$

for GA multi-eng. piston aircraft

$$A_t = 0.02340 \text{ mi}^2 + 0.00179 \text{ mi}^2 = 0.02520 \text{ mi}^2.$$

for GA turboprop aircraft

$$A_t = 0.02390 \text{ mi}^2 + 0.00182 \text{ mi}^2 = 0.02572 \text{ mi}^2.$$

for GA turbojet aircraft

$$A_t = 0.02301 \text{ mi}^2 + 0.00177 \text{ mi}^2 = 0.02478 \text{ mi}^2.$$

for GA helicopters

$$A_t = 0.02301 \text{ mi}^2 + 0 \text{ mi}^2 = 0.02301 \text{ mi}^2.$$

The aircraft crash hit frequencies for General Aviation operations from the Livermore Municipal Airport for the 1995 Fiscal Year are:

$$F = N * P * f(x,y) * A_t$$

For landings

Single-Engine Piston	F =	27065 * (2.15 E-5) * (4.0 E-3) * (0.02478) = 5.77 E-5/yr.
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Multi-Engine Piston	F =	2705 * (2.46 E-5) * (4.0 E-3) * (0.02520) = 6.71 E-6/yr.
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Turboprop	F =	930 * (8.65 E-6) * (4.0 E-3) * (0.02572) = 8.28 E-7/yr.
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Turbojet	F =	558 * (5.11 E-6) * (4.0 E-3) * (0.02478) = 2.83 E-7/yr.
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Helicopters	F =	8404 * (8.43 E-6) * (4.0 E-3) * (0.02301) = 6.52 E-6/yr.
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For takeoffs

Single-Engine Piston	F =	27065 * (1.25 E-5) * (4.5 E-3) * (0.02478) = 3.77 E-5/yr.
----------------------	-----	---

Multi-Engine Piston	F =	2705 * (1.06 E-5) * (4.5 E-3) * (0.02520) = 3.25 E-6/yr.
---------------------	-----	--

Turboprop	F =	930 * (4.67 E-6) * (4.5 E-3) * (0.02572) = 5.03 E-7/yr.
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Turbojet	F =	$558 * (1.85 \text{ E-}6) * (4.5 \text{ E-}3) * (0.02478) = 1.15 \text{ E-}7/\text{yr.}$
Helicopters	F =	$8404 * (6.17 \text{ E-}6) * (4.5 \text{ E-}3) * (0.02301) = 5.37 \text{ E-}6/\text{yr.}$

The combined (takeoffs and landings) General Aviation aircraft crash hit frequencies for Fiscal Year 1995 are:

Single-Engine Piston	F =	$9.54 \text{ E-}5/\text{yr.}$
Multi-Engine Piston	F =	$9.96 \text{ E-}6/\text{yr.}$
Turboprop	F =	$1.33 \text{ E-}6/\text{yr.}$
Turbojet	F =	$3.98 \text{ E-}7/\text{yr.}$
Helicopters	F =	$1.19 \text{ E-}5/\text{yr.}$

The combined (takeoffs and landings) fixed wing aircraft (summation of single-engine piston, multi-engine piston, turboprop, and turbojet) General Aviation aircraft crash hit frequency for Fiscal Year 1995 is $1.07 \text{ E-}4/\text{yr.}$

The combined (takeoffs and landings) total General Aviation aircraft (fixed wing and helicopter) crash hit frequency for Fiscal Year 1995 is $1.19 \text{ E-}4/\text{yr.}$

Similarly, the aircraft crash hit frequencies for General Aviation operations from the Livermore Municipal Airport for the Fiscal Year 1993-95 time period are:

For landings

Single-Engine Piston	F =	$31304 * (2.15 \text{ E-}5) * (4.0 \text{ E-}3) * (0.02478) = 6.67 \text{ E-}5/\text{yr.}$
Multi-Engine Piston	F =	$3129 * (2.46 \text{ E-}5) * (4.0 \text{ E-}3) * (0.02520) = 7.76 \text{ E-}6/\text{yr.}$
Turboprop	F =	$1076 * (8.65 \text{ E-}6) * (4.0 \text{ E-}3) * (0.02572) = 9.57 \text{ E-}7/\text{yr.}$
Turbojet	F =	$645 * (5.11 \text{ E-}6) * (4.0 \text{ E-}3) * (0.02478) = 3.27 \text{ E-}7/\text{yr.}$
Helicopters	F =	$9720 * (8.43 \text{ E-}6) * (4.0 \text{ E-}3) * (0.02301) = 7.54 \text{ E-}6/\text{yr.}$

For takeoffs

Single-Engine Piston	F =	$31304 * (1.25 \text{ E-}5) * (4.5 \text{ E-}3) * (0.02478) = 4.36 \text{ E-}5/\text{yr.}$
Multi-Engine Piston	F =	$3129 * (1.06 \text{ E-}5) * (4.5 \text{ E-}3) * (0.02520) = 3.76 \text{ E-}6/\text{yr.}$
Turboprop	F =	$1076 * (4.67 \text{ E-}6) * (4.5 \text{ E-}3) * (0.02572) = 5.82 \text{ E-}7/\text{yr.}$
Turbojet	F =	$645 * (1.85 \text{ E-}6) * (4.5 \text{ E-}3) * (0.02478) = 1.33 \text{ E-}7/\text{yr.}$
Helicopters	F =	$9720 * (6.17 \text{ E-}6) * (4.5 \text{ E-}3) * (0.02301) = 6.21 \text{ E-}6/\text{yr.}$

The combined (takeoffs and landings) General Aviation aircraft crash hit frequencies for Fiscal Years 1993-95 are:

Single-Engine Piston	F =	$1.10 \text{ E-}4/\text{yr.}$
Multi-Engine Piston	F =	$1.15 \text{ E-}5/\text{yr.}$
Turboprop	F =	$1.54 \text{ E-}6/\text{yr.}$
Turbojet	F =	$4.60 \text{ E-}7/\text{yr.}$
Helicopters	F =	$1.38 \text{ E-}5/\text{yr.}$

The combined (takeoffs and landings) fixed wing aircraft (summation of single-engine piston, multi-engine piston, turboprop, and turbojet) General Aviation aircraft crash hit frequency for Fiscal Years 1993-95 is $1.24 \text{ E-}4/\text{yr.}$

The combined (takeoffs and landings) total General Aviation aircraft (fixed wing and helicopter) crash hit frequency for Fiscal Years 1993-95 is $1.38 \text{ E-}4/\text{yr.}$

The aircraft crash hit frequencies for General Aviation operations from the Livermore Municipal Airport for the Fiscal Year 1991-95 time period are:

For landings

Single-Engine Piston	F =	$32109 * (2.15 \text{ E-}5) * (4.0 \text{ E-}3) * (0.02478) = 6.84 \text{ E-}5/\text{yr.}$
Multi-Engine Piston	F =	$3210 * (2.46 \text{ E-}5) * (4.0 \text{ E-}3) * (0.02520) = 7.96 \text{ E-}6/\text{yr.}$
Turboprop	F =	$1104 * (8.65 \text{ E-}6) * (4.0 \text{ E-}3) * (0.02572) = 9.82 \text{ E-}7/\text{yr.}$
Turbojet	F =	$662 * (5.11 \text{ E-}6) * (4.0 \text{ E-}3) * (0.02478) = 3.35 \text{ E-}7/\text{yr.}$
Helicopters	F =	$9970 * (8.43 \text{ E-}6) * (4.0 \text{ E-}3) * (0.02301) = 7.73 \text{ E-}6/\text{yr.}$

For takeoffs

Single-Engine Piston	F =	$32109 * (1.25 \text{ E-}5) * (4.5 \text{ E-}3) * (0.02478) = 4.48 \text{ E-}5/\text{yr.}$
Multi-Engine Piston	F =	$3210 * (1.06 \text{ E-}5) * (4.5 \text{ E-}3) * (0.02520) = 3.86 \text{ E-}6/\text{yr.}$
Turboprop	F =	$1104 * (4.67 \text{ E-}6) * (4.5 \text{ E-}3) * (0.02572) = 5.96 \text{ E-}7/\text{yr.}$
Turbojet	F =	$662 * (1.85 \text{ E-}6) * (4.5 \text{ E-}3) * (0.02478) = 1.37 \text{ E-}7/\text{yr.}$
Helicopters	F =	$9970 * (6.17 \text{ E-}6) * (4.5 \text{ E-}3) * (0.02301) = 6.37 \text{ E-}6/\text{yr.}$

The combined (takeoffs and landings) General Aviation aircraft crash hit frequencies for Fiscal Years 1991-95 are:

Single-Engine Piston	F =	$1.13 \text{ E-}4/\text{yr.}$
Multi-Engine Piston	F =	$1.18 \text{ E-}5/\text{yr.}$
Turboprop	F =	$1.58 \text{ E-}6/\text{yr.}$
Turbojet	F =	$4.72 \text{ E-}7/\text{yr.}$
Helicopters	F =	$1.41 \text{ E-}5/\text{yr.}$

The combined (takeoffs and landings) fixed wing aircraft (summation of single-engine piston, multi-engine piston, turboprop, and turbojet) General Aviation aircraft crash hit frequency for Fiscal Years 1991-95 is $1.27 \text{ E-}4/\text{yr.}$

The combined (takeoffs and landings) total General Aviation aircraft (fixed wing and helicopter) crash hit frequency for Fiscal Years 1991-95 is $1.41 \text{ E-}4/\text{yr.}$

The aircraft crash hit frequencies for General Aviation operations from the Livermore Municipal Airport for the 1986-95 time period are:

For landings

Single-Engine Piston	F =	$32089 * (2.15 \text{ E-}5) * (4.0 \text{ E-}3) * (0.02478) = 6.84 \text{ E-}5/\text{yr.}$
Multi-Engine Piston	F =	$3208 * (2.46 \text{ E-}5) * (4.0 \text{ E-}3) * (0.02520) = 7.95 \text{ E-}6/\text{yr.}$
Turboprop	F =	$1103 * (8.65 \text{ E-}6) * (4.0 \text{ E-}3) * (0.02572) = 9.81 \text{ E-}7/\text{yr.}$
Turbojet	F =	$662 * (5.11 \text{ E-}6) * (4.0 \text{ E-}3) * (0.02478) = 3.35 \text{ E-}7/\text{yr.}$
Helicopters	F =	$9964 * (8.43 \text{ E-}6) * (4.0 \text{ E-}3) * (0.02301) = 7.73 \text{ E-}6/\text{yr.}$

For takeoffs

Single-Engine Piston	F =	$32089 * (1.25 \text{ E-}5) * (4.5 \text{ E-}3) * (0.02478) = 4.47 \text{ E-}5/\text{yr.}$
Multi-Engine Piston	F =	$3208 * (1.06 \text{ E-}5) * (4.5 \text{ E-}3) * (0.02520) = 3.86 \text{ E-}6/\text{yr.}$
Turboprop	F =	$1103 * (4.67 \text{ E-}6) * (4.5 \text{ E-}3) * (0.02572) = 5.96 \text{ E-}7/\text{yr.}$
Turbojet	F =	$662 * (1.85 \text{ E-}6) * (4.5 \text{ E-}3) * (0.02478) = 1.36 \text{ E-}7/\text{yr.}$
Helicopters	F =	$9964 * (6.17 \text{ E-}6) * (4.5 \text{ E-}3) * (0.02301) = 6.36 \text{ E-}6/\text{yr.}$

The combined (takeoffs and landings) General Aviation aircraft crash hit frequencies for Fiscal Years 1986-95 are:

Single-Engine Piston	F =	$1.13 \text{ E-}4/\text{yr.}$
Multi-Engine Piston	F =	$1.18 \text{ E-}5/\text{yr.}$
Turboprop	F =	$1.58 \text{ E-}6/\text{yr.}$
Turbojet	F =	$4.72 \text{ E-}7/\text{yr.}$
Helicopters	F =	$1.41 \text{ E-}5/\text{yr.}$

The combined (takeoffs and landings) fixed wing aircraft (summation of single-engine piston, multi-engine piston, turboprop, and turbojet) General Aviation aircraft crash hit frequency for Fiscal Years 1986-95 is 1.27 E-4/yr.

The combined (takeoffs and landings) total General Aviation aircraft (fixed wing and helicopter) crash hit frequency for Fiscal Years 1986-95 is 1.41 E-4/yr.

5.4.2 GA Aircraft Crash Hit Frequency from Bay TRACON Aircraft Operations and Oakland ARTCC Aircraft Handled

A SAIC developed computer program called SHARK.EXE [Ref. 5.5] is used to determine the non-airport (in-flight) environment aircraft crash frequency. For the LLNL site, located at 37° 41' North latitude, 121° 42' West longitude, SHARK.EXE determines that the non-airport aircraft crash frequency is 1.33 E-4/mi.² for GA fixed wing aircraft, and 3.11 E-5/mi.² for GA helicopters. Multiplying by the NIF facilities effective target area of 0.02572 mi.² for fixed wing aircraft (based on largest fixed wing aircraft wingspan of 72.5 ft. for turboprops) and 0.02301 mi.² for helicopters gives an aircraft crash frequency for nonairport GA aircraft operations of 3.42 E-6/yr. for GA fixed wing aircraft and 7.16 E-6/yr. for GA helicopters.

5.4.3 GA Crash Hit Frequency, Total for All Flight Environments

The total General Aviation Aircraft Crash Hit Frequency for all flight environments is the sum of the General Aviation aircraft crash hit frequency due to airport operations and nonairport operations (TRACON and ARTCC). The SHARK.EXE code calculates aircraft crash frequency for fixed wing aircraft and helicopters separately, so the total General Aviation Aircraft Crash Hit Frequency is the sum of the aircraft crash hit frequencies for fixed wing aircraft and helicopters summed over the airport and nonairport flight environments.

$$F_{\text{total}} = [F_{\text{fixed wing/airport}} + F_{\text{fixed wing/nonairport}}] + [F_{\text{helicopter/airport}} + F_{\text{helicopter/nonairport}}]$$

For the 1995 Fiscal Year, the total aircraft crash hit frequency for General Aviation in all flight environments is:

$$F_{\text{total}} = [(1.07 \text{ E-4}) + (3.42 \text{ E-6})] + [(1.19 \text{ E-5}) + (7.16 \text{ E-7})] = 1.23 \text{ E-4/yr.}$$

Similarly, for 1993-95, $F_{\text{total}} = [(1.24 \text{ E-4}) + (3.42 \text{ E-6})] + [(1.38 \text{ E-5}) + (7.16 \text{ E-7})] = 1.42 \text{ E-4/yr.}$

For 1991-95, $F_{\text{total}} = [(1.27 \text{ E-4}) + (3.42 \text{ E-6})] + [(1.41 \text{ E-5}) + (7.16 \text{ E-7})] = 1.45 \text{ E-4/yr.}$

For 1986-95, $F_{\text{total}} = [(1.27 \text{ E-4}) + (3.42 \text{ E-6})] + [(1.41 \text{ E-5}) + (7.16 \text{ E-7})] = 1.45 \text{ E-4/yr.}$

5.5 NIF MILITARY AVIATION (MA) AIRCRAFT CRASH HIT FREQUENCY ESTIMATE

5.5.1 MA Aircraft Crash Hit Frequency from Livermore Municipal Airport Operations

From Table 2.1, there were 434 Military Aviation itinerant operations for Fiscal Year 1995 at the Livermore Municipal Airport of which 217 were landings and 217 were takeoffs. For Fiscal Years 1993-95, there were an average of 598 MA itinerant operations per year at Livermore of which 299 were landings, and 299 were takeoffs. For Fiscal Years 1991-95, there were an average of 624 MA itinerant operations at Livermore of which 312 were landings, and 312 were takeoffs. For Fiscal years 1986-95, there were an average of 522 MA itinerant operations at Livermore of which 261 were landings, and 261 were takeoffs. All Military Aviation itinerant takeoff operations were assumed to the East towards LLNL, and all Military Aviation itinerant landing operations were assumed to the West approaching over LLNL.

