SAFETY ANALYSIS

This section discusses the nature and extent of accidents involving air medical transport helicopters and assesses the probability of such an accident involving the use of a helipad at San Francisco General Hospital.

SAFETY ASSESSMENT AND ANALYSIS CRITERIA

> *"Being safe does not eliminate risk, it reduces it."*
>
> Ira J. Blumen, MD

In their introduction to the November 2002 supplement to the Air Medical Physician Handbook, Dr. Ira J. Blumen and the University of Chicago Air Medical Network (UCAN) noted that "There are many ways to review the safety of air medical transport and to assess the relative risk to its crewmembers" and others.[1] This study considered a range of factors related to the safety of helicopters in general, and air medical helicopters specifically, including accident data and risk assessments. Similarly, the California Department of Transportation has conducted aviation safety studies and prepared a "handbook" for airport land use compatibility planning.[2] The findings of this chapter are based in large part on the information contained in these two documents and their derivative sources, among others.

Types of Compatibility Concerns

Typically, heliport, or in this case, helipad land use compatibility concerns fall into one or the other of two broad categories: noise and safety. However, a further division of these two categories of concern into four functional areas allows for a more comprehensive analysis of the issue at hand, i.e., the compatibility of the proposed project with SFGH and its surrounding neighborhoods. The following four categories of concern

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[1] Ira J. Blumen, MD and UCAN Safety Committee, "A Safety Review and Risk Assessment in Air Medical Transport," a supplement to the Air Medical Physician Handbook, Air Medical Physician Association, November 2002.

[2] California Dept. of Transportation, Division of Aeronautics, "Airport land Use Planning Handbook," December 1993. Note that the term "airport" means any landing or takeoff area such as an airport, heliport, helistop, vertiport, gliderport, seaplane base, ultralight flightpark, or balloonport.

> "The establishment of safety criteria comes down to a single basic issue:
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> *"What degree of risk is acceptable to the local community?"*
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> *Caltrans Airport Land Use Planning Handbook*

were originally defined by the California Department of Transportation (Caltrans) in its 1993 "*Airport Land Use Planning Handbook*" and carried forward into its 2002 Handbook update:[3]

- **Safety**: From the perspective of minimizing the risks of aircraft[4] accidents beyond the airport (helipad)[5] environment.
- **Noise**: As defined by cumulative noise exposure contours describing noise from helicopters operations to and from a heliport (discussed in elsewhere in this report).
- **Airspace Protection**: Accomplished by limits on the height of structures and other objects in the helipad vicinity and restrictions on other uses that potentially pose hazards to aircraft in flight.
- **Overflight**: The impacts of routine aircraft flight over a community.

SAFETY

Issues of "safety" are considered to be the most difficult to address with respect to airport and/or heliport/helipad land use compatibility. The reason is that safety concerns are based more on uncertain events that can and <u>may</u> occur, rather than on what <u>will</u> occur. In other words, the operation of a helipad and helicopter flight operations, if carried out under certain prescribed rules and regulations, are <u>not</u> unsafe, but accidents can and do happen regardless. Because aircraft accidents happen infrequently and the time, place and consequences of their occurrence cannot be predicted, the risk concept for assessing safety issues has been adopted.

For determining land use compatibility, the Caltrans Handbook identifies two variables to be used to determine the degree of risk posed by potential aircraft accidents:[6]

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[3] ____, Aeronautics Program, "California Airport Land Use Planning Handbook." January 2002. The purpose of the updated "California Airport Land use Planning Handbook" is to support and amplify the state's requirements for comprehensive airport land use planning.
[4] Helicopters are considered aircraft in the broader sense. The term "rotorcraft" is also applied to helicopters.
[5] The term "airport" includes heliports and helipads by definition.
[6] Op. cit., P. 3-5

- **Accident Frequency**: Where, when and how often aircraft accidents occur.
- **Accident Consequences**: Land uses and land use characteristics that affect the severity of an accident when one does occur.

