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The Safety of Air Ambulances

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The Safety of Air Ambulances

Summary

The estimated rate of air ambulance accidents has been steadily rising since the early 1990s, and has increased at a rapid rate since 1998 when the industry began to expand more rapidly and shift toward a model of more independent private air ambulance services that cover larger geographic areas. Statistics indicate that the large majority of air ambulance accidents are attributable to operational factors related to pilot situation awareness and decision making when faced with adverse environmental conditions such as darkness, deteriorating weather, rugged terrain, or some combination of these factors.

Initiatives to improve air ambulance safety to date have consequently focused on additional pilot training, implementing risk management practices to improve the safety of flight operations, and using various technologies to improve pilot situation awareness in restricted visibility conditions. However, implementation of these safety measures has strictly been voluntary. The National Transporation Safety Board (NTSB) and other aviation safety experts are advocating the mandatory use of formal flight dispatch procedures and risk management practices among air ambulance operators as well as mandatory installation of terrain warning systems on air ambulance aircraft. The NTSB also found that many air ambulance accidents occur when patients are not on board, such as en route to an accident scene. Present regulations allow air ambulances to operate under a less stringent set of rules with regards to weather minimums and pilot duty times when not carrying patients. However, the NTSB believes that air ambulance flights should operate under more stringent commercial operating rules at all times that medical personnel are carried on board. Although maintenance issues have been identified in about 20 percent of all air ambulance accidents, neither the Federal Aviation Administration (FAA) nor the NTSB has placed any specific emphasis on oversight of operators or repair stations that maintain air ambulance aircraft. The present emphasis on air ambulance safety has, instead, been dominated by concerns over flight crew performance and weather-related factors.

A variety of options are available to improve safety among air ambulance operators. These options include intensified oversight of air ambulance operators and regulatory changes to bring all phases of air ambulance operations under the same set of operational rules regarding weather minimums and pilot duty times; possible regulatory changes to provide for sharing and analysis of safety-related data and observations with some degree of impunity; possible aircraft design considerations to improve crash survivability; expanded application of system safety and formal risk management principles to mission planning and flight operations; enhanced training for both pilots and support personnel and operational procedures to improve coordination and situation awareness among the entire air ambulance crew and ground support team; and the use of various technologies to improve pilot situation awareness and augment pilot vision in low visibility conditions.

This report will not be updated.

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Air ambulances that conduct emergency medical service operations and other medical-related transport services include both helicopter emergency medical services (HEMS) that primarily conduct scene response transport of trauma patients and fixed-wing aircraft operations that primarily conduct inter-facility transports of critical care patients. The air ambulance industry has grown significantly over the past 25 years and is widely regarded as having a beneficial effect on improving the chances of survival and recovery for trauma victims and other critical patients, especially in rural areas. However, during this time, the air ambulance industry has been the focus of two in-depth National Transporation Safety Board (NTSB) special safety studies and numerous other investigations by aviation safety researchers that have pointed to continued concerns over the safety of its flight operations, particularly among helicopter air ambulance operators. Although the air ambulance industry and Federal Aviation Administration (FAA) regulators have taken some positive steps to address continued concerns over operational safety, the NTSB and some other aviation safety experts have voiced concerns that not enough has been done to reduce the risk of accidents in air ambulance operations.

This report analyzes available air ambulance safety data, examines the current state of the air ambulance industry and factors that may influence safety within the industry, assesses causal factors underlying the recent spate of air ambulance crashes, and discusses some available options for improving safety.

An Analysis of Air Ambulance Safety Data

A recent increase in the number of crashes involving air ambulances has raised concerns among aviation safety experts. According to a National Transportation Safety Board (NTSB) special study focusing on aviation emergency medical operations released in January 2006, 55 crashes involving air ambulances occurred in the United States between January 2002 and January 2005.[1] The NTSB noted that this number of crashes has not been seen since the 1980s. Given that the current air ambulance fleet is estimated to consist of about 750 helicopters and 150 fixed wing aircraft,[2] each year over the past three years, about one in every 50 helicopter air ambulances has been involved in a crash. An article in *USA Today* offered the following stark analogy: "If commercial airlines lost the same proportion of large

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[1] National Transportation Safety Board, *Special Investigation Report on Emergency Medical Service Operations.* NTSB/SIR-06/01.

[2] Foundation for Air-Medical Research & Education (FARE), *Air Medicine: Accessing the Future of Health Care,* Alexandria, VA: FARE, 2006.

passenger jets as air ambulance companies lost helicopters, 90 airliners would crash each year."[3]

Because there is no centralized database of flight records for the air ambulance industry, no one knows for sure if safety is eroding or if this increase in accidents can be explained by the large growth in the use of helicopters and airplanes for medical evacuation and patient transport. The NTSB notes that while industry estimates suggest that the number of hours flown by air ambulances has increased by about 85% over the past 15 years, the estimated accident rate for helicopter air ambulances has also risen from 3.52 accidents per 100,000 flight hours between 1992 and 2001 to 4.56 accidents per 100,000 flight hours between 1997 and 2001.[4] The NTSB, however, did not provide its own estimates of accident rates or more recent figures on the annual accident rates for air ambulances.

Available accident statistics and analyses reviewed by CRS have focused on helicopter air ambulance operations, which make up more than 80% of the air ambulance fleet. Consequently this report concentrates on safety data and finding related to helicopter air ambulances, although many of the issues and observations may be more broadly applicable to both helicopter and fixed-wing air ambulances.

While much of the flight hour data to substantiate accident rate statistics for air ambulance operations remains sketchy, CRS analyzed helicopter air ambulance safety data and computed accident rates using accidents between 1991 and 2004 identified in the 2006 NTSB special study report, and accident data and industry estimates of hours flown by helicopter air ambulance operators cited in a comprehensive safety review and risk analysis of air ambulance accidents published by the Air Medical Physician Association (AMPA).[5] This analysis estimated that the overall accident rate among air ambulance operators from 1991 to 2004 to be 3.50 accidents per 100,000 flight hours and the fatal accident rate to be 1.13 accidents per 100,000 flight hours. Looking only at the data since 1998 when a notable spike in accidents was first observed, the estimated overall accident rate rose to an average of 4.75 accidents per 100,000 flight hours and the estimated fatal accident rate increased slightly to 1.25 accidents per 100,000 flight hours. Three-year moving averages of the estimated accident rate were computed across the 14 year period

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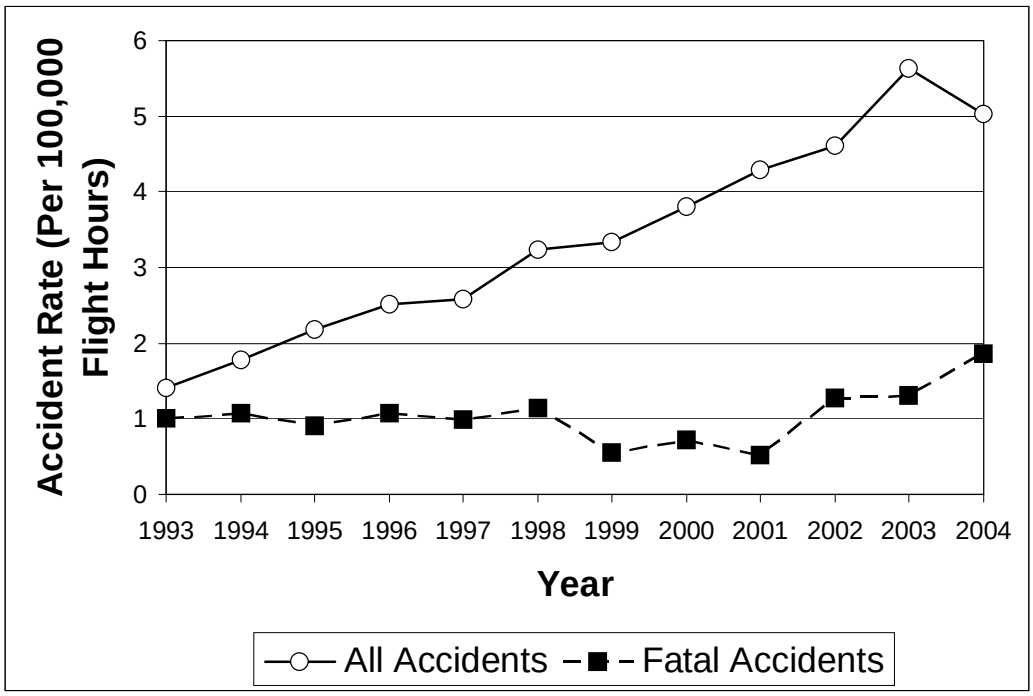
[3] Alan Levin and Robert Davis, "Surge in Crashes Scars Air Ambulance Industry." *USA Today*, July 18, 2005, A1.