The crash rate for small military aircraft operations at the Livermore Municipal Airport was taken from Table 3.53, General Aviation Total Powered Aircraft Crash Rates by Flight Phase. The reason for using General Aviation crash rates for small Military Aviation aircraft operations is that the length of the longest runway (7Left/25Right, 5255 ft.) and the lack of suitable ground facilities at the Livermore Municipal Airport precludes operation of small high performance military aircraft except under special circumstances. Small military aircraft which would use the Livermore Municipal Airport would tend to be similar to General Aviation aircraft. A crash rate of 1.92 E-5/landing is used for small military aircraft during landings. A crash rate during takeoffs of 1.10 E-5/takeoff is used for small military aircraft during takeoffs.

The crash location probability for General Aviation was used for Military Aviation again because of the similarity of Military Aviation aircraft operations and General Aviation aircraft operations at the Livermore Municipal Airport. From Table 3.55, the crash location probability for Military Aviation at 5-6 miles from the runway on the runway centerline while on approach was found to be 4.0 E-3. From Table 3.54, the crash location probability for Military Aviation at 5-6 miles from the runway on the runway centerline while on departure was found to be 4.5 E-3.

From Ref. 5.2, the NIF facility effective target area, A_t , is equal to the fly-in area, A_f , and the skid-in area, A_s .

$$A_t = A_s + A_f$$

where

$$A_s = (WS + R) * S$$

$$A_f = [(WS + R) * H * \cot \phi] + [(2 * L * W * WS)/R] + (L * W)$$

WS = aircraft wingspan, for General Aviation aircraft = 60 ft. [Ref. 5.2]

L = facility length, for NIF = 656 ft. [Ref. 5.1]

W = facility width, for NIF = 410 ft. [Ref. 5.1]

R = diagonal dimension of the facility = $(L^2 + W^2)^{1/2} = 773.59$ ft.

H = facility height, for NIF = 50 ft. [Ref. 5.1]

$\cot \phi$ = mean cotangent of aircraft impact angle,

for Air Carrier aircraft on landing = 10.2 [Ref. 5.2]

for Air Carrier aircraft on takeoff = 10.2 [Ref. 5.2]

S = General Aviation aircraft 90 percentile skid length

on landing = 230 ft. [Ref. 5.2]

on takeoff = 230 ft. [Ref. 5.2]

For landing

$$A_s = (110 + 773.59) * 230 = 191,725 \text{ ft}^2 = 0.00688 \text{ mi}^2.$$

For takeoff

$$A_s = (110 + 773.59) * 230 = 191,725 \text{ ft}^2 = 0.00688 \text{ mi}^2.$$

For landing

$$\begin{aligned} A_f &= [(110 + 773.59) * 50 * 10.2] + [(2 * 656 * 410 * 110) / 773.59] + (656 * 410) \\ &= 735,811 \text{ ft}^2 = 0.02639 \text{ mi}^2. \end{aligned}$$

For takeoff

$$\begin{aligned} A_f &= [(110 + 773.59) * 50 * 10.2] + [(2 * 656 * 410 * 110) / 773.59] + (656 * 410) \\ &= 735,810 \text{ ft}^2 = 0.02639 \text{ mi}^2. \end{aligned}$$

For landing

$$A_t = 0.00688 \text{ mi}^2 + 0.02639 \text{ mi}^2 = 0.03327 \text{ mi}^2.$$

For landing

$$A_t = 0.00688 \text{ mi}^2 + 0.02639 \text{ mi}^2 = 0.03327 \text{ mi}^2.$$

The aircraft crash hit frequency for Military Aviation aircraft operations from the Livermore Municipal Airport for the 1995 Fiscal Year is:

$$F = N * P * f(x,y) * A_t$$

$$\begin{aligned} F &= (217) * (1.92 \text{ E-}5) * (4.0 \text{ E-}3) * (0.03327) \text{ for landing} \\ &= 5.54 \text{ E-}7/\text{yr}. \end{aligned}$$

$$\begin{aligned} F &= (217) * (1.10 \text{ E-}5) * (4.5 \text{ E-}3) * (0.03327) \text{ for takeoff} \\ &= 3.57 \text{ E-}7/\text{yr}. \end{aligned}$$

The total aircraft crash hit frequency, F, due to Military Aviation aircraft operations from the Livermore Municipal Airport for the 1995 Fiscal Year is 9.12 E-7/yr.

Similarly, for the Fiscal Year 1993-95 time period:

$$\begin{aligned} F &= (299) * (1.92 \text{ E-}5) * (4.0 \text{ E-}3) * (0.03327) \text{ for landing} \\ &= 7.64 \text{ E-}7/\text{yr}. \end{aligned}$$

$$\begin{aligned} F &= (299) * (1.10 \text{ E-}5) * (4.5 \text{ E-}3) * (0.03327) \text{ for takeoff} \\ &= 4.92 \text{ E-}7/\text{yr}. \end{aligned}$$

The total aircraft crash hit frequency, F, due to Military Aviation aircraft operations from the Livermore Municipal Airport for Fiscal Years 1993-95 is 1.26 E-6/yr.

For the Fiscal Year 1991-95 time period:

$$\begin{aligned} F &= (312) * (1.92 \text{ E-}5) * (4.0 \text{ E-}3) * (0.03327) \text{ for landing} \\ &= 7.97 \text{ E-}7/\text{yr}. \end{aligned}$$

$$F = (312) * (1.10 \text{ E-}5) * (4.5 \text{ E-}3) * (0.03327) \text{ for takeoff}$$

$$= 5.14 \text{ E-7/yr.}$$

The total aircraft crash hit frequency, F, due to Military Aviation aircraft operations from the Livermore Municipal Airport for Fiscal Years 1991-95 is 1.31 E-6/yr.

For the Fiscal year 1986-95 time period:

$$\begin{aligned} F &= (261) * (1.92 \text{ E-5}) * (4.0 \text{ E-3}) * (0.03327) \text{ for landing} \\ &= 6.67 \text{ E-7/yr.} \end{aligned}$$

$$\begin{aligned} F &= (261) * (1.10 \text{ E-5}) * (4.5 \text{ E-3}) * (0.03327) \text{ for takeoff} \\ &= 4.30 \text{ E-7/yr.} \end{aligned}$$

The total aircraft crash hit frequency, F, due to Military Aviation aircraft operations from the Livermore Municipal Airport for Fiscal Years 1986-95 is 1.10 E-6/yr.

5.5.2 MA Aircraft Crash Hit Frequency from Bay TRACON Aircraft Operations

From Table 2.2, it was found that for Fiscal Year 1995, a total of 22,255 Military Aviation instrument operations were performed by the Bay TRACON. Since no military air units are assigned at the Oakland International Airport and the San Francisco International Airport, a survey of the Military Aviation airport operations at OAK and SFO is not done. Assuming 75% of the FY1995 total are MA approaches and departures from the Southeast, East, and Northeast yields 16,691 of which half or 8,346 are approaches over Livermore, and half or 8,346 are departures over Livermore. Because of the recent shutdown of the Moffet Naval Air Station (NAS) (which formerly based patrol squadrons for the U.S. Navy) and the Alameda NAS (which formerly based carrier air wings for the U.S. Navy), and Fort Ord, the number of large military aircraft, small high performance aircraft and military helicopters which were handled by the Bay TRACON in 1995 has been reduced. Therefore, 30% of the total military instrument operations performed by the Bay TRACON were assumed to be small low performance military aircraft, 30% were assumed to be small high performance military aircraft, 30% were assumed to be large military aircraft, and 10% were assumed to be military helicopters.

Similarly, for the Fiscal Year 1993-95 time period, from Tables 2.2, 10,698 MA approaches and 10,698 MA departures were performed over Livermore per year. During this time period, Moffet NAS, Alameda NAS and Ford Ord were in the process of closing. Therefore, 10% of the total military instrument operations performed by the Bay TRACON were assumed to be small low performance military aircraft, 40% were assumed to be small high performance military aircraft, 30% were assumed to be large military aircraft, and 20% were military helicopters.

For the Fiscal Year 1991-95 time period, from Tables 2.2, 12,264 MA approaches and 12,264 MA departures were performed over Livermore per year. The distribution of military aircraft subcategories was assumed to be similar as for the 1993-95 time period.

For the Fiscal year 1986-95 time period, from Tables 2.2, 21,265 MA approaches and 21,265 MA departures were performed over Livermore per year. The distribution of military aircraft subcategories was assumed to be similar as for the 1993-95 time period.

The crash rates for Military Aviation were calculated from data taken from Table 3.56. The crash rates are calculated in Section 3.5.1. The crash rates for small low performance military aircraft are 9.95 E-8/mile for landing, and 3.32 E-8/mile for takeoff. The crash rates for small high performance military aircraft are 1.66 E-7/mile for landing, and 9.43 E-8/mile for takeoff. The crash rates for large military aircraft are 8.51 E-8/mile for landing, and 3.15 E-8/mile for takeoff. The crash rates for military helicopter are 1.43 E-7/mile for land, and 4.28 E-8/mile for takeoff. Again, a distance of 20 statute miles was assumed for the distance traveled on each approach and departure.

The radius of the potential area affected by a distressed aircraft, R_p , was set equal to glide ratio of the aircraft, g , times the height of aircraft when the initiating event occurred. For the Madwin3 arrival approach procedure for the San Francisco Bay area [Ref. 5.3], the assigned altitude is no greater than 11,000 feet. A glide ratio of 15 was assume to be the maximum glide ratio for Military Aviation aircraft [Ref. 5.4] so, R_p is 15 x 11,000 feet or 165,000 feet or 31.25 miles.

From Ref. 5.2, the NIF facility effective target area, A_t , is equal to the fly-in area, A_f , and the skid-in area, A_s .

$$A_t = A_s + A_f$$

where

$$A_s = (WS + R) * S$$

$$A_f = [(WS + R) * H * \cot \phi] + [(2 * L * W * WS)/R] + (L * W)$$

For all military aircraft subcategories

L = facility length, for NIF = 656 ft. [Ref. 5.1]

W = facility width, for NIF = 410 ft. [Ref. 5.1]

R = diagonal dimension of the facility = $(L^2 + W^2)^{1/2} = 773.59$ ft.

H = facility height, for NIF = 50 ft. [Ref. 5.1]

For small low performance military aircraft

WS = aircraft wingspan = 110 ft. [Ref. 5.2]

$\cot \phi$ = mean cotangent of aircraft impact angle, landing = 10.4 [Ref. 5.2]

$\cot \phi$ = mean cotangent of aircraft impact angle, takeoff = 8.4 [Ref. 5.2]

S = aircraft skid length, landing = 447 ft. [Ref. 5.2]

S = aircraft skid length, takeoff = 246 ft. [Ref. 5.2]

Skid-in area for landing

$$A_s = (110 + 773.59) * 447 = 394,963 \text{ ft}^2 = 0.01417 \text{ mi}^2.$$

Skid-in area for takeoff

$$A_s = (110 + 773.59) * 246 = 217,362 \text{ ft}^2 = 0.00780 \text{ mi}^2.$$

Fly-in area for landing

$$A_f = [(110 + 773.59) * 50 * 10.4] + [(2 * 656 * 410 * 110)/773.59] + (656 * 410)$$

$$= 804,914 \text{ ft}^2 = 0.02887 \text{ mi}^2.$$

Fly-in area for takeoff

$$A_f = [(110 + 773.59) * 50 * 8.4] + [(2 * 656 * 410 * 110)/773.59] + (656 * 410)$$

$$= 716,556 \text{ ft}^2 = 0.02570 \text{ mi}^2.$$

Total effective area for landing

$$A_t = 0.01417 \text{ mi}^2 + 0.02887 \text{ mi}^2 = 0.04304 \text{ mi}^2.$$

Total effective area for takeoff

$$A_t = 0.00780 \text{ mi}^2 + 0.02570 \text{ mi}^2 = 0.03350 \text{ mi}^2.$$

For small high performance military aircraft

WS = aircraft wingspan = 78 ft. [Ref. 5.2]

$\cot \phi$ = mean cotangent of aircraft impact angle, landing = 10.4 [Ref. 5.2]

$\cot \phi$ = mean cotangent of aircraft impact angle, takeoff = 8.4 [Ref. 5.2]

S = aircraft skid length, landing = 447 ft. [Ref. 5.2]

S = aircraft skid length, takeoff = 246 ft. [Ref. 5.2]

Skid-in area for landing

$$A_S = (78 + 773.59) * 447 = 380,659 \text{ ft}^2 = 0.01365 \text{ mi}^2.$$

Skid-in area for takeoff

$$A_S = (78 + 773.59) * 246 = 209,490 \text{ ft}^2 = 0.00751 \text{ mi}^2.$$

Fly-in area for landing

$$\begin{aligned} A_f &= [(78 + 773.59) * 50 * 10.4] + [(2 * 656 * 410 * 78) / 773.59] + (656 * 410) \\ &= 766,023 \text{ ft}^2 = 0.02748 \text{ mi}^2. \end{aligned}$$

Fly-in area for takeoff

$$\begin{aligned} A_f &= [(78 + 773.59) * 50 * 8.4] + [(2 * 656 * 410 * 78) / 773.59] + (656 * 410) \\ &= 680,864 \text{ ft}^2 = 0.02442 \text{ mi}^2. \end{aligned}$$

Total effective area for landing

$$A_t = 0.01365 \text{ mi}^2 + 0.02748 \text{ mi}^2 = 0.04113 \text{ mi}^2.$$

Total effective area for takeoff

$$A_t = 0.00751 \text{ mi}^2 + 0.02442 \text{ mi}^2 = 0.03194 \text{ mi}^2.$$

For large military aircraft,

WS = aircraft wingspan = 223 ft. [Ref. 5.2]

$\cot \phi$ = mean cotangent of aircraft impact angle, landing = 9.7 [Ref. 5.2]

$\cot \phi$ = mean cotangent of aircraft impact angle, takeoff = 7.4 [Ref. 5.2]

S = aircraft skid length, landing = 368 ft. [Ref. 5.2]

S = aircraft skid length, takeoff = 780 ft. [Ref. 5.2]