Measurement

People's perceptions of what may be safe or unsafe are often highly subjective, but safety issues need to be addressed in an objective manner. One effective means of doing so involves the assessment of accident potential. Accident potential is typically measured in terms of frequency. There are both spatial and temporal components to assessing accident potential:

- **Spatial Element**—Describes where accidents are most likely to occur.
- **Temporal Element**—Assesses what the chances are for an accident to occur within a given period of time, or when.

Basis for Criteria

In practice, safety criteria are generally established on a progressive scale with the most severe restrictions imposed for locations with the greatest potential for aircraft accidents. The fact that aircraft accidents have historically occurred most often in locations closest to airport runways prompted the FAA to develop airport safety areas and runway protection zones (formerly known as "clear zones"). The FAA has likewise adopted airport imaginary surfaces for heliports.[7] However, there are no Federal laws or regulations that set safety criteria for helipad environs land use, except with respect to obstruction clearance (approach protection) requirements.

FAA safety criteria for helipads are focused primarily on the protection of the approach and departure corridors to and from the helipad. The 1993 Caltrans "Airport Land Use Planning Handbook" contained information based on extensive research into the distribution of fixed-wing aircraft accidents (but not for helicopters), which was designed to provide a better foundation for the

[7] FAA, Federal Aviation Regulations, Part 77, "Objects Affecting Navigable Airspace," Section 77.29.

establishment of safety criteria. The 2002 Handbook updated this information, and even with the new data, it concedes that the question of what may or may not be safe is still based on what the local community may consider to be acceptable risk.[8] Hence, there is actually little in the way of finite criteria available to local planning agencies with respect to the certainty of specific safety standards for the airport or heliport environs.

As part of the research conducted for the 1993 Handbook, data were gathered regarding the probable effects of a small fixed-wing aircraft colliding with a typical house or other small building.[9] These data and conclusions are equally valid for small helicopters (i.e., those weighing less than 12,500 pounds) and were carried forward in the updated Handbook unchanged. The consequences, then, of an aircraft or helicopter colliding with a building were found to be affected by many variables, including:

- The aircraft weight
- The amount of fuel on board
- The speed of the aircraft, both horizontally and vertically, at the time of the crash
- The angle of contact with the structure (e.g., head-on or glancing)
- The aircraft's attitude when the collision occurred
- The composition of the building's surface material at the point of impact
- The occurrence and extent of fire after the impact

The study determined that the combination of these variables was so great as to preclude definitive conclusions. The effects could only be estimated within a wide-range of possibilities. To the extent that any meaningful could be reached from the data obtained, they can be summarized as follow:

- **Significance of Aircraft Size**—Other factors being equal (which in reality they never are), more damage will be produced by larger or faster aircraft than by smaller or slower ones. The amount of kinetic energy produced by a small, but fully loaded, single-engine airplane flying at

[8] Op. cit., P. 3-7.
[9] Op. cit. P. 8-24.

minimum speed is equivalent to that of a small automobile traveling at about 55 miles per hour. By comparison, a cabin-class twin-engine aircraft (or comparably-sized helicopter) would generate kinetic energy similar to that of a loaded 10-ton truck traveling at 50 miles per hour.[10]

- **Aircraft Design Factors**—Unlike automobiles, aircraft are not designed for collisions. The disintegration of the wings and fuselage of a small general aviation aircraft as it collides with a building dissipates much of the kinetic energy that would otherwise be delivered to the structure. The same holds true for helicopters, except that the rotors would take the place of the airplane's wings.

- **Frequency of Occurrence**—General aviation aircraft and helicopter collisions with buildings of any kind, and residences in particular, happen relatively infrequently, regardless of what the evening news might imply.

- **Range of Consequences**—When an aircraft collides with a building, the results can range from insignificant to catastrophic. Neither data nor analyses can predict the actual effects of a particular incident.