[4] *Ibid.* See also Ira J. Blumen, M.D., and the University of Chicago Aeromedical Safety Committee, *A Safety Review and Risk Assessment in Air Medical Transport*, 2002, Air Medical Physicians Association, Salt Lake City, UT.

[5] CRS analysis of annual accident data and flight hour estimates provided in National Transportation Safety Board, *Special Investigation Report on Emergency Medical Service Operations* and Ira J. Blumen, M.D., and the University of Chicago Aeromedical Network. *A Safety Review and Risk Assessment in Air Medical Transport*, 2002. Note: for 2002 through 2004, CRS interpolated estimated flight hours based on industry flight hour estimates provided for previous years and an estimate of 300,000 hours flown in 2005 cited in the NTSB report. This yielded an average annual increase in flight hours between 2001 and 2004 of roughly 9.3%.

based on available flight time estimates and are shown in **Figure 1**.[6] The trend in the three-year moving average accident rates suggests a steady increase in the accident rate from 1991 through 2003, with a slight reversal of this trend in 2004. The data also show a slight rise in the fatal accident rate over the past five years. While these data demonstrate an increase in helicopter air ambulance accident rates, particularly since 1998, they cannot be regarded as conclusive because of the lack of reliable data on the overall number of hours flown. However, these data, based on best available information, strongly suggest that there is cause for concern regarding the safety trend for air ambulance operations.

Figure 1. Three-Year Moving Average of Estimated Overall and Fatal Accident Rates for Helicopter Air Ambulance Operations



Sources: CRS analysis of annual accident data and flight hour estimates provided in National Transportation Safety Board, *Special Investigation Report on Emergency Medical Service Operations.* NTSB/SIR-06/01 and Ira J. Blumen, M.D., and the University of Chicago Aeromedical Network. *A Safety Review and Risk Assessment in Air Medical Transport,* 2002, Air Medical Physicians Association, Salt Lake City, UT. ***Note***: A three-year moving average computes the accident rate using the data from the current year and the two prior-years.

There are two key concerns regarding these accident rate estimates. First, the trend shows a steady increase in estimated accident rates over the past 14 years, with

[6] A three-year moving average, sometimes referred to as a three-year rolling average, is an accident rate calculation based on accidents and flight hours during the referenced year and the two prior years. So, for example, the data points for 1993 are based on accidents and flight hour estimates for 1991, 1992, and 1993. This is done to provide a more stable metric for analyzing trends among accident rates that may fluctuate significantly from year to year.

a more marked increased since 1998. Second, these estimated accident rates are notably higher than many other commercial aviation sectors. In particular, over the same period (from 1991-2005), non-scheduled air taxi operators, which fly under the same rules as air ambulance operators carrying patients, experienced an overall accident rate of 2.52 accidents per 100,000 flight hours and a fatal accident rate of 0.67 fatal accidents per 100,000 flight hours.[7] While air ambulance operations, particularly helicopter air ambulance operations, by their nature may arguably be inherently more risky than other commercial aviation operations, the relatively higher estimated accident rates coupled with the observed trend of increasing accidents and estimated accident rates suggests that the causes of these accidents and possible options to reduce these numbers is an appropriate topic for policy analysis.

When the NTSB previously examined commercial emergency medical service helicopter operations in 1988, it estimated that the overall accident rate between 1980 and 1985 was 12.34 per 100,000 flight hours, almost twice the estimated accident rate experienced by non-scheduled helicopter air taxis during that period.[8] Moreover, the fatal accident rate of 5.40 per 100,000 flight hour for helicopter air ambulances between 1980 and 1985 was estimated to be about 3 ½ times the fatal accident rate for non-scheduled helicopter air taxis and all turbine-powered helicopters.[9] While more recent accident rate estimates among helicopter air ambulance operators have been climbing steadily, they still appear to be much lower than estimates for the early 1980s. However, the lower observed accident rates in the early 1990s suggest that safety improvements can be made in air ambulance operations to reduce the overall and fatal accident rates compared to recently observed levels. Specifically, between 1991 and 1995, the helicopter air ambulance industry had an estimated 1.81 accidents and 0.91 fatal accidents for every 100,000 flight hours, accident rates that closely resemble those of other commercial aviation operations such as the previously cited statistics for non-scheduled air taxi operators. Arguably, based on these data, the helicopter air ambulance industry has already demonstrated that it can achieve a better safety record than what it has experienced since 1998.

Although air ambulance operations can be inherently riskier than other aviation operations because the environment in which they operate is more dynamic and unpredictable, some experts have raised concerns that the air ambulance industry and the FAA are simply accepting a higher accident rate than other areas of the aviation industry rather than taking steps to reduce the number of accidents.[10] While the FAA and the air ambulance industry have acknowledged that ongoing safety concerns

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[7] Both non-scheduled air taxi operators and air ambulance operations with patients on board are conducted under Title 14 Code of Federal Regulations, Part 135. CRS calculations based on data provided in: National Transportation Safety Board, *Accidents, Fatalities, and Rates, 1986 - 2005, 14 CFR Part 135, Nonscheduled Service (On-demand Air Taxis).*

[8] Non-scheduled helicopter air taxi are operated under Title 14 Code of Federal Regulations, Part 135 and generally do no include local air tours that are exempt from operating under this set of regulations.

[9] National Transportation Safety Board, *Commercial Emergency Medical Service Helicopter Operations,* NTSB/SS-88/01.

[10] Alan Levin and Robert Davis, "Surge in Crashes Scars Air Ambulance Industry."

exist, critics argue that their actions to date — largely consisting of advisory materials and recommendations requiring only voluntary compliance by operators — are inadequate. To further assess the root causes of air ambulance accidents and assess possible policy changes to improve safety in the air ambulance industry, it may be beneficial to examine the operational role of air ambulances as well as the current state of the air ambulance industry and management practices in the air ambulance industry.

The Role of Air Ambulances

When most people think of an air ambulance operation they are likely to first consider helicopter transports of trauma patients, such as car accident victims. This has historically been the predominant form of air ambulance service since its beginnings in the early 1970s. Large scale use of air evacuation of wounded troops was demonstrated to be an effective means of reducing combat mortality both in the Korean and Vietnam conflicts. Based on this experience, civilian air ambulance use in the United States began on a small scale starting in the early 1970s and has grown significantly since. Although some studies have found little or no benefit from helicopter evacuations of civilian trauma patients, numerous studies point to improved chances for recovery and significant reductions in mortality rates when air ambulance services are made available to trauma patients.[11] Medical theory and practice holds that providing critically injured patients with surgical intervention within the first hour after injury – the so-called "Golden Hour" – can significantly improve the chances for survival and recovery.[12] In practice, air ambulances, particularly helicopters, can play an important role in this intervention by providing rapid patient transport to trauma centers where they can be effectively treated, and in some cases providing advanced life support capabilities en route. The availability of this service provides an important role, especially in rural communities that lack readily accessible advanced care facilities and medical specialists.

More recently, there has been increased utilization of air ambulances, both helicopters and airplanes, for both on-scene response and inter-facility transport of critical cardiac patients and stroke victims. Both helicopters and fixed-wing aircraft are also utilized for other inter-facility transfers to give patients access to specialty care facilities and medical specialists. While the on-scene response of a helicopter at a traffic accident is probably what first comes to mind when the term air ambulance is used, today about 54% of all air medical transports are from hospital to hospital, while on-scene responses make up 33%. The remaining 13% include organ and medical supply and speciality medical team transports.[13] Air ambulances can also play an important role in emergency evacuation of critical care patients and

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[11] Association of Air Medical Services (AAMS), *AAMS Brief – Part 3: Air Medical Research and What It Shows*. Alexandria, VA: AAMS; National Transporation Safety Board, *Commercial Emergency Medical Service Helicopter Operations*; Foundation for Air-Medical Research & Education (FARE), *Air Medicine: Accessing the Future of Health Care*.