Skid-in area for landing

$$A_S = (223 + 773.59) * 368 = 366,744 \text{ ft}^2 = 0.01316 \text{ mi}^2.$$

Skid-in area for takeoff

$$A_S = (223 + 773.59) * 780 = 777,337 \text{ ft}^2 = 0.02788 \text{ mi}^2.$$

Fly-in area for landing

$$\begin{aligned} A_f &= [(223 + 773.59) * 50 * 9.7] + [(2 * 656 * 410 * 223) / 773.59] + (656 * 410) \\ &= 907,369 \text{ ft}^2 = 0.03255 \text{ mi}^2. \end{aligned}$$

Fly-in area for takeoff

$$\begin{aligned} A_f &= [(223 + 773.59) * 50 * 7.4] + [(2 * 656 * 410 * 223) / 773.59] + (656 * 410) \\ &= 792,762 \text{ ft}^2 = 0.02844 \text{ mi}^2. \end{aligned}$$

Total effective area for landing

$$A_t = 0.01316 \text{ mi}^2 + 0.03255 \text{ mi}^2 = 0.04570 \text{ mi}^2.$$

Total effective area for takeoff

$$A_t = 0.02788 \text{ mi}^2 + 0.02844 \text{ mi}^2 = 0.05632 \text{ mi}^2.$$

For military helicopter,

WS = aircraft wingspan = 50 ft. [Ref. 5.2]

cot ϕ = mean cotangent of aircraft impact angle = 0.58 [Ref. 5.2]

S = aircraft skid length = 0 ft. [Ref. 5.2]

Skid-in area

$$A_s = (50 + 773.59) * 0 = 0 \text{ ft}^2 = 0 \text{ mi}^2.$$

Fly-in area

$$\begin{aligned} A_f &= [(50 + 773.59) * 50 * 0.58] + [(2 * 656 * 410 * 50) / 773.59] + (656 * 410) \\ &= 327,612 \text{ ft}^2 = 0.01175 \text{ mi}^2. \end{aligned}$$

Total effective area

$$A_t = 0 \text{ mi}^2 + 0.01175 \text{ mi}^2 = 0.01175 \text{ mi}^2.$$

The aircraft crash hit frequencies for Military Aviation aircraft operations in the Bay TRACON flight environment for the 1995 Fiscal Year are:

$$F = N * CR * (4/\pi^2) * (1/R_p) * A_t$$

For landing approaches

$$\text{Small, low perf. AC} \quad F = 2504 * (9.95 \text{ E-}8) * (4/\pi^2) * (1/31.25) * (0.04304) = 1.39 \text{ E-}7/\text{yr.}$$

$$\text{Small, high perf. AC} \quad F = 2504 * (1.66 \text{ E-}7) * (4/\pi^2) * (1/31.25) * (0.04113) = 2.22 \text{ E-}7/\text{yr.}$$

$$\text{Large AC} \quad F = 2504 * (8.51 \text{ E-}8) * (4/\pi^2) * (1/31.25) * (0.04570) = 1.26 \text{ E-}7/\text{yr.}$$

$$\text{Helicopter} \quad F = 835 * (1.43 \text{ E-}7) * (4/\pi^2) * (1/31.25) * (0.01175) = 1.82 \text{ E-}8/\text{yr.}$$

The total military aircraft crash hit frequency for landing approaches for 1995 is 5.05 E-7/yr.

For departures

$$\text{Small, low perf. AC} \quad F = 2504 * (3.32 \text{ E-}8) * (4/\pi^2) * (1/31.25) * (0.03350) = 3.61 \text{ E-}8/\text{yr.}$$

$$\text{Small, high perf. AC} \quad F = 2504 * (9.43 \text{ E-}8) * (4/\pi^2) * (1/31.25) * (0.03194) = 9.78 \text{ E-}8/\text{yr.}$$

$$\text{Large AC} \quad F = 2504 * (3.15 \text{ E-}8) * (4/\pi^2) * (1/31.25) * (0.05632) = 5.76 \text{ E-}8/\text{yr.}$$

$$\text{Helicopter} \quad F = 835 * (4.28 \text{ E-}8) * (4/\pi^2) * (1/31.25) * (0.01175) = 5.44 \text{ E-}9/\text{yr.}$$

The total military aircraft crash hit frequency for departures for 1995 is 1.97 E-7/yr.

The total military aircraft crash hit frequency for 1995 is 7.02 E-7/yr.

The aircraft crash hit frequencies for Military Aviation aircraft operations in the Bay TRACON flight environment for the 1993-95 Fiscal Years are:

$$F = N * CR * (4/\pi^2) * (1/R_p) * A_t$$

For landing approaches

$$\text{Small, low perf. AC } F = 1070 * (9.95 \text{ E-8}) * (4/\pi^2) * (1/31.25) * (0.04304) = 5.94 \text{ E-8/yr.}$$

$$\text{Small, high perf. AC } F = 4279 * (1.66 \text{ E-7}) * (4/\pi^2) * (1/31.25) * (0.04113) = 3.79 \text{ E-7/yr.}$$

$$\text{Large AC } F = 3210 * (8.51 \text{ E-8}) * (4/\pi^2) * (1/31.25) * (0.04570) = 1.62 \text{ E-7/yr.}$$

$$\text{Helicopter } F = 2140 * (1.43 \text{ E-7}) * (4/\pi^2) * (1/31.25) * (0.01175) = 4.66 \text{ E-8/yr.}$$

The total military aircraft crash hit frequency for landing approaches for 1993-95 is 6.47 E-7/yr.

For departures

$$\text{Small, low perf. AC } F = 1070 * (3.32 \text{ E-8}) * (4/\pi^2) * (1/31.25) * (0.03350) = 1.54 \text{ E-8/yr.}$$

$$\text{Small, high perf. AC } F = 4279 * (9.43 \text{ E-8}) * (4/\pi^2) * (1/31.25) * (0.03194) = 1.67 \text{ E-7/yr.}$$

$$\text{Large AC } F = 3210 * (3.15 \text{ E-8}) * (4/\pi^2) * (1/31.25) * (0.05632) = 7.38 \text{ E-8/yr.}$$

$$\text{Helicopter } F = 2140 * (4.28 \text{ E-8}) * (4/\pi^2) * (1/31.25) * (0.01175) = 1.40 \text{ E-8/yr.}$$

The total military aircraft crash hit frequency for departures for 1993-95 is 2.70 E-7/yr.

The total military aircraft crash hit frequency for 1993-95 is 9.17 E-7/yr.

The aircraft crash hit frequencies for Military Aviation aircraft operations in the Bay TRACON flight environment for the 1991-95 Fiscal Years are:

$$F = N * CR * (4/\pi^2) * (1/R_p) * A_t$$

For landing approaches

$$\text{Small, low perf. AC } F = 1226 * (9.95 \text{ E-8}) * (4/\pi^2) * (1/31.25) * (0.04304) = 6.81 \text{ E-8/yr.}$$

$$\text{Small, high perf. AC } F = 4906 * (1.66 \text{ E-7}) * (4/\pi^2) * (1/31.25) * (0.04113) = 4.34 \text{ E-7/yr.}$$

$$\text{Large AC } F = 3679 * (8.51 \text{ E-8}) * (4/\pi^2) * (1/31.25) * (0.04570) = 1.86 \text{ E-7/yr.}$$

$$\text{Helicopter } F = 2453 * (1.43 \text{ E-7}) * (4/\pi^2) * (1/31.25) * (0.01175) = 5.35 \text{ E-8/yr.}$$

The total military aircraft crash hit frequency for landing approaches for 1991-95 is 7.42 E-7/yr.

For departures

$$\text{Small, low perf. AC } F = 1226 * (3.32 \text{ E-8}) * (4/\pi^2) * (1/31.25) * (0.03350) = 1.77 \text{ E-8/yr.}$$

$$\text{Small, high perf. AC } F = 4906 * (9.43 \text{ E-8}) * (4/\pi^2) * (1/31.25) * (0.03194) = 1.92 \text{ E-7/yr.}$$

$$\text{Large AC } F = 3679 * (3.15 \text{ E-8}) * (4/\pi^2) * (1/31.25) * (0.05632) = 8.47 \text{ E-8/yr.}$$

$$\text{Helicopter } F = 2453 * (4.28 \text{ E-8}) * (4/\pi^2) * (1/31.25) * (0.01175) = 1.60 \text{ E-8/yr.}$$

The total military aircraft crash hit frequency for departures for 1991-95 is 3.10 E-7/yr.

The total military aircraft crash hit frequency for 1991-95 is 1.05 E-6/yr.

The aircraft crash hit frequencies for Military Aviation aircraft operations in the Bay TRACON flight environment for the 1986-95 Fiscal Years are:

$$F = N * CR * (4/\pi^2) * (1/R_p) * A_t$$

For landing approaches

Small, low perf. AC	F=	2127 * (9.95 E-8) * (4/ π^2) * (1/31.25) * (0.04304) = 1.18 E-7/yr.
Small, high perf. AC	F=	8506 * (1.66 E-7) * (4/ π^2) * (1/31.25) * (0.04113) = 7.53 E-7/yr.
Large AC	F=	6380 * (8.51 E-8) * (4/ π^2) * (1/31.25) * (0.04570) = 3.22 E-7/yr.
Helicopter	F=	4253 * (1.43 E-7) * (4/ π^2) * (1/31.25) * (0.01175) = 9.27 E-8/yr.

The total military aircraft crash hit frequency for landing approaches for 1986-95 is 1.29 E-6/yr.

For departures

Small, low perf. AC	F=	2127 * (3.32 E-8) * (4/ π^2) * (1/31.25) * (0.03350) = 3.07 E-8/yr.
Small, high perf. AC	F=	8506 * (9.43 E-8) * (4/ π^2) * (1/31.25) * (0.03194) = 3.32 E-7/yr.
Large AC	F=	6380 * (3.15 E-8) * (4/ π^2) * (1/31.25) * (0.05632) = 1.47 E-7/yr.
Helicopter	F=	4253 * (4.28 E-8) * (4/ π^2) * (1/31.25) * (0.01175) = 2.77 E-8/yr.

The total military aircraft crash hit frequency for departures for 1986-95 is 5.37 E-7/yr.

The total military aircraft crash hit frequency for 1986-95 is 1.82 E-6/yr.

5.5.3 MA Aircraft Crash Hit Frequency from Oakland ARTCC Aircraft Handled

From Table 2.7, 195,476 Military Aviation IFR aircraft were handled by the Oakland ARTCC in Fiscal Year 1995. For the Fiscal Year 1993-95 time period, an average of 207,251 MA aircraft were handled per year by the Oakland ARTCC. For the Fiscal Year 1991-95 time period, an average of 273,821 MA aircraft were handled per year by the Oakland ARTCC. For the Fiscal Year 1986-95 time period, an average of 322,092 MA aircraft were handled per year by the Oakland ARTCC. The distribution of high altitude overflights by military aircraft were assumed to be 5% small low performance military aircraft, 55% small high performance military aircraft, and 40% large military aircraft. It is also assumed that few, if any military helicopters are able to operate in ARTCC airspace.

From Ref. 5.5 and Table 3.56, the crash rate for small military aircraft was 4.36 E-6/aircraft handled based on 105 accidents and 24,102,000 sorties for the 1976-93 time period. The crash rate for large military aircraft was 1.23 E-6/aircraft handled based on 9 accidents and 7,289,000 sorties for the 1976-93 time period. The crash rates for military aircraft in ARTCC airspace are expected to be conservatively high because all military aircraft accidents during the 1976-93 time period were included, not just those accidents which occurred while in ARTCC airspace.

The area of the airspace controlled by the Oakland ARTCC has been determined in Ref. 5.5 to be 100,478 mile².

The NIF facility effective target area is as determined in Section 5.5.1 above using the larger of the takeoff or landing effective target area.

The aircraft crash hit frequencies for Military Aviation aircraft operations in the Oakland ARTCC flight environment for the 1995 Fiscal Year are:

$$F = N_c * P_c * (1/A_c) * A_t$$

Small, low perf. AC	F=	$9774 * (4.36 \text{ E-}6) * (1/100478) * (0.04304) = 1.82 \text{ E-}8/\text{yr.}$
Small, high perf. AC	F=	$107512 * (4.36 \text{ E-}6) * (1/100478) * (0.04113) = 1.92 \text{ E-}7/\text{yr.}$
Large AC	F=	$78190 * (1.23 \text{ E-}6) * (1/100478) * (0.05632) = 5.41 \text{ E-}8/\text{yr.}$

The total military aircraft crash hit frequency for 1995 is $2.64 \text{ E-}7/\text{yr.}$

The aircraft crash hit frequencies for Military Aviation aircraft operations in the Oakland ARTCC flight environment for the 1993-95 Fiscal Years are:

$$F = N_c * P_c * (1/A_c) * A_t$$

Small, low perf. AC	F=	$10363 * (4.36 \text{ E-}6) * (1/100478) * (0.04304) = 1.93 \text{ E-}8/\text{yr.}$
Small, high perf. AC	F=	$113988 * (4.36 \text{ E-}6) * (1/100478) * (0.04113) = 2.03 \text{ E-}7/\text{yr.}$
Large AC	F=	$82900 * (1.23 \text{ E-}6) * (1/100478) * (0.05632) = 5.74 \text{ E-}8/\text{yr.}$

The total military aircraft crash hit frequency for 1993-95 is $2.80 \text{ E-}7/\text{yr.}$

The aircraft crash hit frequencies for Military Aviation aircraft operations in the Oakland ARTCC flight environment for the 1991-95 Fiscal Years are:

$$F = N_c * P_c * (1/A_c) * A_t$$

Small, low perf. AC	F=	$13691 * (4.36 \text{ E-}6) * (1/100478) * (0.04304) = 2.55 \text{ E-}8/\text{yr.}$
Small, high perf. AC	F=	$150602 * (4.36 \text{ E-}6) * (1/100478) * (0.04113) = 2.69 \text{ E-}7/\text{yr.}$
Large AC	F=	$109528 * (1.23 \text{ E-}6) * (1/100478) * (0.05632) = 7.58 \text{ E-}8/\text{yr.}$

The total military aircraft crash hit frequency for 1991-95 is $3.70 \text{ E-}7/\text{yr.}$

The aircraft crash hit frequencies for Military Aviation aircraft operations in the Oakland ARTCC flight environment for the 1986-95 Fiscal Years are:

$$F = N_c * P_c * (1/A_c) * A_t$$

Small, low perf. AC	F=	$16105 * (4.36 \text{ E-}6) * (1/100478) * (0.04304) = 3.01 \text{ E-}8/\text{yr.}$
Small, high perf. AC	F=	$177151 * (4.36 \text{ E-}6) * (1/100478) * (0.04113) = 3.16 \text{ E-}7/\text{yr.}$
Large AC	F=	$128837 * (1.23 \text{ E-}6) * (1/100478) * (0.05632) = 8.92 \text{ E-}8/\text{yr.}$

The total military aircraft crash hit frequency for 1986-95 is $4.35 \text{ E-}7/\text{yr.}$

5.5.4 MA Crash Hit Frequency. Total for All Flight Environments

The total Military Aviation Crash Hit Frequency for all flight environments is the sum of the Military Aviation aircraft crash hit frequency due to airport operations, TRACON operations, and ARTCC operations.