Injuries to people on the ground (i.e., people who are not occupants of the aircraft) as a result of general aviation aircraft accidents occur even less frequently than collisions with buildings.[11] Most such accidents take place on airports. National data on injuries to people in residences and other buildings over a 19-year period indicate that only 3.1 accidents per year resulted in fatal or serious injuries to people on the ground. These data were for both helicopters and fixed-wing aircraft. For helicopters only, the accident rate would be substantially less, and even less for air medical helicopters.

HEMS Accident Data Base

Dr. Blumen's study included a comprehensive analysis of various data bases to identify individual helicopter

[10] James L. McElroy, "Aircraft Accidents in the Vicinity of Airports," January 1973.
[11] 2002 Handbook, P. 8-31.

emergency medical services (HEMS) accidents and their corresponding fatalities and injuries.[12] The research model developed by Dr. Blumen and UCAN estimated that since 1972, HEMS have flown around 3.0 million hours and transported 2.75 million patients with only 162 accidents involving medical helicopters and four accidents involving dual-purpose helicopters in the United States.[13] Of these accidents, 67 resulted in fatalities. There were 183 people killed. Of these, 144 were crewmembers. This calculates out to approximately 1 fatal accident for every 45,000 hours flown, or 2.3 fatal HEMS accidents per year on average and 2.73 persons (2.15 crewmembers/0.58 patients) killed per fatal accident. The data do not indicate any incidental fatalities on the ground.

When looked at over the short term, there has been an average of 2.5 fatal HEMS accidents per year since 1990.[14] These accidents have taken the lives of from 5-6 HEMS crewmembers each year. Given these data, it may be concluded that there is the potential for one fatal accident for every 45,000 hours flown by HEMS aircraft, or from 2.3 to 2.5 potentially fatal HEMS accidents per year. Each accident could result in the deaths of from 2.15 to 2.4 crewmembers and less than one patient death per accident.

Given these potential accident rates, the question then becomes one of the safety records of the HEMS providers that would serve San Francisco General Hospital. As noted above, the three most likely providers are: REACH (based in Santa Rosa and Concord), CALSTAR (based in Concord), and Stanford Life Flight (based in Palo Alto).

REACH has had sixteen years of accident free service, with 18,000 hours combined flying time and almost 15,000 patient transfers. This is the equivalent of approximately 920 patients per year. CALSTAR has been in business for nineteen years with no accidents or incidents. The company has 25,000 flight hours and has transported 19,000 patients. CALSTAR transports an average of 1,000 patients per year. Stanford Life Flight has also been in business for nineteen years, and has

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[12] Blumen et al., P. ii.
[13] Op. cit., P. ii.
[14] Ibid.

flown an estimated 14,250 accident-free hours.[15] Life Flight has transported 9,500 patients, or an average of 500 patients per year.

These three HEMS providers fly a combined estimated average of 3,191 hours per year, or an individual average of 1,064 hours per year. On the basis of Dr. Blumen's data of one fatal accident for every 45,000 hours (2.2 fatal accidents per 100,000 hours) flown since 1990, the three HEMS providers have demonstrated an exemplary safety record.

Dr. Blumen's study also looked at varying rates of fatal accidents for different time periods and determined that the average HEMS provider flew an estimated 911 hours per year and experienced fatal accident rates of from 1.38 to 1.69 accidents per 100,000 hours flown.[16] Using the above high and low rates (2.2 and 1.38 fatal accidents per 100,000 hours), any one HEMS provider could expect to have a fatal accident once every 49.9 to 79.3 years on average. Using the above average of 1,064 hours flown per year by the three HEMS providers most likely to use the SFGH helipad, the potential for a fatal accident would be once in a period of from 42.7 to 68.1 years. However, this statistic does not tell the complete story.

When Do HEMS Accidents Occur?

It is important to note that the above accident potentials apply to all phases of the HEMS flight operation, and not just to landings or takeoffs at the hospital helipad. A typical air medical transport operation, whether an accident scene-hospital transfer or hospital-hospital transfer, involves three takeoffs, three enroute segments and three landings.