[12] Foundation for Air-Medical Research & Education (FARE), *Air Medicine*.

[13] *Ibid.*

transport of medical supplies and staff to disaster areas, as was demonstrated in the aftermaths of Hurricanes Katrina and Rita in 2005.[14]

While some critics assert that air ambulance transports are being over utilized,[15] there is generally widespread acceptance of the benefit provided by both the general public and the medical community. The air ambulance community acknowledges that utilization of air ambulances in some cases may, in retrospect, prove to have been unnecessary. This, they argue, is to be expected if the medical community is to assure that the maximum number of patients who could potentially benefit from air ambulance services are provided with this service. Over the past 15 years, guidelines for air medical dispatch have been refined by the air ambulance community and emergency room physicians. These various guidelines set forth circumstance-specific and patient-specific criteria for decision makers assessing whether to dispatch a flight as well as for analysts reviewing and modeling utilization and refining resource allocation across a particular geographic area.[16] The industry also argues that while air ambulance services are comparatively costly when examined on a single-case basis, appropriately used air medical transport is cost-effective on a system-wide basis, largely due to more efficient coverage of large geographic areas, reduced patient transport times, and more rapid intervention that can reduce overall patient care costs.[17] In general, air ambulance services have garnered wide community support and endorsement from the medical community as being a beneficial and cost-effective service for improving access to critical health care and increasing the chances of survival and recovery for trauma victims and critically ill patients, particularly in areas where access to specialized health care is limited. Consequently, air ambulance utilization is likely to continue its steady growth throughout the United States, particularly in rural areas. This expectation of continued growth for the industry draws particular attention to the ongoing safety concerns, because continued growth without any improvement to safety could trigger widespread public concern over the safety of these operations which has already been evidenced to some degree based on recent media coverage of the issue.[18]

State of the Air Ambulance Industry

The civilian air ambulance industry can trace its origins back to the early 1970s with the creation of the Maryland State Police aviation program in 1970 and the first hospital-based medical helicopter service at St. Anthony's Hospital in Denver, Colorado in 1972. Prior to then, police departments in the 1960s and early 1970s had

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[14] *Ibid.* Note: Unlike other helicopters and aircraft used in search and rescue (SAR) and relief missions during natural disasters, dedicated air ambulances are specially equipped and staffed for transporting sick and injured patients. This report only discusses safety data and issues for dedicated air ambulance aircraft.

[15] Barry Meier. "Crashes Start Debate on Safety of Sky Ambulances." *The New York Times*, February 28, 2005.

[16] Foundation for Air-Medical Research & Education (FARE), *Air Medicine*.

[17] *Ibid.*

[18] See especially Barry Meier. "Crashes Start Debate on Safety of Sky Ambulances" and Alan Levin and Robert Davis, "Surge in Crashes Scars Air Ambulance Industry."

used helicopters on occasion to transport critical patients, but provided very limited en route patient care. The air ambulance industry gradually grew during the 1970s and by 1980 included 32 helicopter emergency services flying 39 helicopters. During the 1980s, the industry grew fivefold and by 1990 included 174 helicopter emergency services and 231 helicopters. The industry experienced continued growth in the 1990s expanding to 231 helicopter emergency services flying 400 helicopters by 2000.[19]

A variety of factors, including increases in Medicare reimbursement rates for air ambulance services and recent declines in available emergency medical and advanced patient care services in rural areas, have resulted in a significant growth in the air ambulance industry over the past five years. In 2005, there were 272 helicopter emergency services flying 753 helicopters in the United States, roughly an 88% increase in the number of helicopter air ambulances compared to the size of the industry in 2000. In 2005, there were also an estimated 150 fixed-wing airplanes dedicated to air ambulance operations used mostly for inter-hospital transfers.[20] Based on industry flight hour estimates, growth in the use of air ambulances has been increasing at a rate of about 4.5% per year over the past 15 years, and most observers believe that this steady growth in both the size of the dedicated air ambulance fleet in the United States and the utilization of air ambulances will continue over the next several years.

While some states and municipalities and other public agencies operate air ambulances as public aircraft, most air ambulance services are privately owned and operated, either directly by a hospital or hospital consortium or by private aviation medical service providers. The Maryland State Highway Patrol has a comprehensive helicopter air ambulance capability that covers the entire state, while the California Highway Patrol and the Virginia and Delaware State Police provide air ambulance services in portions of those states. Several county police forces and emergency medical units throughout the United States also perform air ambulance missions. Also, federally operated aircraft provided by the U.S. Coast Guard in Alaska and the U.S. Army in Hawaii conduct civilian air ambulance operations. CRS estimates that federal, state, and local government-operated aircraft currently account for about 10% of air ambulance operations in the United States. However, private operators make up the large majority of air ambulance services across the United States.[21] Unlike aircraft that are operated by a state or local agency which are considered public aircraft and therefore not under direct FAA oversight, air ambulances operated by private companies are regulated by the FAA, and therefore have been the focus of safety studies examining safety within the industry and the FAA's actions to monitor and regulate safety.[22] These private aviation medical providers may operate under

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[19] Foundation for Air-Medical Research & Education (FARE), *Air Medicine*.

[20] *Ibid.*

[21] See the Association of Air Medical Services (AAMS), *Atlas & Database of Air Medical Services (ADAMS)*. AAMS National Office, Alexandria, VA for a comprehensive geographic database of air ambulance service coverage across the United States.

[22] CRS is not aware of any study examining the safety of public aircraft used as air (continued...)

direct contract providing aircraft and flight crews to a specific hospital or hospital consortium, or as is becomingly increasingly more common, may act more as a independent entity with affiliations with various hospitals over a large geographic region.

In the late 1990s, regulatory changes requiring ambulance services, including air ambulances, to bill patients separately from hospital charges as well as increases in Medicare reimbursement for air ambulance flights in some regions, brought about significant changes to the industry.[23] Most helicopter emergency medical services in the 1980s and early 1990s were either run directly by hospitals and emergency facilities or, more commonly, operated under hospital-managed contracts with aviation companies that provided the helicopters and pilots.[24] Today, many of these services are now operated by stand-alone, private entities with hospital affiliations, and in many locations, there is direct competition between air ambulance service providers within a region.

While some states and local governments provide air ambulance services as a public good or quasi-public good, privately-run operations are far more common. The Maryland State Police Aviation Command, as an example of a state-run system, derives about two-thirds of its funding from automobile registration fees and the remainder from general state treasury funding for the state police. Patients are consequently not required to pay for transport and medical costs provided by this service. In the privately-operated air ambulance model, by contrast, patients or their insurers are directly billed for charges incurred for air ambulance transport. Although privately-operated air ambulance services provide an important function in the communities they serve, critics argue that the financial pressures associated with operating these services as well as insufficient regulatory requirements and oversight may be significant factors that could negatively affect flight safety across the industry.

Although competition and associated pressures to conduct missions was already present when the NTSB examined air ambulance helicopter safety in 1988, it was generally concluded that helicopter patient transport at that time was not profitable on the basis of transportation alone. In fact, a 1986 survey cited by the NTSB found that patients were, on average, only charged for about 75% of the direct cost of air ambulance transport.[25] Hospitals made up for these losses through charges for other advanced care services provided at the hospital. Thus, the competition that existed

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[22] (...continued)
ambulances or any study comparing safety between private air ambulance operators and those operated by state and local government entities.