For the 1995 Fiscal Year, the total aircraft crash hit frequency for Military Aviation in all flight environments is:

$$F_{\text{total}} = (9.12 \text{ E-}7) + (7.02 \text{ E-}7) + (2.64 \text{ E-}7) = 1.88 \text{ E-}6/\text{yr.}$$

Similarly, for Fiscal Years 1993-95, $F_{\text{total}} = (1.26 \text{ E-}6) + (9.17 \text{ E-}7) + (2.80 \text{ E-}7) = 2.45 \text{ E-}6/\text{yr.}$

For Fiscal Years 1991-95, $F_{\text{total}} = (1.31 \text{ E-6}) + (1.05 \text{ E-6}) + (3.70 \text{ E-7}) = 2.73 \text{ E-6/yr.}$

For Fiscal Years 1986-95, $F_{\text{total}} = (1.10 \text{ E-6}) + (1.82 \text{ E-6}) + (4.35 \text{ E-7}) = 3.36 \text{ E-6/yr.}$

5.6 NIF TOTAL AIRCRAFT CRASH HIT FREQUENCY ESTIMATE

The total aircraft crash hit frequencies for the NIF facilities due to all aircraft operations in all flight environments is the sum of the aircraft crash hit frequencies for Air Carriers, Air Taxis, General Aviation and Military Aviation. The results for Fiscal Year 1995, Fiscal Years 1993-95, 1991-95 and 1986-95 are presented below.

	AIR CARRIERS	AIR TAXIS	GENERAL AVIATION	MILITARY AVIATION	TOTAL
1995	4.95 E-7/yr. Sec. 5.2.4	9.80 E-6/yr. Sec. 5.3.4	1.23 E-4/yr. Sec. 5.4.3	1.88 E-6/yr. Sec. 5.5.4	1.35 E-4/yr.
1993-95 Average	4.61 E-7/yr. Sec. 5.2.4	1.05 E-5/yr. Sec. 5.3.4	1.42 E-4/yr. Sec. 5.4.3	2.45 E-6/yr. Sec. 5.5.4	1.55 E-4/yr.
1991-95 Average	4.53 E-7/yr. Sec. 5.2.4	1.03 E-5/yr. Sec. 5.3.4	1.45 E-4/yr. Sec. 5.4.3	2.73 E-6/yr. Sec. 5.5.4	1.59 E-4/yr.
1986-95 Average	4.37 E-7/yr. Sec. 5.2.4	9.63 E-6/yr. Sec. 5.3.4	1.45 E-4/yr. Sec. 5.4.3	3.36 E-6/yr. Sec. 5.5.4	1.59 E-4/yr.

As can be seen by the numbers presented above, the aircraft crash hit frequency for the NIF facilities is dominated by General Aviation, constituting about 91% of the total frequency. Air Taxis represent the next most important component of the aircraft crash hit frequency for the NIF facilities, constituting about 7% of the total frequency. Air Carriers and Military Aviation constitute only a minor part of the total frequency. In terms of the flight environment, about 90% of the total aircraft crash hit frequency is due to aircraft operations at the Livermore Municipal Airport. The Bay TRACON aircraft operations represent about 7% of the total frequency. The Oakland ARTCC aircraft operations represent about 3% of the total aircraft crash hit frequency.

Figure 5.1

Layout of LLNL Site 200 Showing Location of NIF
[Ref. 5.1]

Figure 5.2

Proposed Location for NIF at LLNL Site 200
[Ref. 5.1]

Figure 5.3
Layout of NIF Laser and Target Area Building (LTAB)
[Ref. 5.1]

Figure 5.4

NIF Laser and Target Area Building (LTAB) Floor Plan
[Ref. 5.1]

Figure 5.5

NIF Laser and Target Area Building (LTAB) Cross-Sectional View
 [Ref. 5.1]

5.7 REFERENCES

- [5.1] National Ignition Facility Preliminary Safety Analysis Report, UCRL-ID-123759/NIF-LLNL-96-238, Lawrence Livermore National Laboratory, Livermore, CA, September 30, 1996.
- [5.2] Accident Analysis for Aircraft Crash into Hazardous Facilities. DOE Standard DOE-STD-3014-96, U.S. Department of Energy, Washington, DC, October 1996.
- [5.3] U.S. Terminal Procedures, Southwest (SW) Vol. 2 of 2, National Oceanic and Atmospheric Administration, National Ocean Service, Silver Springs, MD, effective 30 January, 1997 to 27 March, 1997.
- [5.4] Quest for Performance, the Evolution of Modern Aircraft, NASA SP-468, Laurence K. Loftin, Jr., National Aeronautics and Space Administration, Scientific and Technical Information Branch, Washington, DC, 1985.
- [5.5] Data Development Technical Support Document for the Aircraft Crash Risk Analysis Methodology (ACRAM) Standard, UCRL-ID-124837, Rev. 1, Chris Y. Kimura, Ronald E. Glaser, Richard W. Mensing, Tom Lin, Timothy A. Haley, Andrew B. Barto, and Martin A. Stutzke, Lawrence Livermore National Laboratory, Livermore, CA, September 26, 1996.

Appendix to Section 5

A5.1 NIF Aircraft Crash Hit Frequency Calculation Spreadsheet

AIR CARRIERS

Livermore Municipal Airport (LVK) ATCT

Operations, N

1995 0

0

1993-95

Average

0

0

1991-95

Average

0

0

1988-95

Average

0.1

0.1

Crash Rate,
CR

/Landing

3.85E-07

/Takeoff

2.86E-07

/Landing

3.85E-07

/Takeoff

2.86E-07

/Landing

3.85E-07

/Takeoff

2.86E-07

/Landing

3.85E-07

/Takeoff

2.86E-07

Crash
Location

1.72E-02

3.95E-03

1.72E-02

3.95E-03

1.72E-02

3.95E-03

1.72E-02

3.95E-03

Facility
Area, At
mi.^2

0.07325

0.07325

0.07325

0.07325

0.07325

0.07325

0.07325

0.07325

Facility
Crash Hit
Frequency

0

0

0

0

0

0

4.80E-11

8.27E-12

Total: 5.43E-11

NOTES

Table 3.9, Crash rate for 14 CFR 121 flight operations for 1973-1994, accidents with destroyed or major damage to airframe, runway approach flight phase for airport landing operations

Table 3.9, Crash rate for 14 CFR 121 flight operations for 1973-1994, accidents with destroyed or major damage to airframe initial climb flight phase for airport takeoff operations

Table 3.11, Crash location for Air Carriers at 5miles from runway centerline for landings

Table 3.10, Crash location for Air Carriers at 5 miles from runway centerline for takeoffs

NIF Effective Area Calculation

WS = Wing Span, for 14 CFR 121 Air Carriers (ft.) = 100
L = facility length (ft.) = 856
W = facility width (ft.) = 410
R = diagonal dimension of the facility (ft.) = $(L^2 + W^2)^{.50}$ = 773.59
H = facility height (ft.) = 50
S = 14 CFR 121 Air Carrier Skid Distance (ft.) = 1440
cot θ = 10.2

Skid-In Area = $(WS + R) * S$ ft.^2 mi.^2
 $(100+773.59)*1440$ 1257984.49 0.04512

Fly-In Area = $((WS+R)*H*cot\theta) + ((2*L*W*WS)/R) + (L*W)$
 $((100+773.59)*50*10.2) + ((2*856*410)/773.59) + (856*410)$
784024.95 0.02812

Effective Area = Skid-In Area + Fly-In Area 2041989.44 0.07325

Bay TRACON (C90)

$$FP = N \cdot CR \cdot (4/\pi)^2 \cdot (1/Rp) \cdot At$$

	IFR Aircraft Handled	OAK Inst. Operations	SFO Inst. Operations	OAK+SFO Inst. Ops.		Crash Rate, CR (/mi.)	(4/pi)^2	(1/Rp)	Facility Area, At mi.^2	Facility Crash Hit Frequency
1995	501,976	164,384	299,444	463,828						
-Int'l Air Carrier Flights (assume 5% of total)				440,837	No. of Approaches					
Assume 75% of flts app. & dep. from SE, E, NE				330,477	165,239	2.08E-09	0.4052847	0.032	0.07325	3.24E-07
					No. of Departures					
					165,239	5.50E-10	0.4052847	0.032	0.07325	8.64E-08
										Total: 4.10E-07
93-95 Avg.	476,782	139,020	291,530	430,550						
-Int'l Air Carrier Flights (assume 5% of total)				409,023	No. of Approaches					
Assume 75% of flts app. & dep. from SE, E, NE				306,767	153,383	2.08E-09	0.4052847	0.032	0.07325	3.01E-07
					No. of Departures					
					153,383	5.50E-10	0.4052847	0.032	0.07325	8.02E-08
										Total: 3.81E-07
91-95 Avg.	473,854	126,841	296,301	422,942						
-Int'l Air Carrier Flights (assume 5% of total)				401,795	No. of Approaches					
Assume 75% of flts app. & dep. from SE, E, NE				301,346	150,673	2.08E-09	0.4052847	0.032	0.07325	2.95E-07
					No. of Departures					
					150,673	5.50E-10	0.4052847	0.032	0.07325	7.88E-08
										Total: 3.74E-07
86-95 Avg.	481,715	102,880	306,653	409,533						
-Int'l Air Carrier Flights (assume 5% of total)				389,056	No. of Approaches					
Assume 75% of flts app. & dep. from SE, E, NE				291,792	145,896	2.08E-09	0.4052847	0.032	0.07325	2.86E-07
					No. of Departures					
					145,896	5.50E-10	0.4052847	0.032	0.07325	7.63E-08
										Total: 3.62E-07

Oakland ARTCC (ZOA)

$$FP = Nc \cdot Pc \cdot (1/At) \cdot At$$

	IFR Aircraft Handled, Nc		In-Flight Crash Rate (/AC handled)	Oakland ARTCC Area, Ac mi.^2	1/At	Facility Area, At mi.^2	Facility Crash Hit Frequency
1995	961,986		1.21E-07	100,478	9.952E-06	0.07325	6.52E-08
1993-95 Average	906,884		1.21E-07	100,478	9.952E-06	0.07325	6.02E-08
1991-95 Average	886,927		1.21E-07	100,478	9.952E-06	0.07325	7.65E-08
1986-95 Average	843,660		1.21E-07	100,478	9.952E-06	0.07325	7.47E-08

TOTAL AIR CARRIER
Facility Crash Hit Frequency

1995	4.95E-07
1993-95 Average	4.61E-07
1991-95 Average	4.53E-07
1986-95 Average	4.37E-07

NOTES

Table 3.9, Crash rate for 14 CFR 121 flight operations for 1973-1994, accidents with destroyed or major damage to airframe, airport approach flight phase for TRACON operations

Table 3.9, Crash rate for 14 CFR 121 flight operations for 1973-1994, accidents with destroyed or major damage to airframe, climb to cruise flight phase for TRACON operations

Rp = Potential Area radius = g * h
g = glide ratio, for commercial aircraft, assume 15
h = assigned height, for Madwin 3 arrival assume 11000'
Rp = 15 * 11000' = 165000' = 31.25 mi.

Facility Area At determined from above.

Facility Area At determined from above.

AIR TAXIS

Livermore Municipal Airport (LVK) ATCT
All Air Taxi flight operations are itinerant operations.

All Air Taxi flight operations are itinerant operations.			Crash Rate, CR	Crash Location	Facility Area, At mi.^2	Facility Crash Hit Frequency	
Itinerant Operations		Itinerant Landings	/Landing				
1995	127	64	1.92E-05	4.00E-03	0.02520	1.23E-07	
		Takeoffs 64	/Takeoff 1.10E-05	4.50E-03	0.02520	7.92E-08	
						Total:	2.02E-07
1993-95 Average	292	148	1.92E-05	4.00E-03	0.02520	2.83E-07	
		Takeoffs 148	/Takeoff 1.10E-05	4.50E-03	0.02520	1.82E-07	
						Total:	4.65E-07
1991-95 Average	406	203	1.92E-05	4.00E-03	0.02520	3.93E-07	
		Takeoffs 203	/Takeoff 1.10E-05	4.50E-03	0.02520	2.53E-07	
						Total:	6.46E-07
1986-95 Average	410	205	1.92E-05	4.00E-03	0.02520	3.97E-07	
		Takeoffs 205	/Takeoff 1.10E-05	4.50E-03	0.02520	2.56E-07	
						Total:	6.52E-07

NOTES

Table 3.53, Crash rate for 14 CFR 91 flight operations for 1986-1994 General Aviation Total Powered Aircraft, landing approach flight phase for airport landing operations

Table 3.53, Crash rate for 14 CFR 91 flight operations for 1986-1994, General Aviation Total Powered Aircraft, initial climb and climb to cruise flight phases for airport takeoff operations

Table 3.55, Crash Location for General Aviation at 5miles from runway centerline for landings

Table 3.54, Crash Location for Air Carriers at 5 miles from runway centerline for takeoffs

NIF Effective Area Calculation for Air Taxi Aircraft Operations @ Livermore Airport

WS = Wing Span, for 14 CFR 135 Air Carriers (ft.) = 60
L = facility length (ft.) = 656
W = facility width (ft.) = 410
R = diagonal dimension of the facility (ft.) = $(L^2 + W^2)^{0.50}$
= 773.59
H = facility height (ft.) = 50
S = 14 CFR 135 Air Carrier Skid Distance (ft.) = 60
based on mean skid distance for GA aircraft
cot θ = 8.2

Skid-In Area = $(WS + R) * S$ ft.^2 mi.^2
(60+773.59)*60 50015.19 0.00179

Fly-In Area = $((WS+R)*H*cot\theta) + ((2*L*W*WS)/R) + (L*W)$
[(60+773.59)*50*8.2] + [(2*656*410*60)/773.59] + (656*410)
652451.96 0.02340

Effective Area = Skid-In Area + Fly-In Area 702467.15 0.02520

Bay TRACON (O90)

$$FP = N \cdot CR \cdot (4/\pi^2) \cdot (1/Rp) \cdot At$$

	IFR Aircraft Handled	OAK Inst. Operations	SFO Inst. Operations	OAK+SFO Inst. Ops.	No. of Approachs	Crash Rate, CR (/mi.)	(4/pi^2)	(1/Rp)	Facility Area, At mi.^2	Facility Crash Hit Frequency
1995	216,973	52,554	96,937	149,491	No. of Approachs 56,059	9.54E-08	0.4052847	0.0480	0.03327	8.54E-08
Assume 75% of flts app. & dep. from SE, E, NE				112,118	No. of Departures 56,059	1.06E-08	0.4052847	0.0480	0.03327	9.50E-07
										Total: 9.49E-08
93-95 Avg.	205,985	55,344	101,479	156,823	No. of Approachs 56,809	9.54E-08	0.4052847	0.0480	0.03327	8.96E-08
Assume 75% of flts app. & dep. from SE, E, NE				117,617	No. of Departures 56,809	1.06E-08	0.4052847	0.0480	0.03327	9.96E-07
										Total: 9.96E-08
91-95 Avg.	209,122	53,869	96,651	150,520	No. of Approachs 56,445	9.54E-08	0.4052847	0.0480	0.03327	8.60E-08
Assume 75% of flts app. & dep. from SE, E, NE				112,890	No. of Departures 56,445	1.06E-08	0.4052847	0.0480	0.03327	9.56E-07
										Total: 9.56E-08
86-95 Avg.	179,939	49,474	90,270	139,744	No. of Approachs 52,404	9.54E-08	0.4052847	0.0480	0.03327	7.98E-08
Assume 75% of flts app. & dep. from SE, E, NE				104,808	No. of Departures 52,404	1.06E-08	0.4052847	0.0480	0.03327	8.88E-07
										Total: 8.87E-08

Oakland ARTCC (ZOA)

$$FP = Nc \cdot Pc \cdot (1/At) \cdot At$$

	IFR Aircraft Handled	In-Flight Crash Rate (/AC handled)	Oakland ARTCC Area, Ac mi.^2	1/At	Facility Area, At mi.^2	Facility Crash Hit Frequency
1995	210,332	1.56E-08	100,478	9.962E-08	0.03327	1.08E-07
1993-95 Average	217,531	1.56E-08	100,478	9.962E-08	0.03327	1.12E-07
1991-95 Average	217,680	1.56E-08	100,478	9.962E-08	0.03327	1.12E-07
1986-95 Average	210,548	1.56E-08	100,478	9.962E-08	0.03327	1.09E-07

TOTAL AIR TAXI

Facility Crash Hit Frequency

1995 9.80E-08

1993-95 Average 1.05E-08

1991-95 Average 1.03E-08

1986-95 Average 9.63E-08

NOTES

Table 3.16, Crash Rate for Scheduled 14 CFR 135 flight operations for 1980-1994, landing approach flight phase used for TRACON landing approach operations

Table 3.16, Crash Rate for Scheduled 14 CFR 135 flight operations for 1980-1994, climb to cruise flight phase used for TRACON departure operations

Rp = Potential Area radius = g * h

g = glide ratio, for nonscheduled 14 CFR 135 aircraft, similar to General Aviation aircraft, assume = 10

h = assigned height, for Madwin 3 arrival assume 11000'

Rp = 10 * 11000' = 110000' = 20.83 mi.