The time of day, type of mission (purpose of the flight), and phase of flight are all important considerations, and all have their own accident rates. For example, nighttime air medical transport flights average 38% of total flights, but account for 49% of the HEMS accidents.[17] Helicopter flight phases include takeoff, maneuvering, climb, cruise,

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[15] Life Flight has had one incident involving a wire strike at a scene pickup during this period. The FAA differentiates between accidents and incidents.
[16] Op. cit. P. IV.
[17] Op. cit. P.5.

descent, approach, hover and landing. Most helicopter accidents occur during the cruise phase (36%).[18] The second most occur during takeoff (26%), with maneuvering, landing, and approach accounting for 9% each. The hover phase accounts for about 5-6% of total accidents, and climb and descent accounting for about 2% each. Flying into poor weather conditions was cited as the primary cause of cruise-phase accidents, particularly that of flying into instrument meteorological conditions (IMC) while enroute.[19]

The Blumen-UCAN study gave considerable attention to the accident rates associated with the purpose of a given flight. The study identified three basic HEMS mission accident types: non-patient accidents, scene accidents, and interhospital accidents. Non-patient accidents (e.g., training, PR, maintenance, fueling) accounted for 18% of all HEMS accidents. Scene accidents accounted for 35% of all accidents, and interhospital accidents accounted for the remaining 47%. Of these accidents, 65% were classified as pilot error and 25% were mechanical failures. The remaining 10% of causal factors were yet to be determined or unknown.

SFGH Accident Potential

Based on the above information, the potential for a fatal helicopter accident at, or on approach to or departure from, a San Francisco General Hospital Helipad is a function of the overall accident potential, the operational phase, and the percentage of time the helicopters would use SFGH (as opposed to other hospital helipads or accident scenes). As noted above, the fatal accident potential for any one of the three SFGH HEMS providers is one per every 52.7 to 68.1 years. **But, since not all operations by these HEMS providers would be conducted at SFGH, further refinement is necessary.**

Some operations would be scene to hospital transfers and others would be hospital-to-hospital transfers. Only one-third of the operations involved in transporting these patients would involve SFGH. It is estimated that only about 23% of all transfers by the three HEMS providers would involve SFGH. Also, 36% of all accidents occur in the cruise phase, leaving 64% involving all other phases.

[18] Ibid.
[19] Ibid.

The cruise phase has no direct bearing on helicopter safety at or near SFGH. When all of these factors are considered, the probability for a fatal accident at or near SFGH by any one of the three anticipated HEMS providers would be on the order of one in 1,329 to 1,717 years, or roughly one in 1,500 years.[20] While the potential for a fatal helicopter accident at or near SFGH is not zero, the fact remains that helicopter emergency medical services operations are not unsafe.

HEMS Accident Rate Comparison

Dr. Blumen and the UCAN Safety Committee compared the average accident rates for the various types of aviation operations, helicopters and HEMS operators for the period of 1982-1999, and for 10-years and 5-years, respectively. The 18-year average accident rate for HEMS operations was below that for civilian helicopters overall and general aviation.[21] For the 10-year average, HEMS was fifty percent less than for helicopters and general aviation. Over the past five years, the HEMS accident rate went up, but was still significantly less than for all helicopter operations and general aviation.

Fatal accidents were another matter, however. HEMS fatality rates surpassed all other components of civil aviation over the 18-year study period, but were less than for all helicopters and general aviation for the 10-year period. The HEMS fatality rate surpassed both helicopters and general aviation for the 5-year period.[22] For statistical comparison purposes, Blumen and UCAN extrapolated an annual fatality rate of 196 per 100,000 crewmembers.[23] The actual rate may be closer to 68 annual fatalities per 100,000 HEMS aircrew members (based on 6 aircrew member fatalities annually out of a

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[20] The formula is $P_{sfgh} = P_f / (A_s + A_h) \times U_{sfgh} \times O_p$. Where P_{sfgh} is the probability of a fatal HEMS accident at SFGH. P_f = Overall local HEMS fatal accident potential (1 in 52.7 to 68.1 years). A_s = % scene accidents at receiving hospitals (0.35 X 0.33) = 0.1155. A_h = % hospital-to-hospital related accidents (0.47 X 0.33) = 0.1551. U_{sfgh} = % of total HEMS operations to/from SFGH (0.229). O_p = % operational phases minus cruise (1.0 - 0.36) = 0.64.