[23] Barry Meier, "Crashes Start Debate on Safety of Sky Ambulances." *The New York Times*, February 28, 2005. Also see, Title 42 Code of Federal Regulations, Part 414, Subpart H: *Fee Schedule for Ambulance Services.*

[24] *Ibid.* See also, National Transportation Safety Board, *Safety Study: Commercial Emergency Medical Service Helicopter Operations.*

[25] National Transportation Safety Board, *Safety Study: Commercial Emergency Medical Service Helicopter Operations.*

in the 1980s was largely between hospitals. From a business perspective, air ambulances, at that time, were largely seen as a marketing tool to increase public recognition of the hospital within the community and attract patients. In the current environment, however, the competition appears to be more directly related to the flight mission as the business model for most private-sector air ambulance services has been shifting toward stand-alone operators that market their services to local hospitals, emergency officials, and even to the general public.[26] One example of marketing to the general public is the sales of yearly "memberships" that will cover any gaps not paid by insurance for air ambulance transports.[27] Various competitive pressures, including direct competition among services and the desire to satisfy hospital and emergency medical service administrators that oversee air ambulance contracts, can potentially affect flight safety if they factor into decisions regarding whether to accept or continue a flight mission. Operating air ambulances as private businesses may also create financial pressures that could lead some operators to forego safety improvements or enhancements that are not specifically required in order to keep operational costs at a minimum. These various operational pressures that exist in the air ambulance industry and their potential impact on safety will be considered in greater detail along with other possible causal and contributing factors in air ambulance crashes.

Causes of Air Ambulance Crashes

The large majority of air ambulance accidents occur due to a chain of circumstances involving pilot decision-making and performance and flight conditions such as weather and terrain. In particular, darkness, reduced visibility, and rising terrain present significant challenges and risks to air ambulance operators – particularly helicopter operators – and are often cited as causal factors in accidents. Pilot knowledge or "situation awareness" regarding weather conditions and terrain has also been found to be a significant factor in a large number of air ambulance accidents.

CRS analyzed a database of 120 helicopter air ambulance accidents compiled by the Helicopter Association International that occurred between 1991 and 2004. Causal factors were categorized based on brief descriptions of the accident circumstances and weather conditions provided in this database. The results of this analysis are shown in **Figure 2**.

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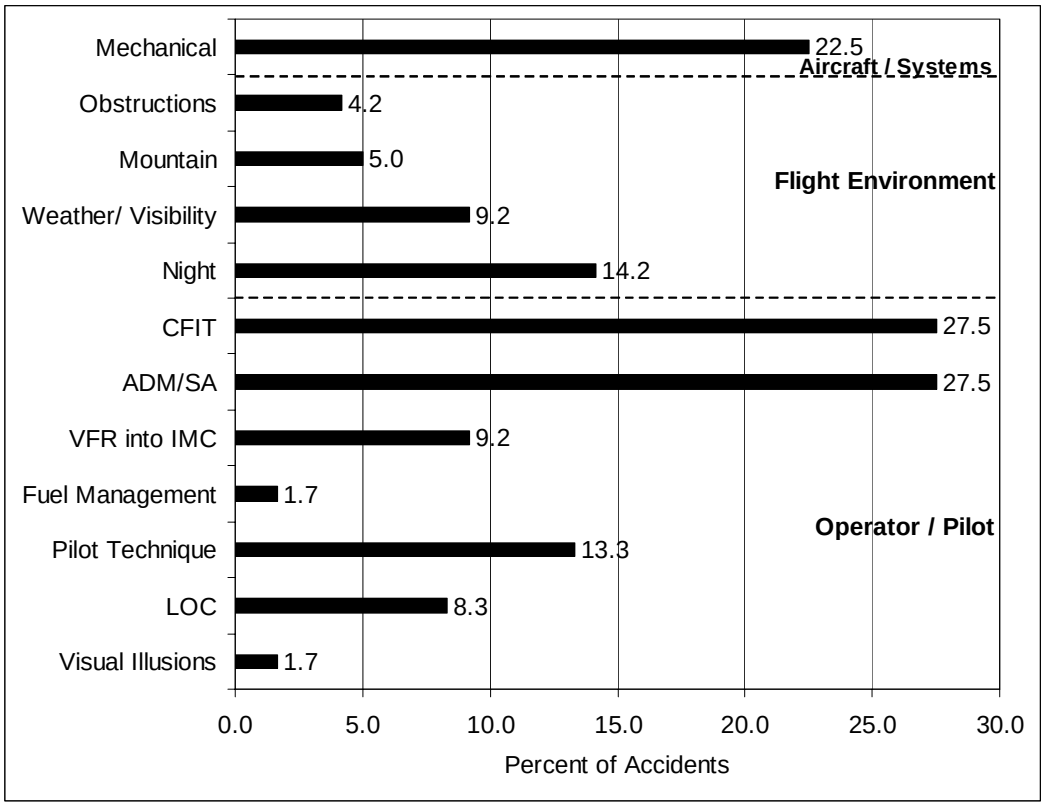
[26] Barry Meier, "Crashes Start Debate on Safety of Sky Ambulances."

[27] *Ibid.*

Figure 2. Factors in Helicopter Air Ambulance Accidents (1991 -2004)



Source: CRS analysis of accident synopses provided in Helicopter Association International, *Air Medical Service Accidents, 1991 thru 1994,* Alexandria, VA. ***Note***: CFIT: Controlled Flight into Terrain; ADM: Aeronautical Decision Making; SA: Situation Awareness; VFR into IMC: Visual Flight Rules into Instrument Meteorological Conditions. Percentages sum to more than 100% because many accidents were assigned to more than one causal factor.

Interaction Between Pilots and Flight Conditions. The interplay between the pilot or flight crew (the operator) and environmental factors such as weather and terrain played a part in roughly 80% of the accidents examined. This finding closely matches other analyses examining the causes of air ambulance crashes.[28] One of the most common causal factors in these accidents, cited in 27.5% of the crashes, was what aviation safety experts refer to as controlled flight into terrain (CFIT), a broad category that generally involves a loss of situation awareness regarding surrounding terrain, often in poor visibility or at night. The other most cited factor, also identified in 27.5% of the accidents, was aeronautical decision making and situation awareness (ADM/SA), which refers to a pilot's knowledge of factors affecting the safety of flight and the ability to evaluate risk based on these factors and make appropriate informed decisions. Another contributor to helicopter air ambulance crashes, related to errant pilot decision making, is continuing a flight using outside visual references as is permissible under visual flight rules (VFR) into

[28] See Ira J Blumen, M.D., and the University of Chicago Aeromedical Safety Committee, *A Safety Review and Risk Assessment in Air Medical Transport*.

poor weather and visibility conditions, known to aviators as instrument meteorological conditions (IMC). Continued VFR into IMC, as it is referred to by air safety experts, was cited as a causal factor in 9% of helicopter air ambulance crashes. Other pilot-related factors cited in a number of accidents included loss of aircraft control, pilot technique, and visual illusions, all factors that frequently crop up in poor visibility conditions when a pilot loses visual reference to the horizon or the ground below and is unable to effectively transition to flight solely by reference to cockpit instruments. These flight operational factors are a central concern and have been the focus of the NTSB's safety recommendations regarding air ambulance operations as well as the efforts of the FAA and the air ambulance industry to encourage voluntary implementation of systems safety and risk management concepts in air ambulance operations.

Pilot Situation Awareness of Weather Conditions. In its most recent review of air ambulance safety, the NTSB found that situation awareness can often be lacking in air ambulance operations for a variety of reasons, but was chiefly concerned with the lack of formal flight dispatch procedures among operators. Air ambulance pilots lack the benefit of consistent, comprehensive flight dispatch procedures and often rely on emergency (911) dispatchers, referred to in the industry as communications specialists, or emergency medical personnel that typically have no formal training in flight dispatch procedures. In 11 of the 55 accidents reviewed by the NTSB in their 2006 special study, incomplete or missing information regarding weather, route of flight, and coordination with on-scene rescue personnel factored into the causal chain of the accident. The NTSB, consequently, recommended that the FAA require air ambulance operators to use formalized dispatch and flight-following procedures that include up-to-date weather information and assistance in flight risk assessment decisions.[29] In response to this recommendation, policymakers might opt to assess the benefits and costs of implementing formal flight dispatch procedures and specific training in these procedures to both flight crews and ground communication specialists in the emergency medical field that coordinate and dispatch air ambulance missions.