NIF Effective Area Calculation for Air Taxi Aircraft Operations within Bay TRACON and Oakland ARTCC

WS = Wing Span, for 14 CFR 135 Air Carriers (ft.) = 60

L = facility length (ft.) = 656

W = facility width (ft.) = 410

R = diagonal dimension of the facility (ft.) = (L^2 + W^2)^0.50

= 773.59

H = facility height (ft.) = 50

S = 14 CFR 135 Air Carrier Skid Distance (ft.) = 230

based on 90 percentile skid distance for GA aircraft

cot θ = 14 CFR 135 Air Carrier mean cotangent of impact angle = 10.2

based on 14 CFR 121 Air Carrier mean cotangent of impact angle

Skid-In Area = (WS + R) * S ft.^2 mi.^2
(60+773.59)*230 191724.88 0.00888

Fly-In Area = ((WS+R)*H*cotθ)+(2*L*W*WS/R)+(L*W)
((60+773.59)*50*10.2)+((2*656*410*60)/773.59)+(656*410)
735810.61 0.02639

Effective Area = Skid-In Area + Fly-In Area 927535.49 0.03327

NOTES

Table 3.16 Crash Rate for Scheduled 14 CFR 135 flight operations for 1980-1994, climb to cruise, cruise/enroute, initial descent, and flight phases combined for ARTCC operations, landings assumed equal to aircraft handled

Facility Area At determined from above.

GENERAL AVIATION

Livermore Municipal Airport (LVK) ATCT

1995	Airport Operations			Itinerant Landings	Subcategory Operations	Crash Rate /Landing	LLNL Crash Location	Facility Area, At mi.^2	Facility Crash Hit Frequency
	Total	Local	Itinerant						
	225,730	148,406	79,324	39,662					
1-Eng. Piston					27,065	2.15E-05	4.00E-03	0.02478	5.77E-05
Multi-Eng. Piston					2,705	2.46E-05	4.00E-03	0.02520	6.71E-06
Turboprop					930	8.65E-06	4.00E-03	0.02572	8.28E-07
Turbojet					558	5.11E-06	4.00E-03	0.02478	2.83E-07
Helicopter					8,404	8.43E-06	4.00E-03	0.02301	6.52E-06
				Takeoffs 39,662		/Takeoff			
1-Eng. Piston					27,065	1.25E-05	4.50E-03	0.02478	3.77E-05
Multi-Eng. Piston					2,705	1.06E-05	4.50E-03	0.02520	3.25E-06
Turboprop					930	4.67E-06	4.50E-03	0.02572	5.03E-07
Turbojet					558	1.85E-06	4.50E-03	0.02478	1.15E-07
Helicopter					8,404	6.17E-06	4.50E-03	0.02301	5.37E-06
								Total:	1.19E-04

1993-95	Airport Operations			Itinerant Landings	Subcategory Operations	Crash Rate /Landing	LLNL Crash Location	Facility Area, At mi.^2	Facility Crash Hit Frequency
	Total	Local	Itinerant						
Average	252,192	160,442	91,750	45,875					
1-Eng. Piston					31,304	2.15E-05	4.00E-03	0.02478	6.67E-05
Multi-Eng. Piston					3,129	2.46E-05	4.00E-03	0.02520	7.76E-06
Turboprop					1,076	8.65E-06	4.00E-03	0.02572	9.57E-07
Turbojet					645	5.11E-06	4.00E-03	0.02478	3.27E-07
Helicopter					9,720	8.43E-06	4.00E-03	0.02301	7.54E-06
				Takeoffs 45,875		/Takeoff			
1-Eng. Piston					31,304	1.25E-05	4.50E-03	0.02478	4.36E-05
Multi-Eng. Piston					3,129	1.06E-05	4.50E-03	0.02520	3.78E-06
Turboprop					1,076	4.67E-06	4.50E-03	0.02572	5.82E-07
Turbojet					645	1.85E-06	4.50E-03	0.02478	1.33E-07
Helicopter					9,720	6.17E-06	4.50E-03	0.02301	6.21E-06
								Total:	1.38E-04

1991-95	Airport Operations			Itinerant Landings	Subcategory Operations	Crash Rate /Landing	LLNL Crash Location	Facility Area, At mi.^2	Facility Crash Hit Frequency
	Total	Local	Itinerant						
Average	246,184	152,076	94,108	47,054					
1-Eng. Piston					32,109	2.15E-05	4.00E-03	0.02478	6.84E-05
Multi-Eng. Piston					3,210	2.46E-05	4.00E-03	0.02520	7.96E-06
Turboprop					1,104	8.65E-06	4.00E-03	0.02572	9.82E-07
Turbojet					662	5.11E-06	4.00E-03	0.02478	3.35E-07
Helicopter					9,970	8.43E-06	4.00E-03	0.02301	7.73E-06
				Takeoffs 47,054		/Takeoff			
1-Eng. Piston					32,109	1.25E-05	4.50E-03	0.02478	4.48E-05
Multi-Eng. Piston					3,210	1.06E-05	4.50E-03	0.02520	3.86E-06
Turboprop					1,104	4.67E-06	4.50E-03	0.02572	5.96E-07
Turbojet					662	1.85E-06	4.50E-03	0.02478	1.37E-07
Helicopter					9,970	6.17E-06	4.50E-03	0.02301	6.37E-06
								Total:	1.41E-04

NOTES

General Aviation Subcategory Distribution Adjustment Calculation

	FAA Region		Adjusted No. of Landings (Calculated)	Adjusted Pct. (Calculated)
	Western-Pacific	Total No. of Landings (Table 2.5)		
1-Eng. Piston	4,260,364	66.14%	4,385,050	66.24%
Multi-Eng. Piston	425,670	6.61%	438,334	6.82%
Turboprop	146,419	2.27%	150,704	2.35%
Turbojet	87,844	1.36%	90,415	1.41%
Helicopter	1,322,682	20.54%	1,361,598	21.19%
Gliders	130,263	2.02%	134,075	
Balloons	68,274	1.06%	70,272	
Subtotal:	6,441,916	100.00%	6,630,448	
Exp./Home Built	122,267			
Exp./Exhibition	17,389			
Exp./Other	48,656			
Subtotal:	188,532			
Total	6,630,448			

Table 3.45, GA Single-Eng. Crash Rate, landing approach flight phase for airport landings

Table 3.45, GA Single-Eng. Crash Rate, initial climb, climb to cruise flight phases for airport takeoffs

Table 3.46, GA Multi-Eng. Crash Rate, landing approach flight phase for airport landings

Table 3.46, GA Multi-Eng. Crash Rate, initial climb, climb to cruise flight phases for airport takeoffs

Table 3.47, GA Turboprop Crash Rate, landing approach flight phase for airport landings

Table 3.47, GA Turboprop Crash Rate, initial climb, climb to cruise flight phases for airport takeoffs

Table 3.48, GA Turbojet Crash Rate, landing approach flight phase for airport landings

Table 3.48, GA Turbojet Crash Rate, initial climb, climb to cruise flight phases for airport takeoffs

Table 3.52, GA Helicopter Crash Rate, landing approach flight phase for airport landings

Table 3.52, GA Helicopter Crash Rate, initial climb, climb to cruise flight phases for airport takeoffs

Table 3.55 Crash Location for GA at 5 miles from runway centerline for landings

Table 3.54 Crash Location for GA at 5 miles from runway centerline for takeoffs

NIF Effective Area Calculation

WS = Wing Span, for GA 1-eng. piston (ft.) =	50
for GA multi-eng. piston (ft.) =	60
for GA turboprop (ft.) =	72.5
for GA turbojet (ft.) =	50
for GA helicopters (ft.) =	50
L = facility length (ft.) =	856
W = facility width (ft.) =	410
R = diagonal dimension of the facility (ft.) =	(L^2 + W^2)^.50 = 773.59
H = facility height (ft.) =	50
S = GA Skid Distance for fixed wing aircraft (ft.) =	60
= GA Skid Distance for helicopters (ft.) =	0
cot θ =	8.2

Skid-In Area =	(WS + R) * S	ft.^2	mi.^2
for GA 1-eng. piston (ft.) =	(50+773.59)*60	49415.19	0.00177
for GA multi-eng. piston (ft.) =	(60+773.59)*60	50015.19	0.00179
for GA turboprop (ft.) =	(72.5+773.59)*60	50765.19	0.00182
for GA turbojet (ft.) =	(50+773.59)*60	49415.19	0.00177
for GA helicopters (ft.) =	(50+773.59)*0	0	0.00000

Airport Operations				Itinerant	Subcategory	Crash Rate	LLNL Crash	Facility	Facility	Fly-In Area =	((WS+R)*H*cotθ))+((2*L*W*WS)/R)+(L*W)		
Total	Local	Itinerant	Landings	Operations	/Landing	Location	Area, At	Crash Hit					
1986-95	223,288	129,237	94,061	47,026							for GA 1-eng. piston (ft.) =	641398.38	0.02301
Average	1-Eng. Piston				32,089	2.15E-05	4.00E-03	0.02478	6.84E-05		for GA multi-eng. piston (ft.) =	652451.96	0.02340
	Multi-Eng. Piston				3,208	2.46E-05	4.00E-03	0.02520	7.95E-06		for GA turboprop (ft.) =	666268.94	0.02390
	Turboprop				1,103	8.85E-06	4.00E-03	0.02572	9.81E-07		for GA turbojet (ft.) =	641398.38	0.02301
	Turbojet				662	5.11E-06	4.00E-03	0.02478	3.35E-07		for GA helicopters (ft.) =	641398.38	0.02301
	Helicopter				9,984	8.43E-06	4.00E-03	0.02301	7.73E-06	Effective Area =	Skid-In Area + Fly-In Area		
				Takeoffs		/Takeoff					for GA 1-eng. piston (ft.) =	690613.56	0.02478
				47,026							for GA multi-eng. piston (ft.) =	702467.15	0.02520
	1-Eng. Piston				32,089	1.25E-05	4.50E-03	0.02478	4.47E-05		for GA turboprop (ft.) =	717034.13	0.02572
	Multi-Eng. Piston				3,208	1.06E-05	4.50E-03	0.02520	3.86E-06		for GA turbojet (ft.) =	690613.56	0.02478
	Turboprop				1,103	4.87E-06	4.50E-03	0.02572	5.96E-07		for GA helicopters (ft.) =	641398.38	0.02301
	Turbojet				662	1.86E-06	4.50E-03	0.02478	1.36E-07				
	Helicopter				9,984	6.17E-06	4.50E-03	0.02301	6.36E-06				
								Total:	1.41E-04				

All General Aviation flight operations outside of Livermore Airport Control Zone (non-airport environment) considered by SAIC SHARK.EXE Program

In-Flight (Non-Airport) Crash Frequency using SAIC SHARK.EXE Program	/mi ² /yr	Facility	Facility
for 37o 41' N, 121o 42' W		Area, At	Crash Hit
General Aviation	1.33E-04	mi. ²	Frequency
Helicopters	3.11E-05		
		Total:	4.14E-06

TOTAL GENERAL AVIATION			
Facility Crash Hit Frequency			
	LVK Airport	+Non-Airport-	Total
1995 1-Eng. Piston	9.54E-05		
Multi-Eng. Piston	9.98E-06		
Turboprop	1.33E-06		
Turbojet	3.98E-07		
Total Fixed Wing	1.07E-04	3.42E-06	1.11E-04
Helicopter	1.19E-05	7.16E-07	1.26E-05
Total General Aviation	1.19E-04		1.23E-04
1993-95 Average 1-Eng. Piston	1.10E-04		
Multi-Eng. Piston	1.15E-05		
Turboprop	1.54E-06		
Turbojet	4.60E-07		
Total Fixed Wing	1.24E-04	3.42E-06	1.27E-04
Helicopter	1.38E-05	7.18E-07	1.45E-05
Total General Aviation	1.38E-04		1.42E-04
1991-95 Average 1-Eng. Piston	1.13E-04		
Multi-Eng. Piston	1.18E-05		
Turboprop	1.58E-06		
Turbojet	4.72E-07		
Total Fixed Wing	1.27E-04	3.42E-06	1.30E-04
Helicopter	1.41E-05	7.18E-07	1.48E-05
Total General Aviation	1.41E-04		1.45E-04
1986-95 Average 1-Eng. Piston	1.13E-04		
Multi-Eng. Piston	1.18E-05		
Turboprop	1.58E-06		
Turbojet	4.72E-07		
Total Fixed Wing	1.27E-04	3.42E-06	1.30E-04
Helicopter	1.41E-05	7.18E-07	1.48E-05
Total General Aviation	1.41E-04		1.45E-04

MILITARY AVIATION

Livermore Municipal Airport (LVK) ATCT

	Airport Operations			Itinerant
	Total	Local	Itinerant	
1995	1,098	864	434	217
				Takeoffs
				217

	Airport Operations			Itinerant
	Total	Local	Itinerant	
1993-95	859	261	598	299
Average				Takeoffs
				299

	Airport Operations			Itinerant
	Total	Local	Itinerant	
1991-95	854	230	624	312
Average				Takeoffs
				312

	Airport Operations			Itinerant
	Total	Local	Itinerant	
1988-95	894	171	522	261
Average				Takeoffs
				261

Crash Rate, CR	Crash Location
/Landing	4.00E-03
/Takeoff	
1.10E-05	4.50E-03

Crash Rate, CR	Crash Location
/Landing	4.00E-03
/Takeoff	
1.10E-05	4.50E-03

Crash Rate, CR	Crash Location
/Landing	4.00E-03
/Takeoff	
1.10E-05	4.50E-03

Crash Rate, CR	Crash Location
/Landing	4.00E-03
/Takeoff	
1.10E-05	4.50E-03

Facility Area, At mi.^2	Facility Crash Hit Frequency
0.03327	5.54E-07
0.03327	5.57E-07
Total:	9.12E-07

Facility Area, At mi.^2	Facility Crash Hit Frequency
0.03327	7.64E-07
0.03327	4.92E-07
Total:	1.26E-06

Facility Area, At mi.^2	Facility Crash Hit Frequency
0.03327	7.97E-07
0.03327	5.14E-07
Total:	1.31E-06

Facility Area, At mi.^2	Facility Crash Hit Frequency
0.03327	6.67E-07
0.03327	4.30E-07
Total:	1.10E-06

NOTES

Table 3.56, Crash Rate for small military aircraft, Class A and B mishaps, landing and runway approach flight phases combined for airport landing operations

Table 3.56, Crash Rate for small military aircraft, Class A and B mishaps, off airport events, takeoff and initial climb flight phases combined for airport takeoff operations

Crash location based on General Aviation accident distributions (most Military Aviation flights into Livermore similar to General Aviation flts.)