[21] General aviation is defined as all civil aviation except that classed as air carrier or air taxi.

[22] Blumen et al. P. IV.

[23] The actual projected annual fatality rate is 1.96 per thousand crewmembers, based on an estimated 8,792 HEMS crewmembers, and extrapolated to 100,000. This totals 17.23 crew fatalities, which is over seven times the 2.4 annual crewmember fatalities mentioned earlier.

population of 8,792 crewmembers) based on conflicting information in Blumen's study. Nonetheless, it must be pointed out that this high rate may be grossly exaggerated, when one considers the small HEMS crewmember population. Regardless, as can be seen below, 68 fatalities per 100,000 are significant.

Risk Assessment Factors

The above data can be compared to the findings of the National Safety Council, which prepares statistics on the leading causes of death from injuries in the United States. In its "Report on Injuries, 2001," the Council noted that the leading causes of fatal unintentional injures had not changed during the period 1970-1998, except that "suffocation by ingested object (choking)" supplanted "fires and burns" as the fifth leading cause of accidental death. There were 97,300 unintentional injury deaths in the U.S. in 2000. The leading causes of unintentional-Injury deaths for 1998 (the latest available figures) were motor vehicles (43,501), falls (16,274), poisoning (10,255), drowning (4,406), and choking (3,515). Bicycling accounted for about 800 deaths in collisions with motor vehicles.

Deaths and Injuries in the Community. In 2000, there were 22,000 fatalities attributable to death in public places or places used in a public way and not involving motor vehicles. Most sports, recreation, and transportation deaths are included, but work-related deaths are not. The five leading causes of fatal accidents in the community are falls, drowning, air, water, and rail transportation. The data are not broken out by each category and air transportation accidents include both commercial air carrier and general aviation. However, historical data for deaths related to air transportation indicate a rate of 0.3 deaths per 100,000 population. Again, this statistic includes not only deaths in private flying accidents, but also passengers killed in commercial aviation accidents and military aviation accidents. Crewmembers are not included in the statistic, but the deaths of people on the ground killed as a result of the accident are included.

Historically, the rate of deaths from unintentional injuries per 100,000 population have approximated the following:

Motor Vehicle Accidents	17.3

Falls	5.0
Poison	2.3
Drowning	1.8
Fires/Burns	1.6
Other	7.4
Total	35.4

In statistical terms, and based on the above, an individual who is not an air crewmember is over 100 times more likely to die from an injury sustained in any other form of accident than one involving air transportation, and almost 60 times more likely to die from an injury sustained in an automobile accident. Statistically, involvement in a fatal general aviation accident is even less likely. However, for HEMS aircrew members, the odds are not so favorable.

On the other hand, being a patient transported by a HEMS helicopter is relatively safe, by comparison. Over a period of 22 years, Blumen and UCAN estimated that a total of 2,745,207 patients were transported by HEMS providers.[24] Of these, only 21 patients lost their lives in HEMS accidents. This corresponds to a death rate of 0.76 per 100,000 patients flown. If a patient survives a motor vehicle accident, a fall, or fire, there is a very high likelihood of he or she making it to the hospital safely when transported by an air medical helicopter.

AIRSPACE PROTECTION

The protection of an airport's airspace (i.e., the area above ground level used for the maneuvering of aircraft in flight) is critical to reducing the potential for aircraft accidents. The same is true for a helipad, and airspace protection is an essential component of helipad land use compatibility planning.

Compatibility Objectives

To avoid the development of land uses which, by posing hazards to flight, can increase the risk of an accident. Of particular concern are:

- Obstructions to airspace.
- Land uses that attract birds, or create visual or electronic interference with air navigation.