Mission Pressures. Aviation safety experts have also pointed to pressures to complete the mission as factors that can lead to poor judgment among air ambulance pilots and contribute to accidents. In 1988, the NTSB found that mission pressures could be exacerbated by a lack of on-site supervision among operators, particularly those operators that service a broad geographic area. In many of these instances, the NTSB found that a pilot's immediate supervisor was not located at the pilot's base station or hospital, and in some cases, was located in a distant city. The NTSB concluded that isolation from management forces pilots to look for structure and guidance from other sources, particularly hospital emergency service administrators and personnel. This arrangement can result in pilots placing greater importance on the medical mission and potentially may compromise sound judgment with regard to flight safety. The NTSB noted that:

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[29] National Transportation Safety Board, *Special Investigation Report on Emergency Medical Service Operations.*

> [h]ospital management, the EMS medical personnel, and the dispatchers can all intentionally or unintentionally put pressure on the pilots to take a flight in marginal weather conditions. The reasons for these pressures include misunderstanding or lack of understanding of weather-related considerations, genuine zeal to get a job done, or even competition between EMS programs.[30]

The NTSB also found that, besides the pressures to complete missions based on medical need influencing flight safety considerations, the relationship between air ambulance operators and hospitals can play a role in decisions regarding whether to accept or continue a mission. Pilots may feel pressured to accept or continue missions in marginal weather conditions in order to satisfy hospital administrators and maintain good business relations with them. In privately-operated air ambulance services, the hospital is, in essence, a customer of the air ambulance service, and pilots may feel compelled to satisfy their customer by accepting and completing a maximum number of missions. These pressures may be even greater at hospitals and in regions where there is direct competition among air ambulance providers.

A survey of helicopter air ambulance pilots found that while pressure to accept or continue missions is a significant concern, pilots more frequently cited pressure to speed up response time as the most significant pressure factor affecting mission safety. Internal and external pressures to speed up response time could cause pilots to miss important risk factors and fail to obtain a full understanding of the weather, route of flight, obstacles and obstructions en route, and other key pieces of information during the flight preparation process.

Policymakers may consider options to require specific training and implementation of risk management techniques for air ambulance operators dealing with the specific operational environment and operational pressures of the air ambulance industry. While the FAA has provided a variety of training materials and resources on aeronautical decision making that are both general in nature as well as specific to unique considerations for helicopter and air ambulance operations, decision making and various external pressures that may effect pilot judgment on air ambulance missions is often not covered in depth during initial and recurrent pilot training. Therefore, policymakers may consider more formal training and testing of aeronautical decision making concepts specific to air ambulance operations as a possible option for mitigating accidents related to poor judgment and decision making errors.

Besides training in aeronautical decision making, formal techniques for evaluating the operational risks associated with each flight assignment may benefit pilots in the decision making process. The FAA has recommended that helicopter air ambulance operators implement formal operational risk assessment programs to evaluate flight safety and risk for every mission.[31] The recommended practices include empowering pilots to be the final decision authority in accepting or declining

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[30] National Transportation Safety Board, *Commercial Emergency Medical Service Helicopter Operations*, p. 17.

[31] Federal Aviation Administration. *FAA Notice N8000.301: Operational Risk Assessment Programs for Helicopter Emergency Medical Services*. August 1, 2005.

a mission assignment; incorporating formal risk assessment tools for gauging the level of risk on a specific mission; and carrying out a risk mitigation plan to reduce risks to acceptable levels when feasible. Factors considered in formal pre-flight risk assessments include weather and visibility conditions; terrain and route of flight; pilot qualifications, experience ,and fitness for duty; any maintenance issues such as inoperative equipment; and aircraft performance capabilities and limitations. Examples of techniques for mitigating risk factors may include more stringent weather minimums for less experienced pilots; more stringent weather minimums when certain equipment is inoperative or otherwise unavailable; and the use of special equipment to improve a pilot's situation awareness and ability to see and avoid terrain and obstructions at night and in poor visibility. While the FAA has issued voluntary guidance to helicopter air ambulance operators set up these risk management programs, the NTSB has recommended that these flight risk evaluation programs be made mandatory for all air ambulance operators, and require formal training in the risk evaluation process for all employees directly involved in flight missions, not just pilots.[32]

Conditions in the Flight Environment. With regard to environmental conditions, night, weather, obstructions (such as power-lines) and mountainous terrain, or some combination of these factors was found to have played a role in a large number of the helicopter air ambulance accidents reviewed by CRS. Presently, air ambulance operators, for the most part, are not required to equip their aircraft with instruments that could improve situation awareness regarding height above terrain and potential terrain collisions, nor are they required to utilize any special equipment that could enhance visibility at night and in poor weather conditions. While the FAA, in its guidance to air ambulance operators and inspectors who oversee these operations issued in January, 2006, identified this equipment as a means to avoid loss of control and CFIT accidents, it has not required use of this equipment to date.[33] However, the NTSB issued a recommendation to the FAA, based on its 2006 special study findings, that would specifically require the use of terrain warning systems on air ambulances.[34]

Mechanical Failures and Maintenance Related Crashes. In addition to flight operational factors and conditions of flight, a significant proportion (about 22%) of the helicopter air ambulance accidents examined were found to be attributable, at least in part, to some type of mechanical failure. This finding roughly matches that of an earlier comprehensive study looking specifically at maintenance-related helicopter air ambulance accidents over a 24-year period which concluded that 23% of all helicopter air ambulance accidents reviewed were maintenance-

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[32] National Transportation Safety Board, *Special Investigation Report on Emergency Medical Service Operations*

[33] Federal Aviation Administration. *Helicopter Emergency Medical Services (HEMS) Loss of Control (LOC) and Controlled Flight Into Terrain (CFIT) Accident Avoidance Programs,* Flight Standards Handbook Bulletin for Air Transportation (HBAT) 06-02A, January 23, 2006.

[34] National Transportation Safety Board, *Special Investigation Report on Emergency Medical Service Operations*.

related.[35] That study found that 50% of helicopter air ambulance crashes attributable to mechanical or maintenance-related causes were engine related, while 24% were due to failures of the main rotor drive or transmission, 13% were attributed to malfunctions of the tail rotor system, and another 13% were attributed to faulty flight controls. These findings suggest that maintenance of air ambulances poses a significant safety risk. However, neither the FAA nor the NTSB has identified maintenance practices among air ambulance aircraft as a specific area for concern. Consequently, present efforts to prevent air ambulance crashes are focused, instead, on risk factors associated with flight operations and pilot performance. Available data suggests that policymakers might also choose to consider a more in-depth examination of maintenance practices in the air ambulance industry to identify ways to reduce maintenance-related accidents.

Options for Improving Safety

Based on available data summarized above suggesting that flight operational factors are the central cause of the large majority of air ambulance accidents, options for improving safety have focused on possible changes to flight operations and practices among air ambulance operators. These various options have been framed in terms of possible alternatives for changing regulatory standards and oversight of air ambulance operators, incorporating system safety and risk management principles into the decision making processes regarding air ambulance missions, providing additional or supplemental training for flight crews as well as medical crews, and incorporating various technologies to aid pilots and improve safety in low visibility conditions.

Regulatory Standards and Oversight

Media coverage of air ambulance safety has raised concerns over the degree of oversight that the FAA has devoted to air ambulance operators, asserting that the FAA has been unable to keep pace with the industry's rapid growth.[36] Those expressing concern believe that the FAA has been lax in inspecting air ambulance operations, particularly for new operators and operational bases, as well as at remote base stations that are distant from company headquarters.[37] In terms of regulations, critics also contend that the FAA has been slow to take action to better regulate safety among air ambulance operators. The NTSB noted that while the FAA has taken a positive step toward improving air ambulance safety by creating a task force in August 2004 to look into helicopter air ambulance accidents, that task force had not yet made any specific recommendations or proposals for regulatory change.[38] The FAA has, however, issued special guidance to helicopter air ambulance operators and has intensified efforts to review these operators' training and procedures.

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[35] Ira J. Blumen, M.D., and the University of Chicago Aeromedical Safety Committee, *A Safety Review and Risk Assessment in Air Medical Transport*, 2002.

[36] Alan Levin and Robert Davis, "Surge in Crashes Scars Air Ambulance Industry."

[37] *Ibid.*

[38] National Transportation Safety Board, *Special Investigation Report on Emergency Medical Service Operations*.