NIF Effective Area Calculation

WS = Wing Span, for General Aviation aircraft (ft.) =	60
L = facility length (ft.) =	656
W = facility width (ft.) =	410
R = diagonal dimension of the facility (ft.) =	$(L^2 + W^2)^{0.50}$
	= 773.59
H = facility height (ft.) =	50
S = General Aviation aircraft Skid Distance (ft.)	
based on the 90 percentile skid distance for General Aviation	
for landing =	230
for takeoff =	230
cot ϕ = Air Carrier aircraft mean cotangent of impact angle	
for landing =	10.2
for takeoff =	10.2
Skid-In Area =	$(WS + R) * S$
For landing =	$(110 + 773.59) * 230$
For takeoff =	$(110 + 773.59) * 230$
	191724.88 0.00688
Fly-In Area =	$((WS + R) * H * \cot \phi) + ((2 * L * W * WS) / R) + (L * W)$
For landing =	$((110 + 773.59) * 50 * 10.2) + ((2 * 656 * 410 * 110) / 773.59) + (656 * 410)$
	736810.61 0.02639
For takeoff =	$((110 + 773.59) * 50 * 10.2) + ((2 * 656 * 410 * 110) / 773.59) + (656 * 410)$
	736810.61 0.02639
Effective Area =	Skid-In Area + Fly-In Area
For landing =	927535.49 0.03327
For takeoff =	927535.49 0.03327

Bay TRACON (O90)

$$FP = N \cdot CR \cdot (4/\pi)^2 \cdot (1/Rp) \cdot A$$

1995	IFR Aircraft Handled	SE, E, NE fts.	No. of Approaches	Aircraft Subcategory	Crash Rate, CR			(1/Rp)	Facility Area, At mi. ²	Facility Crash Hit Frequency
					/mi.	(4/π) ²				
	22,255	18,891	8,346	Small/Low	2,504	9.95E-08	0.4052847	0.032	0.04304	1.39E-07
				Small/High	2,504	1.68E-07	0.4052847	0.032	0.04113	2.22E-07
				Large	2,504	8.51E-08	0.4052847	0.032	0.04570	1.26E-07
				Helicopter	835	1.43E-07	0.4052847	0.032	0.01175	1.82E-08
			No. of Departures						Total Landing	5.05E-07
			8,346	Small/Low	2,504	3.32E-08	0.4052847	0.032	0.03350	3.61E-08
				Small/High	2,504	9.43E-08	0.4052847	0.032	0.03194	9.78E-08
				Large	2,504	3.15E-08	0.4052847	0.032	0.06832	5.76E-08
				Helicopter	835	4.28E-08	0.4052847	0.032	0.01175	5.44E-09
									Total Takeoff	1.97E-07
									1995 Total	7.02E-07

1993-95 Average	IFR Aircraft Handled	SE, E, NE fts.	No. of Approaches	Aircraft Subcategory	Crash Rate, CR			(1/Rp)	Facility Area, At mi. ²	Facility Crash Hit Frequency
					/mi.	(4/π) ²				
	26,529	21,397	10,698	Small/Low	1,070	9.95E-08	0.4052847	0.032	0.04304	5.94E-08
				Small/High	4,279	1.68E-07	0.4052847	0.032	0.04113	3.79E-07
				Large	3,210	8.51E-08	0.4052847	0.032	0.04570	1.62E-07
				Helicopter	2,140	1.43E-07	0.4052847	0.032	0.01175	4.68E-08
			No. of Departures						Total Landing	6.47E-07
			10,698	Small/Low	1,070	3.32E-08	0.4052847	0.032	0.03350	1.54E-08
				Small/High	4,279	9.43E-08	0.4052847	0.032	0.03194	1.67E-07
				Large	3,210	3.15E-08	0.4052847	0.032	0.06832	7.38E-08
				Helicopter	2,140	4.28E-08	0.4052847	0.032	0.01175	1.40E-08
									Total Takeoff	2.70E-07
									1993-95 Average Total	9.17E-07

1991-95 Average	IFR Aircraft Handled	SE, E, NE fts.	No. of Approaches	Aircraft Subcategory	Crash Rate, CR			(1/Rp)	Facility Area, At mi. ²	Facility Crash Hit Frequency
					/mi.	(4/π) ²				
	32,704	24,528	12,264	Small/Low	1,226	9.95E-08	0.4052847	0.032	0.04304	6.81E-08
				Small/High	4,906	1.68E-07	0.4052847	0.032	0.04113	4.34E-07
				Large	3,679	8.51E-08	0.4052847	0.032	0.04570	1.88E-07
				Helicopter	2,463	1.43E-07	0.4052847	0.032	0.01175	5.35E-08
			No. of Departures						Total Landing	7.42E-07
			12,264	Small/Low	1,226	3.32E-08	0.4052847	0.032	0.03350	1.77E-08
				Small/High	4,906	9.43E-08	0.4052847	0.032	0.03194	1.92E-07
				Large	3,679	3.15E-08	0.4052847	0.032	0.06832	6.47E-08
				Helicopter	2,463	4.28E-08	0.4052847	0.032	0.01175	1.60E-08
									Total Takeoff	3.10E-07
									1991-95 Average Total	1.05E-06

NOTES

Table 2.2, assume 75% of Military Aircraft handled by Bay TRACON approach and depart from San Francisco Bay Region from/to Southeast, East, and Northeast.

Assume all approaches and departures divided as 30% small low performance military aircraft, 30% small high performance military aircraft, 30% large military aircraft, and 10% military helicopter for 1995.

Assume all approaches and departures divided as 10% small low performance military aircraft, 40% small high performance military aircraft, 30% large military aircraft, and 20% military helicopter for 1993-95, 1991-95, and 1988-95.

Table 3.56, Crash Rate for military aircraft, Class A and B mishaps, off airport events, landing and runway approach flight phases combined for TRACON operations, assumed 20 mi. for distance traveled on approach.

Table 3.56, Crash Rate for small military aircraft, Class A and B mishaps, off airport events, takeoff and initial climb flight phases combined for TRACON operations, assumed 20 mi. for distance traveled on departure.

Assume small Cs, and other Ts from Table 3.56 for small low performance military aircraft.

Assume all As, and Fs, and T-37 and T-38 from Table 3.56 for small high performance military aircraft.

Assume all Bs, and all Cs except small Cs from Table 3.56 for large military aircraft.

Rp = Potential Area radius = g * h
g = glide ratio, for military aircraft, assume 15
h = assigned height, for Madwin 3 arrival assume 11000'
Rp = 15 * 11000' = 165000' = 31.25 mi.

NIF Effective Area Calculation for Small Military Aircraft operations within Bay TRACON and Oakland ARTCC

WS = Wing Span, for Small Low Performance AC (ft.) = 110
WS = Wing Span, for Small High Performance AC (ft.) = 78
WS = Wing Span, for Large Military Aircraft (ft.) = 223
WS = Wing Span, for Military Helicopters (ft.) = 50
L = facility length (ft.) = 656
W = facility width (ft.) = 410
R = diagonal dimension of the facility (ft.) = (L² + W²)^{0.50} = 773.59
H = facility height (ft.) = 50

S = Small Military Aircraft Skid Distance (ft.)
for Small Low Performance Military AC, landing = 447
for Small Low Performance Military AC, takeoff = 246
for Small High Performance Military AC, landing = 447
for Small High Performance Military AC, takeoff = 246
for Large Military AC, landing = 368
for Large Military AC, takeoff = 780
for Military Helicopters = 0

IFR Aircraft Handled	SE, E, NE fts.	No. of Approaches	Aircraft Subcategory	Crash Rate, CR /mi. (4/pi^2)		(1/Rp)	Facility Area, At mi.^2	Facility Crash Hit Frequency	
1986-95 Average	56,707	42,530	21,265 Small/Low	2,127	9.95E-06	0.4052847	0.032	0.04304	1.18E-07
			Small/High	8,506	1.66E-07	0.4052847	0.032	0.04113	7.53E-07
			Large	6,360	8.51E-06	0.4052847	0.032	0.04570	3.22E-07
			Helicopter	4,253	1.43E-07	0.4052847	0.032	0.01175	9.27E-06
		No. of Departures					Total Landing		1.29E-06
		21,265	Small/Low	2,127	3.32E-06	0.4052847	0.032	0.03350	3.07E-06
			Small/High	8,506	9.43E-06	0.4052847	0.032	0.03194	3.32E-07
			Large	6,360	3.15E-06	0.4052847	0.032	0.05632	1.47E-07
			Helicopter	4,253	4.28E-06	0.4052847	0.032	0.01175	2.77E-06
							Total Takeoff		5.37E-07
							1986-95 Average Total		1.82E-06

Oakland ARTCC (ZOA)

FP = Nc * Pc * (1/Ac) * At	IFR Aircraft Handled	Aircraft Subcategory	IFR AC Handled by Subcategory	In-Flight Crash Rate (/AC handled)	Oakland ARTCC Area, Ac mi. ²	1/Ac	Facility Area, At mi. ²	Facility Crash Hit Frequency
1995	195,476	Small/Low	9,774	4.36E-06	100,478	9.952E-06	0.04304	1.82E-06
		Small/High	107,512	4.36E-06	100,478	9.952E-06	0.04113	1.92E-07
		Large	78,190	1.23E-06	100,478	9.952E-06	0.05632	5.41E-06
							1995 Total	2.64E-07
1993-95 Average	207,251	Small/Low	10,363	4.36E-06	100,478	9.952E-06	0.04304	1.93E-06
		Small/High	113,988	4.36E-06	100,478	9.952E-06	0.04113	2.03E-07
		Large	82,900	1.23E-06	100,478	9.952E-06	0.05632	5.74E-06
							1993-95 Average Total	2.80E-07
1991-95 Average	273,821	Small/Low	13,891	4.36E-06	100,478	9.952E-06	0.04304	2.55E-06
		Small/High	150,602	4.36E-06	100,478	9.952E-06	0.04113	2.69E-07
		Large	109,528	1.23E-06	100,478	9.952E-06	0.05632	7.58E-06
							1991-95 Average Total	3.70E-07
1986-95 Average	322,092	Small/Low	16,105	4.36E-06	100,478	9.952E-06	0.04304	3.01E-06
		Small/High	177,151	4.36E-06	100,478	9.952E-06	0.04113	3.16E-07
		Large	128,837	1.23E-06	100,478	9.952E-06	0.05632	8.92E-06
							1986-95 Average Total	4.35E-07

NOTES

Assume all high altitude overflights divided as 5% small low performance military aircraft, 55% small high performance military aircraft and 40% large military aircraft.

In-flight crash rate for small military aircraft based on 105 accidents for 1973-1993, 24,102,000 small military aircraft sorties for 1976-1993.

In-flight crash rate for large military aircraft based on 9 accidents for 1976-1993, 7,269,000 large military aircraft sorties for 1976-1993.

Facility Area At taken to be larger of landing or takeoff effective area

TOTAL MILITARY AVIATION Facility Crash Hit Frequency

1995	1.88E-06
1993-95 Average	2.45E-06
1991-95 Average	2.73E-06
1986-95 Average	3.38E-06

cot θ = Air Carrier aircraft mean cotangent of impact angle

for Small Low Performance Military AC, landing =	10.4
for Small Low Performance Military AC, takeoff =	8.4
for Small High Performance Military AC, landing =	10.4
for Small High Performance Military AC, takeoff =	8.4
for Large Military AC, landing =	9.7
for Large Military AC, takeoff =	7.4
for Military Helicopters =	0.58

Small Low Performance Military Aircraft

Skid-In Area = (WS + R) * S	ft. ²	mi. ²
For landing = (110+773.59)*447	394963.14	0.01417
For takeoff = (110+773.59)*246	217362.27	0.00780

Fly-In Area =	$((WS+R)*H*cot\theta)+((2*L*W*WS)/R)+(L*W)$		
For landing =	$[(110+773.59)*50*10.4]+[(2*656*410*110)/773.59]+(656*410)$	804914.40	0.02887
For takeoff =	$[(110+773.59)*50*8.4]+[(2*656*410*110)/773.59]+(656*410)$	718555.76	0.02570

Effective Area = Skid-In Area + Fly-In Area	1199877.55	0.04304
For landing =	1199877.55	0.04304
For takeoff =	933918.02	0.03350

Small High Performance Military Aircraft

Skid-In Area = (WS + R) * S	ft. ²	mi. ²
For landing = (78+773.59)*447	380659.14	0.01365
For takeoff = (78+773.59)*246	209490.27	0.00751

Fly-In Area =	$((WS+R)*H*cot\theta)+(2*L*W*WS/R)+(L*W)$		
For landing =	$[(78+773.59)*50*10.4]+[(2*656*410*78)/773.59]+(656*410)$	768022.93	0.02748
For takeoff =	$[(78+773.59)*50*8.4]+[(2*656*410*78)/773.59]+(656*410)$	680664.28	0.02442

Effective Area =	Skid-In Area + Fly-In Area		
For landing =		1146682.07	0.04113
For takeoff =		890354.55	0.03194

Large Military Aircraft

Skid-In Area = (WS + R) * S	ft. ²	mi. ²
For landing = (223+773.59)*368	368743.81	0.01316
For takeoff = (223+773.59)*780	777337.43	0.02788

Fly-In Area =	((WS+R)*H*cotθ)+((2*L*W*WS/R)+(L*W)	
For landing =	((223+773.59)*50*9.7)+((2*656*410*223)/773.59)+(656*410)	907369.40 0.03255
For takeoff =	((223+773.59)*50*7.4)+((2*656*410*223)/773.59)+(656*410)	792761.96 0.02844

Effective Area =	Skid-In Area + Fly-In Area		
For landing =		1274113.21	0.04570
For takeoff =		1570099.39	0.05632