[24] Op. cit. P. v.

Measurement

Requirements for airspace protection are a function of several variables distinct to each helipad, including:

- The dimensions and layout of the final approach and takeoff area (FATO).
- The type of operating procedures established for the helipad (visual or instrument operations).
- The performance characteristics of the helicopters operating at the helipad.

Compatibility Strategies

Strategies for the protection of the helipad's airspace are related directly to the type of potential hazard:

- **Airspace Obstructions—**Buildings and other structures, trees, and antennae should be limited in height so as not to penetrate any of the FAR Part 77 heliport obstruction clearance surfaces, thereby avoiding potential hazards to flight. Any structure or object that penetrates these three-dimensional surfaces is considered to be an obstacle, obstruction or major obstruction depending on the degree of penetration. Major obstructions may affect the aeronautical use of the airspace.

- **Other Hazards to Flight—**Land uses that generate smoke, glare, electromagnetic interference or other hazards to flight, including bird attractants should be avoided or modified to achieve compatibility.

Basis for Criteria

The criteria for determining airspace obstructions and other hazards to flight have been established in the Federal Aviation Regulations (FARs) and other regulations and guidelines since the mid-1970's. FAR Part 77, "Objects Affecting Navigable Airspace" sets forth the criteria to be used for protecting the airspace around a helipad.

Finding. The preliminary rooftop helipad designed for San Francisco General Hospital is in conformity with FAA airspace protection criteria, with the exception that some rooftop antennae and other protuberances may have to be relocated away from the immediate area of the helipad.

OVERFLIGHT

Of the various compatibility categories aircraft overflight is the most subjective.[25] The issue of aircraft overflight is primarily a perceptual issue relating to safety and is more common to residential uses than to commercial, office or industrial uses. This is based on the fact that many people are sensitive to the frequent presence of aircraft overhead even at noise levels lower than typically considered significant (i.e., under DNL 65dB). This sensitivity is often expressed in terms of fear or annoyance by people residing in communities around an airport. However, this category of compatibility concern is not one for which many communities have adopted policies or planning criteria. However, it must also be pointed out that the FAA has full authority for the control of aircraft in flight.

Compatibility Objectives

In one sense, the compatibility objective for overflight is the same as for noise, i.e., avoid overflying sensitive land uses that can lead to annoyance and complaints. However, this is not always possible given the broad geographic area subject to overflight by air medical helicopters arriving or departing a helipad at SFGH.

Measurement

Empirical studies have documented that not just noise, but the absolute number of overflights in a given residential area are key factors for annoyance. Generally concerns about overflights are highest in close-in areas under arrival and departure tracks.

Compatibility Strategies

The best strategy to avoid potential annoyance from aircraft overflight is to avoid overflying noise sensitive

[25] As the term is applied here, an *overflight* means any distinctly visible or audible passage of an aircraft, and not necessarily one that is directly overhead.

residential uses. A good noise abatement strategy, especially for helicopters, is to use transportation corridors (e.g., freeways, highways) as much as possible before lining up for final approach to the helipad.

Basis for Criteria

Experience is the best teacher, and many airports and heliports have learned that noise abatement flight procedures may be necessary to minimize the potential for annoyance and complaints from surrounding neighborhoods. Conversely, other helicopter operations in the area, such as news helicopters and traffic reporters, may color community attitudes toward a hospital helipad. Hence, any noise abatement overflight procedures for a hospital helipad should be looked at in a broader context.

CONCLUSIONS

There are a number of conclusions that can be drawn from the above data and analyses. First and foremost is the fact that air medical helicopter operations are not inherently unsafe, but accidents can and do happen. Secondly, should an accident occur as a result of air medical helicopter operations at San Francisco General Hospital, the greatest danger would be to the aircrew members. There is little evidence to support any danger to surrounding neighborhoods, even though some of these neighborhoods could be subject to helicopter overflight.