Conducting Special Emphasis Inspections. In Fall 2005, the FAA initiated a special emphasis inspection program targeting helicopter air ambulance operators. The inspection program is designed to focus on policies, procedures, training, communications, and management of flight operations and the development of safety culture among operators with the goal of identifying and correcting factors known to contribute to accidents among helicopter air ambulances.[39] The FAA has also issued a special bulletin for developing and critiquing air ambulance operator training programs and operating procedures that are specifically designed to prevent loss of control and CFIT accidents.[40] FAA inspectors will be looking for specific improvements to pilot training to deal with inadvertent flight into low visibility conditions, flight solely by reference to cockpit instruments, and recovery from unusual aircraft attitudes.[41] Inspectors will also be looking at air ambulance operators to see if they have implemented various procedures, such as pre-flight assessments of obstacles and terrain considerations along the route of flight, and the use of approved technologies to aid in-flight situation awareness in an effort to curtail accidents.

Applying Consistent Regulatory Requirements During All Phases of Operation. The NTSB also noted that when patients are not on board, for example during positioning flights or en route to an accident scene, air ambulance operators may operate under a less stringent set of regulations, because the FAA regards medical personnel on board as essential crew members.[42] When operating under these less stringent regulations, air ambulance operators have no set minimum requirements for in-flight visibility nor do any regulations pertaining to flight and duty time for pilots apply. The NTSB found that, of the 55 air ambulance accidents studied, 35 occurred while operating under these less stringent regulations without patients on board. In 10 of these accidents, the flights were being conducted in weather conditions that would not have met the minimum requirements for operation under the more stringent set of commercial regulations required for flights with patients on board. The NTSB concluded that, in its opinion, medical personnel on

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[39] Federal Aviation Administration. Notice N8000.307: *Special Emphasis Inspection Program for Helicopter Emergency Medical Services*. September 27, 2005.

[40] Federal Aviation Administration. *Flight Standards Handbook Bulletin for Air Transportation (HBAT) 06-02A: Helicopter Emergency Medical Services (HEMS) Loos of Control (LOC) and Controlled Flight Into Terrain (CFIT) Accident Avoidance Programs*. Effective 1/23/2006, Revised 3/14/2006.

[41] Aircraft attitude refers to its orientation relative to the horizon. Examples of unusual attitudes include a steep bank, a dive, a steep climb, or some combination of these conditions.

[42] National Transportation Safety Board, *Special Investigation Report on Emergency Medical Service Operations*. Note: Currently flights without patients may be operated under regulations prescribed in Title 14 Code of Federal Regulations (CFR), Part 91, whereas flights with patients on board must be operated under regulations contained in Title 14, CFR Part 135. For the purposes of this discussion, the principal differences between these two sets of regulations are that under Part 91, there are no flight and duty time limitations and there are less stringent requirements regarding weather conditions that operators are permitted to fly in.

board do not meet the definition of required crew members for flight operational purposes, and therefore recommended that the FAA require air ambulance operators to comply with more stringent commercial flight regulations whenever medical personnel are on board, as they currently do when carrying patients.

The fact that air ambulance operations without patients are conducted under separate regulatory guidelines also has a potential impact on those operations conducted with patients on board. This is because without any specific duty time regulations being applied to flights conducted without patients, such flights are not counted in a pilot's duty time totals. Therefore, lengthy flight operations without patients on board could contribute to pilot fatigue and affect safety during subsequent flights with patients on board. While regulations currently include industry specific flight time and rest time requirements for helicopter air ambulance pilots,[43] flights flown without patients are not required to be considered in complying with these regulations. Therefore, notwithstanding the NTSB's recommendation to conduct all flights with medical personnel on board as commercial operations subject to specific duty time limitations, policy makers may consider alternative approaches to account for and limit pilot duty times in air ambulance operations in a manner that more accurately reflects actual flight time logged, regardless of whether patients are on board or not.

Addressing Concerns Over Pilot Fatigue. Addressing the specific issue of pilot fatigue and duty time regulations among air ambulance operators is regarded by many aviation safety experts as being very important because the combination of stress, rotating shift work, and operating at or near the minimal flight crew staffing levels needed to maintain 24/7 operations is common across the industry and predisposes pilots to acute and chronic fatigue.[44] While fatigue has not been identified as a causal or contributing factor in very many air ambulance accidents, this may largely be due to the difficulty in substantiating the presence of fatigue following an accident. In 1988, the NTSB noted that, while pilot fatigue had only been identified in one of the accidents it reviewed, pilot fatigue was suggested by some in the EMS helicopter industry to be the primary cause of accidents.[45] Since that time, because no notable changes have taken place with regard to regulations or practices pertaining to pilot duty times across the industry, preventing pilot fatigue would appear to still be a significant objective for improving safety in air ambulance operations. Therefore, in addition to addressing the broader question of whether air ambulance flights should adhere to commercial flight regulations during all phases of a mission, including times when patients are not on board, policymakers may consider possible changes in pilot duty time and flight time regulations to address concerns over the potential role of fatigue in the safety of flight operations.

To fully address the issue of pilot fatigue, specific regulations pertaining to flight time and rest requirements may need to be examined separately from the issue

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[43] See Title 14, Code of Federal Regulations § 135.271.

[44] National Transportation Safety Board, *Commercial Emergency Medical Service Helicopter Operations*.

[45] *Ibid.*

of requiring air ambulance operators to conform to other commercial operating regulations. In particular, those regulations pertaining to weather minimums and weather reporting requirements, when conducting flights with medical personnel on board, may need to be examined as a separate issue. Specifically, air ambulance operators have voiced concerns that applying existing commercial flight regulations to patient pick-up flights may significantly limit the ability of air ambulances to accept missions in reduced visibility. This, according to an industry trade group, is due to the fact that commercial regulations, as currently written, require approved weather reporting at the intended destination in order to fly solely by reference to instruments.[46] This could significantly limit operators to visual flight conditions only. Working around this issue may require specific exemptions or a separate set of requirements for air ambulance operators. Although regulations and policies pertaining to weather and flight duty time standards for air ambulance operations are both important issues for consideration, uniformly applying commercial flight regulations designed primarily for other purposes to all facets of air ambulance operations may be an imperfect solution. Policy makers may consider tailoring these regulations to the specific safety concerns and operational needs of the air ambulance industry by dealing with those regulations pertaining to weather minimums and those regulations pertaining to pilot duty times as distinct policy issues.

Increasing Maintenance Oversight. As previously mentioned, little attention has been given to the oversight of maintenance practices at facilities that maintain and repair air ambulance aircraft. However, consistent with this report's findings, an in-depth study of maintenance-related accidents found that about 23% of helicopter air ambulance accidents may be attributed, in part, to mechanical or maintenance issues. About one-third of these accidents were regarded as being the result of inadequate or improper maintenance.[47] Given that aviation safety experts have devoted considerable attention to airline maintenance practices, the lack of any specific focus on maintenance of air ambulance operations is somewhat surprising, but this is likely attributable to the fact that these maintenance safety issues are largely eclipsed by concerns over flight operational safety issues which account for the large majority of air ambulance crashes. Nevertheless, policymakers may consider whether additional oversight and scrutiny of air ambulance maintenance practice may be able to provide additional insight into specific maintenance practices that compromise safety and available options for preventing maintenance-related incidents and accidents.

Improving Aircraft Crashworthiness. Aircraft crashworthiness and accident survivability is another regulatory issue that hasn't received much attention with regard to air ambulance safety. A comprehensive examination of helicopter air ambulance crash injuries and fatalities found that main cabin occupants of air ambulance helicopters had about 4.5 times the risk of death or serious injury

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[46] Graham Warwick. "Medical Alert." *Flight International*, February 21-27, 2006, pp. 72–73.