Military Helicopters

Skid-In Area = (WS + R) * S	ft. ²	mi. ²
(50+773.59)*0	0	0.00000

Fly-In Area =	$((WS+R)*H*cot\theta)+((2*L*W*WS)/R)+(L*W)$	
	$[(50+773.59)*50*0.58]+[(2*656*410*50)/773.59]+(656*410)$	
	327611.94	0.01175

Effective Area = Skid-In Area + Fly-In Area	327611.94	0.01175
	327611.94	0.01175

NIF Aircraft Crash Hit Frequency

	AIR CARRIERS		AIR TAXIS		GENERAL AVIATION		MILITARY AVIATION		ALL AVIATION CATEGORIES TOTAL	Pct.
1995 Total	4.95E-07	0.37%	9.80E-08	7.24%	1.23E-04	91.00%	1.88E-08	1.39%	1.35E-04	
Livermore ATCT	0.00E+00		2.02E-07		1.19E-04		9.12E-07		1.20E-04	88.77%
Bay TRACON	4.10E-07		9.49E-08				7.02E-07		1.06E-05	7.84%
Oakland ARTCC	8.52E-08		1.08E-07		4.14E-08		2.84E-07		4.59E-08	3.40%
1993-95 Average	4.81E-07	0.30%	1.05E-05	6.79%	1.42E-04	91.34%	2.45E-08	1.58%	1.55E-04	
Livermore ATCT	0.00E+00		4.65E-07		1.38E-04		1.26E-08		1.39E-04	89.78%
Bay TRACON	3.81E-07		9.98E-08				9.17E-07		1.13E-05	7.25%
Oakland ARTCC	8.02E-08		1.12E-07		4.14E-08		2.80E-07		4.81E-08	2.97%
1991-95 Average	4.63E-07	0.29%	1.03E-05	6.50%	1.45E-04	91.50%	2.73E-08	1.72%	1.59E-04	
Livermore ATCT	0.00E+00		6.46E-07		1.41E-04		1.31E-08		1.43E-04	90.13%
Bay TRACON	3.74E-07		9.66E-08				1.05E-08		1.10E-05	6.92%
Oakland ARTCC	7.85E-08		1.12E-07		4.14E-08		3.70E-07		4.70E-08	2.98%
1986-95 Average	4.37E-07	0.28%	9.63E-08	6.07%	1.45E-04	91.54%	3.36E-08	2.12%	1.59E-04	
Livermore ATCT	5.43E-11		6.52E-07		1.41E-04		1.10E-08		1.43E-04	90.03%
Bay TRACON	3.62E-07		8.87E-08				1.82E-08		1.11E-05	6.97%
Oakland ARTCC	7.47E-08		1.09E-07		4.14E-08		4.35E-07		4.75E-08	3.00%

GLOSSARY

Air Carrier: As defined by the Federal Aviation Administration (FAA), the commercial system of air transportation consisting of the Certificated Air Carriers, Air Taxis (including commuters), Supplemental Air Carriers, Commercial Operators of Large Aircraft, and Air Travel Clubs. As defined by air traffic controllers in tabulating air traffic activity, aircraft in general commercial service capable of carrying 70 or more passengers irrespective of the the aviation flight rules under which the flight occurs.

Aircraft Accident: As defined by the National Transportation Safety Board (NTSB), an occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, and in which any person suffers a fatal or serious injury as a result of being in or upon the aircraft or by direct contact with the aircraft or anything attached thereto, or in which the aircraft receives substantial damage.

Aircraft Crash: For Commercial Aviation, see Commercial Aircraft Crash. For General Aviation, see General Aviation Crash. For Military Aviation, see Military Aircraft Crash.

Aircraft/Aviation Category: The broadest, most general classification defined for aircraft and aviation. These categories are: 1) Air Carrier, 2) Air Taxi, 3) General Aviation, and 4) Military Aviation.

Aircraft Operation: As defined by the Federal Aviation Administration (FAA) near an airport, the number of arrivals and departures from the airport at which an airport traffic control tower is located. Operations include aircraft which: 1) operate in the local traffic pattern or within sight of the airport, 2) are known to be departing for, arriving from flight in the local practice areas located within a 20-mile radius of the airport, or 3) execute simulated instrument approaches or low passes at the airport. See also Airport Operation.

Aircraft/Aviation Subcategory: The next level of classification below Category defined for aircraft and aviation. For Air Carriers and Air Taxis, no subcategories are defined. For General Aviation, seven subcategories of aircraft/aviation are defined: 1) Single-engine piston powered, fixed-wing, 2) Multi-engine piston powered, fixed wing, 3) Turboprop powered, fixed-wing, 4) Turbojet/turbofan powered, fixed-wing, 5) Piston-engine powered, rotary wing, 6) Turboshift powered, rotary wing, and 7) Other. For Military Aviation, three subcategories of aircraft/aviation are defined: 1) Large (which includes most Bombers, Cargo or transports), 2) Small (which includes most Fighters, Attack aircraft, and Trainers), and 3) Helicopters.

Aircraft Type: As defined by the Federal Aviation Administration (FAA), a specific make and basic model of aircraft, including modifications that do not change its handling or flight characteristics. As used with respect to the certification of aircraft, those aircraft which are similar in design. Examples include the Douglas DC-7 and the DC-7C, the Lockheed 1049G and 1049H, and the Fokker F-27 and F-27F.

Airport: As defined by the Federal Aviation Administration (FAA), an area of land or water that is used or intended to be used for the landing and takeoff of aircraft, and includes its buildings and facilities, if any. Airports include heliports, STOLports, and seaplane bases.

Airport Approach Flight Phase: The Flight Phase which consists of the time the aircraft intercepts the initial navigation fix defined by U.S. terminal approach procedures for that specific airport, runway and approach, until the aircraft crosses the outer marker defined by U.S. terminal approach procedures for that specific airport, runway and approach.

Airport Operation: An Aircraft Operation which occurs in the Near Airport Environment. As defined by the Federal Aviation Administration (FAA), the number of arrivals and departures from the airport at which the Airport Traffic Control Tower is located. Airport Operations are classified as either Local or Itinerant Operations. See also Aircraft Operation.

Airport Traffic: As defined by the Federal Aviation Administration (FAA), aircraft operating in the air or on an airport surface exclusive of loading ramps and parking areas.

Airport Traffic Control Tower (ATCT): As defined by the Federal Aviation Administration (FAA), a central operations facility in the terminal air traffic control system, which consists of a tower cab structure, including an associated IFR room if radar equipped, and uses air/ground communications, radar, visual signaling, and other services to provide safe and expeditious movement of terminal air traffic.

Air Route Traffic Control Center (ARTCC): The FAA air traffic control facility responsible for providing air traffic control service to aircraft operating on IFR flight plans in controlled airspace, primarily Class A Airspace. ARTCCs are the central authority for issuing IFR clearances, and provide nationwide monitoring of each IFR flight, usually during the Enroute Flight Phase.

Air Taxi: As defined by the Federal Aviation Administration (FAA), a classification of air carriers which transports in accordance with 14 CFR 135 [Ref. G.11], persons, property, and mail using small aircraft (under 30 seats or a maximum payload capacity of less than 7,500 pounds). As defined by air traffic controllers in tabulating air traffic activity, aircraft in general commercial service that carry less than 70 passengers. As this classification includes small single-engine aircraft, the flight must usually be identified as an air taxi flight in its flight plan or the aircraft carries a commercial livery in order for the flight to be counted as an Air Taxi flight.

Airway: The system of designated routes between VOR or VORTAC stations. Included within the definition of Airway are High Altitude (Jet) Routes, Low Altitude (Victor) Routes, and Military Training Routes.

Armed Forces: As defined by 14 CFR 1.1 [Ref. G.1], the United States Air Force (USAF), United States Army (USA), United States Navy (USN), United States Marine Corps (USMC), and the United States Coast Guard (USCG), including their regular and reserve component and members serving without component status.

Class A Airspace: As defined by 14 CFR 71.33 [Ref. G.2], that airspace of the United States, including that airspace overlying the waters within 12 nautical miles of the coast of the 48 contiguous States, from 18,000 feet Mean Sea Level to and including FL600 (60,000 feet mean sea level) excluding the states of Alaska and Hawaii, Santa Barbara Island, Farallon Island, and the airspace south of latitude 25° 04' 00" North. All operations are conducted under instrument flight rules (IFR) and are subject to ARTCC clearances and instructions. Aircraft separation and safety advisories are provided by the ARTCC. Formerly called Positive Control Areas (PCAs).

Class B Airspace: Generally the airspace from the surface to 10,000 feet mean sea level (MSL) surrounding U.S. airports with more than 150,000 annual instrument flight rule (IFR) operations or 650,000 annual passenger enplanements. The configuration of each Class B Airspace is individually tailored and consists of a surface area, usually 5 nautical miles in radius from the primary airport, and two or more layers extending laterally from the core at 3 to 10 nautical mile increments (typically) to a radius of approximately 20 nautical miles, with each layer having a prescribed altitude floor. Class B Airspace is designed to contain all published instrument procedures once an aircraft enters the airspace. Operations may be under either IFR or visual flight rules (VFR) with all aircraft subject to air traffic control clearances and instructions. Air traffic control provides aircraft separation and safety advisories. Formerly called Terminal Control Areas (TCAs).

Class C Airspace: Generally, the airspace from the surface to approximately 4,000 feet mean sea level (MSL) surrounding U.S. airports with more than 75,000 annual instrument flight rule (IFR) operations at the primary airport, or 100,000 annual IFR operations at the primary and secondary airports in the terminal hub area, or 250,000 annual passenger enplanements at the primary airport. The configuration of each Class C Airspace is individually tailored and consists of a surface area of 5 nautical miles radius from the primary airport, and another layer with a prescribed altitude floor, extending laterally from the core to a radius of 10 nautical miles. Operations may be under either instrument flight rules (IFR) or visual flight rules (VFR), with all aircraft subject to air traffic control clearances and instructions. Air traffic control provides aircraft separation between IFR/IFR and IFR/special VFR (SVFR) aircraft. VFR operations are given traffic advisories and, upon request, collision resolution instructions. Formerly called Airport Radar Service Areas (ARSAs).

Class D Airspace: The airspace from the surface to 2,500 feet above ground level (AGL) within a 5 statute mile (4.3 nautical mile) radius of the center of the airport. Operations may be under either instrument flight rules (IFR) or visual flight rules (VFR), with all aircraft subject to air traffic control clearances and instructions. Air traffic control separation service is provided to IFR aircraft only, but all aircraft will be given traffic advisories and, upon request, conflict resolution instructions. Formerly called Airport Traffic Areas (ATAs) and Control Zones (CZs).

Climb to Cruise Flight Phase: The Flight Phase which consists of the time after the Takeoff Flight Phase when the aircraft landing gear is retracted and all aircraft flaps are in their normal cruise configuration until the aircraft has reached its initial assigned cruising or enroute altitude.

Commercial Aircraft Crash: Any Aircraft Accident involving an aircraft type generally used for commercial service during flight operations (defined as the beginning of takeoff roll to landing touchdown) which results in the destruction of or substantial damage to the aircraft. Fatal or serious injury sustained as a result of the Aircraft Accident itself, without related destruction or substantial damage to the aircraft is not a criterion for consideration as a Commercial Aircraft Crash.

Commercial Airport: As defined by the Federal Aviation Administration (FAA), a Public Airport which is determined to enplane 2,500 or more passengers annually and receive scheduled passenger service of aircraft.

Commercial Aviation: All aspects of aviation involving aircraft operated under 14 CFR 121 [Ref. G.6], 125 [Ref. G.7], 127 [Ref. G.8], 129 [Ref. G.9], and 135 [Ref. G.11] regulations.

Commuter Air Carrier: As defined by the Federal Aviation Administration (FAA), an Air Taxi operator which performs at least five round trips per week between two or more points and publishes flight schedules which specify the times, days of the week, and points between which such flights are performed. Also called Scheduled Air Taxis.

Crash Location Distribution: The normalized conditional probability distribution (i.e., given that the aircraft crash occurs) in terms of x, y coordinates as a function of the location of the facility relative to the airport.

Cruise Flight Phase: See Enroute Flight Phase.

Descent from Cruise Flight Phase: The Flight Phase which consists of the time when the aircraft begins its descent from its final assigned cruising or enroute altitude until the aircraft intercepts the initial navigation fix defined by U.S. terminal approach procedures for that specific airport, runway and approach,

Demand Air Taxi: As defined by the Federal Aviation Administration (FAA), an Air Taxi operator which performs charter air service or less than five round trips per week between two or more points. Also called Nonscheduled Air Taxis.

Enroute: The Flight Phase which includes the Climb to Altitude Flight Phase, Enroute or Cruise Flight Phase, and the Descent from Cruise Flight Phase.

Enroute Analysis: The aircraft crash frequency analysis for Aircraft Operations outside of the Near Airport and TRACON Environments. See also In-Flight Analysis.

Enroute Environment: The airspace outside of the Near Airport and TRACON Environments. See also In-Flight Environment.

Enroute Flight Phase: For Air Carriers and Air Taxis, the Flight Phase which consists of the time when the aircraft has reached its initial assigned cruising or enroute altitude until the time the aircraft begins its descent from its final assigned cruising or enroute altitude. Minor adjustments in assigned cruising or enroute altitude are considered to be part of the Enroute Flight Phase. For Military Aviation, the Flight Phase from the point where the aircraft altitude is not affected by its proximity to the runway. For Military Aviation, also called In-Flight Phase.

Fatal Injury: As defined by the National Transportation Safety Board (NTSB), any injury which results in death within 30 days of the accident.

Flight Phase: The parts of flight which are distinctly different for each due to the configuration of the aircraft and/or the conditions under which the flight is taking place. The following flight phases are generally defined: Ground operations, Taxi, Takeoff, Initial Climb, Climb to Altitude, Enroute or Cruise, Descent from Cruise, Airport Approach, Runway Approach, Landing, and Other.

14 CFR 91: Flight operations conducted under Title 14 (Aeronautics and Space) of the Code of Federal Regulations, Subchapter F, Air Traffic and General Operating Rules, Part 91, General Operating and Flight Rules [Ref. G.3].

14 CFR 103: Flight operations conducted under Title 14 (Aeronautics and Space) of the Code of Federal Regulations, Subchapter F, Air Traffic and General Operating Rules, Part 103, Ultralight Vehicles [Ref. G.4].

14 CFR 105: Flight operations conducted under Title 14 (Aeronautics and Space) of the Code of Federal Regulations, Subchapter F, Air Traffic and General Operating Rules, Part 105, Parachute Jumping [Ref. G.5].

14 CFR 121: Flight operations conducted under Title 14 (Aeronautics and Space) of the Code of Federal Regulations, Subchapter G, Air Carriers, Air Travel Clubs, and Operators for Compensation or Hire: Certification and Operations, Part 121, Certification and Operations: Domestic, Flag, and Supplemental Air Carriers and Commercial Operators of Large Aircraft [Ref. G.6].

14 CFR 125: Flight operations conducted under Title 14 (Aeronautics and Space) of the Code of Federal Regulations, Subchapter G, Air Carriers, Air Travel Clubs, and Operators for Compensation or Hire: Certification and Operations, Part 125, Certification and Operations: Airplanes Having a Seating Capacity of 20 or More Passengers or a Maximum Payload Capacity of 6,000 Pounds or More [Ref. G.7].

14 CFR 127: Flight operations conducted under Title 14 (Aeronautics and Space) of the Code of Federal Regulations, Subchapter G, Air Carriers, Air Travel Clubs, and Operators for Compensation or Hire: Certification and Operations, Part 127, Certification and Operations of Scheduled Air Carriers with Helicopters [Ref. G.8].

14 CFR 129: Flight operations conducted under Title 14 (Aeronautics and Space) of the Code of Federal Regulations, Subchapter G, Air Carriers, Air Travel Clubs, and Operators for Compensation or Hire: Certification and Operations, Part 129, Operations: Foreign Air Carriers and Foreign Operators of U.S.-Registered Aircraft Engaged in Common Carriage [Ref. G.9].

14 CFR 133: Flight operations conducted under Title 14 (Aeronautics and Space) of the Code of Federal Regulations, Subchapter G, Air Carriers, Air Travel Clubs, and Operators for Compensation or Hire: Certification and Operations, Part 133, Rotorcraft External-Load Operations [Ref. G.10].

14 CFR 135: Flight operations conducted under Title 14 (Aeronautics and Space) of the Code of Federal Regulations, Subchapter G, Air Carriers, Air Travel Clubs, and Operators for Compensation or Hire: Certification and Operations, Part 135, Air Taxi Operators and Commercial Operators [Ref. G.11].

14 CFR 137: Flight operations conducted under Title 14 (Aeronautics and Space) of the Code of Federal Regulations, Subchapter G, Air Carriers, Air Travel Clubs, and Operators for Compensation or Hire: Certification and Operations, Part 137, Agricultural Aircraft Operations [Ref. G.12].

General Aviation: All aspects of aviation involving aircraft operated under 14 CFR 91 [Ref. G.3], 103 [Ref. G.4], 105 [Ref. G.5], 133 [Ref. G.10], and 137 [Ref. G.12] regulations.

General Aviation Airport: As defined by the Federal Aviation Administration (FAA), any Airport which is used or to be used for public purposes, under the control of a public agency, the landing area of which is publicly owned.

General Aviation Crash: As defined by the NTSB for Aircraft Accidents.

High Altitude (Jet) Routes: The designated air routes based on radials from VOR or VORTAC stations extending from 18,000 feet Mean Sea Level (MSL) and up to and including 45,000 feet Mean Sea Level (MSL) (Flight Level 450).

IFR Aircraft Handled: As defined by the Federal Aviation Administration (FAA), the number of IFR Departures multiplied by two plus the number of IFR Overs. Assumes that the number of departures (acceptances, extensions, and originations of IFR flight plans) is equal to the number of landings (IFR flight plans closed).

IFR Departures: As defined by the Federal Aviation Administration (FAA), IFR Flights originating in the ARTCC's area, accepted by the ARTCC under the Sole Enroute clearance procedures, and extended by the ARTCC.

IFR Flight: As defined by the Federal Aviation Administration (FAA), flight conducted in accordance with instrument flight rules.

IFR Overs: As defined by the Federal Aviation Administration (FAA), IFR Flights that originate outside the ARTCC area and passes through the area without landing.

ILS: Instrument Landing System.

In-Flight: The Flight Phase which includes the Climb to Altitude Flight Phase, Enroute or Cruise Flight Phase, and the Descent from Cruise Flight Phase. For Military Aviation only, the Flight Phase where the aircraft altitude is not affected by its proximity to the runway. See also Enroute.

In-Flight Analysis: The aircraft crash frequency analysis for Aircraft Operations outside of the Near Airport and the TRACON Environments. See also Enroute Analysis.

In-Flight Environment: The airspace outside of the Near Airport and TRACON Environments. See also Enroute Environment.

Initial Climb Flight Phase: The Flight Phase which consists of the time the aircraft wheels leave the ground until the aircraft landing gear is retracted and all aircraft flaps are in their normal cruise configuration.

Instrument Landing System: A precision instrument approach system which normally consists of a localizer to provide course guidance to the runway, a glide slope to provide vertical guidance during the approach, and a marker beacon to provide aural and/or visual identification of a specific position along an instrument approach landing.

Instrument Operation: An aircraft operation in accordance with an IFR flight plan or an operation where IFR separation between aircraft is provided by a terminal control facility or an Air Route Traffic Control Center.

Itinerant Operation: As defined by the Federal Aviation Administration (FAA), all aircraft operations other than Local Operations. See Airport Operations.

Jet Routes: See High Altitude Routes.

Landing: For Air Carriers, Air Taxis, and General Aviation, Landing includes the Airport Approach Flight Phase, the Runway Approach Flight Phase, and the Landing Flight Phase. For Military Aviation, Landing will be considered as the Flight Phase from the point where the aircraft altitude is affected by its proximity from the approach runway to its departure from the runway under a controlled taxi.

Landing Flight Phase: The Flight Phase which consists of the time the aircraft wheels initially make contact with the runway or landing surface until the aircraft leaves the runway or landing surface onto the designated taxiway.

Local Operation: As defined by the Federal Aviation Administration (FAA), operations performed by aircraft which 1) operate in the local traffic pattern or within sight of the airport; 2) are known to be departing for, or arriving from flight in local practice areas located within a 20-mile radius of the airport; or 3) execute simulated instrument approaches or low passes at the airport. See Airport Operations.

Low Altitude (Victor) Airway: The designated routes based on radials from VOR or VORTAC stations extending from a minimum of 1200 feet above ground level, up to but not including 18,000 feet Mean Sea Level (MSL).

Military Aviation: All aspects of aviation involving the Armed Forces of the United States. Military Aviation does not include charter flights performed for the Armed Forces.

Military Training Routes: The system of designated routes used by the Armed Forces of the United States.

Near Airport Analysis: The aircraft crash frequency analysis for Aircraft Operations in the Near Airport Environment.

Near Airport Environment: The airspace area extending from the center of the airport outwards to a radius of approximately 5 miles to 35 miles depending on the presence (or absence) of a TRACON and other air traffic control considerations. The airspace near an Airport which encompasses the local

airport traffic pattern, the airport runway approach pattern(s), and the airport initial climb departure pattern(s). This is generally the airspace near an airport where the aircraft are in the Runway Approach Flight Phase, Landing Flight Phase, the Takeoff Flight Phase, and the Initial Climb Flight Phase.

Nonairport Environment: The TRACON and the Enroute/In-Flight Environments. The airspace outside of the Near Airport Environment.

Nonprecision Approach Procedure: As defined by 14 CFR 1.1 [Ref. G.1], a standard instrument approach procedure in which no electronic glide slope is provided.

Nonscheduled Air Taxi: See Demand Air Taxi.

PAR: Precision Approach Radar.

Precision Approach Procedure: As defined by 14 CFR 1.1 [Ref. G.1], a standard instrument approach procedure in which an electronic glide slope is provided, such as ILS and PAR.

Public Aircraft: As defined by 14 CFR 1.1 [Ref. G.1], aircraft used only in the service of a government, or a political subdivision. It does not include any government-owned aircraft engaged in carrying persons or property for commercial purposes.

Public Airport: See General Aviation Airport.

Rotary Wing Aircraft (Rotorcraft): As defined by 14 CFR 1.1 [Ref. G.1], a heavier-than-air aircraft that depends principally for its support in flight on the lift generated by one or more rotors. More commonly known as helicopters.

Runway Approach Flight Phase: The Flight Phase which consists of the time the aircraft crosses the outer marker defined by U.S. terminal approach procedures for that specific airport, runway and approach, until the aircraft wheels initially make contact with the runway.

Scheduled Air Taxi: See Commuter Air Carrier.

Serious Injury: As defined by the National Transportation Safety Board (NTSB) in 49 CFR 830.2 [Ref. G.13], any injury which 1) requires hospitalization for more than 48 hours, commencing within 7 days from the date the injury was received; 2) results in a fracture of any bone (except simple fractures of fingers, toes, or nose); 3) involves lacerations which cause severe hemorrhages, nerve, muscle, or tendon damage; 4) involves injury to any internal organ; or 5) involves second- or third-degree burns, or any burns affecting more than 5 percent of body surface.

Substantial Damage: As defined by the National Transportation Safety Board (NTSB) in 49 CFR 830.2 [Ref. G.13].

- (1) Except as provided in subparagraph (2) of this paragraph, substantial damage means damage or structural failure which adversely affects the structural strength, performance or flight characteristics of the aircraft and which would normally require major repair or replacement of the affected component.
- (2) Engine failure, damage limited to an engine, bent fairings or cowlings, dented skin, small punctured holes in the skin of fabric, ground damage to rotor or propeller blades, damage to landing gear, wheels, tires, flaps, engine accessories, brakes, or wingtips are not considered "substantial damage".

TACAN: Tactical Air Navigation. A UHF electronic rho (distance)-theta (azimuth) air navigation aid which provides suitably equipped aircraft (primarily military) with a continuous indication of bearing and distance to the TACAN facility.

Takeoff: For Air Carriers, Air Taxis and General Aviation, Takeoff includes the Takeoff Flight Phase, and the Initial Climb Flight Phase. For Military Aviation, Takeoff is considered to be the Flight Phase from the application of takeoff power on the runway to the point where the aircraft altitude is not affected by its proximity from the departure runway.

Takeoff Flight Phase: The Flight Phase which consists of the beginning of the aircraft takeoff roll to the moment the aircraft wheels leave the ground.

TRACON: Terminal Radar Approach Control. The air traffic control facility responsible for providing approach/departure aircraft separation, especially for IFR operations, for the airspace area approximately 5 miles radius from the primary airport extending outwards to approximately 35 miles from the primary airport.

TRACON Analysis: The aircraft crash frequency analysis for Aircraft Operations in the TRACON Environment.

TRACON Environment: The airspace outside of the Near Airport Environment and inside and beneath the Enroute/In-Flight Environment in which all air traffic is under the control of the local TRACON.

VFR Flight: As defined by the Federal Aviation Administration (FAA), flight conducted in accordance with visual flight rules.

Victor Airway: See Low Altitude Airway.

VOR: Very high frequency Omnidirectional Radio range. Used as a basis for navigation in the national airspace system.

VORTAC: Colocated VOR and TACAN navigation aids. An air navigation aid providing azimuth and distance measuring equipment at one site.

References

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- [G.2] "Designation of Class A, Class B, Class C, Class D, and Class E Airspace Areas; Airways; Routes; and Reporting Points", Title 14 Aeronautics and Space, Code of Federal Regulations, Subchapter E-Airspace, Part 71 (14 CFR 71), U.S. National Archives and Record Administration, Washington, DC, January 1, 1995.
- [G.3] "Air Traffic and General Operating and Flight Rules", Title 14 Aeronautics and Space, Code of Federal Regulations, Chapter I-Federal Aviation Administration, Department of Transportation, Subchapter F, Air Traffic and General Operating Rules, Part 91 (14 CFR 91), U.S. National Archives and Record Administration, Washington, DC, January 1, 1995.
- [G.4] "Ultralight Vehicles", Title 14 Aeronautics and Space, Code of Federal Regulations, Chapter I-Federal Aviation Administration, Department of Transportation, Subchapter F, Air Traffic and General Operating Rules, Part 103 (14 CFR 103), U.S. National Archives and Record Administration, Washington, DC, January 1, 1995.
- [G.5] "Parachute Jumping", Title 14 Aeronautics and Space, Code of Federal Regulations, Chapter I-Federal Aviation Administration, Department of Transportation, Subchapter F, Air Traffic and General Operating Rules, Part 105 (14 CFR 105), U.S. National Archives and Record Administration, Washington, DC, January 1, 1995.
- [G.6] "Certification and Operations: Domestic, Flag, and Supplemental Air Carriers and Commercial Operators of Large Aircraft", Title 14 Aeronautics and Space, Code of Federal Regulations, Chapter I-Federal Aviation Administration, Department of Transportation, Subchapter G-Air Carriers, Air Travel Clubs, and Operators for Compensation or Hire: Certification and Operations, Part 121 (14 CFR 121), U.S. National Archives and Record Administration, Washington, DC, January 1, 1995.
- [G.7] "Certification and Operations: Airplanes Having a Seating Capacity of 20 or More Passengers or a Maximum Payload of 6,000 Pounds or More", Title 14 Aeronautics and Space, Code of Federal Regulations, Chapter I-Federal Aviation Administration, Department of Transportation, Subchapter G-Air Carriers, Air Travel Clubs, and Operators for Compensation or Hire: Certification and Operations, Part 125 (14 CFR 125), U.S. National Archives and Record Administration, Washington, DC, January 1, 1995.
- [G.8] "Certification and Operations of Scheduled Air Carriers with Helicopters", Title 14 Aeronautics and Space, Code of Federal Regulations, Chapter I-Federal Aviation Administration, Department of Transportation, Subchapter G-Air Carriers, Air Travel Clubs, and Operators for Compensation or Hire: Certification and Operations, Part 127 (14 CFR 127), U.S. National Archives and Record Administration, Washington, DC, January 1, 1995.
- [G.9] "Operations: Foreign Air Carriers and Foreign Operators of U.S.-Registered Aircraft Engaged in Common Carriage", Title 14 Aeronautics and Space, Code of Federal Regulations, Chapter I-Federal Aviation Administration, Department of Transportation, Subchapter G-Air Carriers, Air Travel Clubs, and Operators for Compensation or Hire: Certification and Operations, Part 129 (14 CFR 129), U.S. National Archives and Record Administration, Washington, DC, January 1, 1995.

- [G.10] "Rotorcraft External-Load Operations", Title 14 Aeronautics and Space, Code of Federal Regulations, Chapter I-Federal Aviation Administration, Department of Transportation, Subchapter G-Air Carriers, Air Travel Clubs, and Operators for Compensation or Hire: Certification and Operations, Part 133 (14 CFR 133), U.S. National Archives and Record Administration, Washington, DC, January 1, 1995.
- [G.11] "Air Taxi Operators and Commercial Operators", Title 14 Aeronautics and Space, Code of Federal Regulations, Chapter I-Federal Aviation Administration, Department of Transportation, Subchapter G-Air Carriers, Air Travel Clubs, and Operators for Compensation or Hire: Certification and Operations, Part 135 (14 CFR 135), U.S. National Archives and Record Administration, Washington, DC, January 1, 1995.
- [G.12] "Agricultural Aircraft Operations", Title 14 Aeronautics and Space, Code of Federal Regulations, Chapter I-Federal Aviation Administration, Department of Transportation, Subchapter G-Air Carriers, Air Travel Clubs, and Operators for Compensation or Hire: Certification and Operations, Part 137 (14 CFR 137), U.S. National Archives and Record Administration, Washington, DC, January 1, 1995.
- [G.13] "Notification Reporting of Aircraft Accidents or Incidents and Overdue Aircraft, and Preservation of Aircraft Wreckage, Mail, Cargo, and Records", Title 49 Transportation, Chapter VIII-National Transportation Safety Board, Part 830 (49 CFR 830), U.S. National Archives and Record Administration, Washington, DC, October 1, 1995.