[47] Based on data presented in Ira J. Blumen, M.D., and the University of Chicago Aeromedical Safety Committee, *A Safety Review and Risk Assessment in Air Medical Transport*, 2002.

compared to occupants of other helicopters.[48] The study concluded that the increased risk is likely attributable to cabin design modifications to accommodate emergency medical missions. The study went on to identify greater relative risks among lighter weight air ambulance helicopters (i.e., helicopters weighing less than 4,500 pounds) in crashes where there was a post-crash fire, among occupants not wearing shoulder harnesses, and for mechanical-related crashes. For larger helicopters (i.e., helicopters weighing more than 4,500 pounds), these distinctions between air ambulances and other helicopters were not as noticeable. This finding could have important implications if the service model for helicopter air ambulance operations continues to shift toward more autonomous private operators who may be more likely to use smaller, lighter-weight helicopters to keep aircraft acquisition and operating costs low. The study concluded that the use of energy-absorbing seats that can handle greater crash forces in combination with lap and double-shoulder (five-point) harnesses, along with greater attention to crashworthiness in designing cabin modifications for air ambulance operations could significantly improve occupant survivability and reduce the severity of crash-related injuries. Based on an analysis of military helicopter crash data, the study also concluded that the use of helmets by flight crews and medical crews could significantly reduce the risk of serious and fatal head injuries in a crash. Policymakers may consider whether specific design guidance or standards for seats, seatbelts, and interior design modifications as well as operational requirements for equipment such as shoulder harnesses and helmets could reduce fatalities and mitigate injury risks in air ambulance crashes. Equipment and design standards and requirements would likely have to strike a balance between providing flight and medical crews with adequate protective measures while ensuring that these safety measures do not unduly prevent or interfere with patient care and other critical mission functions.

Implementing System Safety and Risk Management Principles

The degree to which safety principles are trained and practiced as a matter of routine within the air ambulance industry is a matter of considerable interest. While the FAA and trade organizations within the industry have issued guidance to operators to improve safety practices,[49] available accident statistics suggest that these safety measures either have not yet been adequately adopted and implemented across the industry or have not been particularly effective. The principal trade organization of air ambulance operators, the Association of Air Medical Services, recently launched an initiative, called "Vision Zero", with the goal of attaining an industry-wide commitment to "...to reduce and eliminate errors of consequence—those events within the transport medicine environment that result in serious injury or fatality – and to reduce the entire spectrum of helicopter accidents by 80% over the next

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[48] See also Ira J. Blumen, M.D., and the University of Chicago Aeromedical Safety Committee, *A Safety Review and Risk Assessment in Air Medical Transport*, 2002.

[49] See, for example: AAMS, *AAMS Brief – Part One: Our Commitment to Safety*." Alexandria, VA: AAMS; AAMS, *Air Medical Service Safety Initiative*, Alexandria, VA: AAMS; and Federal Aviation Administration, *FAA Notice N8000.301: Operational Risk Assessment Programs for Helicopter Emergency Medical Services*.

decade."[50] While these efforts suggest that the industry as a whole is concerned about the current level of safety among air ambulance operators and desires to take positive steps to improve safety, some, including the NTSB, argue that voluntary measures to improve safety such as this are insufficient, and certain safety-related changes such as formal dispatch procedures and risk management practices should require mandatory, industry-wide compliance. Policymakers, either at the FAA or in Congress, will ultimately have to weigh the merits of this argument and determine whether the safety benefits of these initiatives outweigh the costs associated with implementing them.

In its special study examining air ambulance accidents occurring between January 2002 and January 2005, the NTSB found that a formal risk evaluation of the mission may have prevented 13 of the 55 accidents reviewed.[51] However, the NTSB found that most operators have not implemented a formal risk evaluation process, even though guidelines for setting up such a process has been made available by the FAA. While the FAA has issued guidelines for implementing risk assessment programs for helicopter air ambulance operations, this material is only advisory in nature and is not required to be implemented.[52] Therefore, the NTSB formally recommended that the FAA require all air ambulance operators to develop and implement flight risk evaluation programs and train all employees involved in decision-making and support of flight operations on participating in these risk evaluation processes.[53]

In the airline industry, several initiatives to improve the collection and analysis of safety-related operational data have taken root and are now common practice. For example, air carrier flight operational quality assurance (FOQA) programs collect extensive flight operational data. Using data mining techniques, operations that fall outside the defined parameters of safe operations are identified and subsequently investigated to determine the circumstances surrounding the incident, with the goal of reducing or eliminating events that compromise safety and could lead to an accident. Many airline safety programs also include internal reporting mechanisms and specific "whistleblower" protections for employees that identify hazardous operational practices. Mechanisms have been put in place at several airlines, through a program called the Aviation Safety Action Program (ASAP), allowing employees to voluntarily provide confidential reports regarding safety concerns to the FAA with specific protections against negative consequences, except in those cases involving suspected criminal actions or drug and alcohol misuse.[54] The objective of these programs is to provide a mechanism for preemptively identifying and correcting unsafe operations before they lead to an accident. While comprehensive FOQA and

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[50] AAMS, "Vision Zero: The Time Is Now," p. 1., AAMS, Alexandria, VA.

[51] National Transportation Safety Board, *Special Investigation Report on Emergency Medical Service Operations*.

[52] See Federal Aviation Administration, *FAA Notice N8000.301: Operational Risk Assessment Programs for Helicopter Emergency Medical Services.* August 1, 2005.

[53] National Transportation Safety Board, *Special Investigation Report on Emergency Medical Service Operations*.

[54] See Title 49 USC, § 40123, and Title 14 Code of Federal Regulations, Part 193.

ASAP programs may be too complex to effectively implement in the air ambulance industry, policymakers may consider whether similar approaches to information sharing and safety data analysis regarding critical safety issues could be feasibly implemented across the air ambulance industry.

Training and Procedures for Flight and Medical Crews

It has been reported that, in 2000, representatives from the air ambulance industry approached the FAA with a proposal to require that air ambulance pilots and crew members receive training in crew resource management (CRM). This type of training is mandatory for airline crews and focuses on how to effectively communicate risk information and use available resources to assess and manage operational risks.[55] However, this proposal has not yet resulted in any FAA recommendations or regulatory proposals. Presently, there are no specific training requirement for pilots on topics such as CRM, risk management, and aeronautical decision making beyond the general understanding of these topics required to obtain commercial pilot certification and appropriate ratings required for employment, such as helicopter and instrument ratings. These general requirements are considered relatively minimal, and many safety experts argue that they do not receive adequate coverage in general flight training and pilot testing. Moreover, training received on these topics in the course of general flight training is not tailored to the specific operational conditions and pressures that a pilot or crew member might experience in air ambulance operations. Thus, any specific training in dealing with operational risks unique to the flight environment of air ambulances is provided solely at the discretion of the operator. While some operators provide this training in various forms, there is no industry standard for course content or objectives for these types of training programs.

In the NTSB's 1988 study of helicopter air ambulance safety, it found that among the 14 instrument-rated pilots involved in the crashes it examined, only one was current to fly solely by instruments.[56] Similarly, a later analysis of pilot qualifications among air ambulance operators concluded that, while a greater percentage of air ambulance operators were instrument rated, a lack of instrument currency or proficiency could be a detriment because instrument-rated pilots may overestimate their instrument training skills and press on in deteriorating conditions, despite not having adequate recent experience and practice with instrument flight procedures.[57] Examining training practices in the medical helicopter industry, the NTSB found a wide range of approaches to training, and noted that while many operators had well-defined training programs on paper, actual training did not adequately address real-world conditions in the operational environment. The NTSB recommended supplemental training material on aeronautical decision making be incorporated into initial and recurrent training for pilots. The NTSB also

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[55] Alan Levin and Robert Davis, "Surge in Crashes Scars Air Ambulance Industry."

[56] National Transportation Safety Board, *Commercial Emergency Medical Service Helicopter Operations*.

[57] Ira J. Blumen, M.D., and the University of Chicago Aeromedical Safety Committee, *A Safety Review and Risk Assessment in Air Medical Transport*, 2002.

recommended that guidelines for FAA inspectors be revised to include reviews and approvals of initial and recurrent training for pilots to ensure that they provide adequate levels of instruction on poor weather operations and accident scene procedures.[58] The recently initiated FAA targeted inspection program for helicopter air ambulance operators[59] appears to directly address these concerns, and therefore, the effectiveness of ongoing FAA inspections of helicopter air ambulance operators may be of particular interest as an issue for oversight of the FAA.

Besides flight crew training, there has also been a recent emphasis on providing aviation-specific training to other members of the air ambulance team, principally communications specialists that dispatch and monitor air ambulance flights. The FAA has also suggested, but does not yet require, special training for ground communications specialists that dispatch and track air ambulance flights covering aviation weather, flight operations, and flight tracking procedures.[60] Unlike the airlines, which must used FAA-certified dispatchers, air ambulance pilots are typically dispatched by EMS dispatchers or communication specialists who typically do not receive any formal training in aviation operations or aviation weather. The NTSB has recommended that all air ambulance operators implement formal flight dispatch procedures utilizing dedicated aviation dispatchers with formal aviation-specific knowledge and experience that can assist pilots in assessing weather data, provide comprehensive flight following, and aid pilots in making informed decisions whether to accept or continue a mission.[61] Policymakers will need to determine the feasability of requiring dedicated flight dispatchers in the air ambulance environment, and whether these services require an FAA certified dispatcher approved under existing FAA training and certification requirements for flight dispatchers. Alternatively, policymakers may evaluate whether mandatory training of existing emergency medical communication specialists that work with or for air ambulance operators on aviation-specific dispatch procedures, aviation weather, aircraft capabilities, flight following, and so on, would meet the intent of this recommendation. At least one company has already developed aviation-specific training for emergency medical communication specialists conforming to FAA recommended training for ground communication specialists and hopes that this form of training will be mandated for the entire industry.[62]

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[58] National Transportation Safety Board, *Commercial Emergency Medical Service Helicopter Operations*.

[59] Federal Aviation Administration. *Flight Standards Handbook Bulletin for Air Transportation (HBAT) 06-02A: Helicopter Emergency Medical Services (HEMS) Loss of Control (LOC) and Controlled Flight Into Terrain (CFIT) Accident Avoidance Programs*. Effective 1/23/2006, Revised 3/14/2006.

[60] *Ibid.*

[61] National Transportation Safety Board, *Special Investigation Report on Emergency Medical Service Operations*.

[62] "Air Dispatcher Training Should Make EMS Flights Safer." *Air Safety Week*, April 24, 2006, p. 3.

Technology to Improve Safety in Low Visibility Conditions

Various technologies are available to improve visibility and pilot situation awareness of terrain, obstacles, and weather. While these technologies may be of benefit to improve the safety of air ambulance missions, some operators have expressed concern over the cost of installing and maintaining these systems if doing so was made mandatory as the NTSB has recommended. Others have questioned whether these technologies are appropriately suited for air ambulance use, or whether modifications may be needed to tailor these devices to the unique mission profiles and needs of air ambulance operators, particularly for use on helicopter air ambulance missions.

Terrain Warning Systems. The NTSB's recent assessment of air ambulance safety included a recommendation to equip all helicopters and aircraft used in emergency medical services with terrain awareness and warning systems (TAWS, previously referred to as enhanced ground proximity warning systems or EGPWS).[63] These devices provide pilots with visual displays and audible alerts for terrain avoidance. Advanced Class A TAWS (TAWS-A) that rely on detailed terrain databases, Global Positioning System (GPS) data or other means of precise aircraft positioning, and radio altimeters to provide height above terrain information are already required on all commercially operated aircraft with 10 or more passenger seats. Slightly less sophisticated versions of TAWS, called Class B TAWS (TAWS-B), which do not include radio altimeter height above terrain inputs, are required on all turbojets and turboprops, whether commercially or privately operated, having six or more passenger seats. A typical TAWS-B installation may cost between $10,000 and $30,000 per aircraft depending on existing equipment configurations. While some larger fixed-wing air ambulance aircraft may already fall under the requirement for TAWS-B installation if they have seating for six or more passengers, most helicopter and airplanes used as air ambulances do not. The NTSB specifically recommended that air ambulance operators install TAWS and provide adequate training in the use of TAWS to their flight crews, although it did not specify whether these aircraft should be equipped with TAWS-A or TAWS-B.[64] The NTSB believes that TAWS could help prevent many controlled flight into terrain or CFIT accidents, which, as previously noted constituted one of the two most common causal factors cited in air ambulance accidents.

Some operators have voiced concern, however, that false alarms generated by the TAWS systems could distract pilots. These operators are worried that high false alarm rates – particularly among helicopter air ambulances that frequently operate in close proximity to terrain in a manner not typical of other aircraft and flight operations – could largely negate any benefit that TAWS may provide in terms of improving pilot situation awareness regarding terrain clearance. While false alarms are a potential concern when using TAWS systems because they may distract pilots, the NTSB and other aviation safety experts believe that the benefits of TAWS in improving pilot situation awareness regarding the surround terrain far outweigh any

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[63] National Transportation Safety Board, *Special Investigation Report on Emergency Medical Service Operations*.

[64] *Ibid.*

negative effects that might occur due to false alarms. However, further operational testing of TAWS usage in simulated air ambulance missions may be needed to fully assess the suitability of TAWS in helicopter air ambulance operations.

Technologies to Enhance In-Flight Visibility. In addition to TAWS, a variety of technologies are available to improve pilot situation awareness regarding terrain and obstacles during low visibility conditions and at night. As shown in **Figure 2**, nighttime visual conditions were a contributing factor in 14% and reduced visibility due to weather was a factor in 9% of the helicopter air ambulance crashes examined between 1991 and 2004. Technologies to improve visibility under these restricted visibility conditions and at night could mitigate these types of accidents.

One broad category of available technologies to improve pilot vision, referred to as night vision imaging systems (NVIS), rely on various forms of infrared sensors or cameras to enhance a pilots view of the outside scene and avoid terrain and obstructions at night. One example of NVIS technology is night vision goggles NVGs), used extensively in military helicopter operations, which can be worn by pilots to improve out-the-window visibility and aid in the avoidance of terrain and obstacles, such as power lines. An FAA study found that properly used NVGs can increase safety, enhance situation awareness, and reduce pilot workload during flights at night.[65] Although the FAA has approved the use of NVGs and recommends they be deployed for helicopter air ambulance operations, the NTSB found that most operators do not use NVGs because they have only been recently made available for non-military aviation use, equipping aircraft and training pilots is expensive, and they can only be used effectively in sparsely populated areas where there isn't much ambient light. While the NTSB found that the use of night vision goggles may have mitigated 13 of the 55 accidents it examined in its 2006 special study, it did not formally recommend NVG usage, recognizing that these systems are not usable in all situations.

Besides NVGs, other imaging systems are available for aviation use. Forward looking infrared cameras (FLIR) can provide enhanced images of night and low visibility scenes. FLIR images can be projected on screens in the cockpit or through head-up displays (HUDs) that overlay the enhanced image on top of the out the window scene. Recently certified enhanced vision systems (EVS) use similar principles to present images generated from special infrared cameras in the cockpit, usually on a HUD. EVS systems have been specifically certified by the FAA for use in instrument flight operations for flying approaches to airports in poor visibility and at night and several business and commercial jets have been equipped with this new technology. Such systems could potentially be used to improve visibility and situation awareness in air ambulance operations, especially for helicopter air ambulance operations that fly into unprepared landing sites where navigational aids and instrument approach procedures are not available to guide the pilot.

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[65] W. T. Sampson, G. B. Simpson, and D. L. Green. *Night Vision Goggles in Emergency Medical Services (EMS) Helicopter.* DOT/FAA/RD-94/21 (1994): Federal Aviation Administration,

In addition to the aforementioned technologies that rely on cameras or sensors to enhance vision by capturing information outside the spectrum of what is visible to the human eye, the FAA has also approved synthetic vision systems (SVS) for operational use. Unlike EVS, which relies on sensors or cameras to collect information from the outside scene, SVS relies on precise positioning, principally from very precise GPS receivers,[66] and accurate onboard terrain databases to present pilots with a computer-generated image of the known terrain features and obstacles in and around the aircraft's flight path. These images can be overlaid on top of navigational instruments, or like EVS, can be projected on a head-up display to overlay on top of the out-the-window view. Coupled with highly accurate positioning information, SVS can potentially provide helicopter air ambulance pilots with accurate navigation and terrain avoidance capabilities in low visibility and night conditions. As these technologies further advance, some combination of EVS and SVS imaging may be able to provide air ambulance pilots with situation awareness of terrain and obstacles that matches, or in some cases, surpasses visual capabilities in unrestricted daylight conditions. Systems that combine EVS and SVS imaging are currently in the testing and certification process and may provide a means to enhance cockpit situation awareness in air ambulance operations in the near future.[67]

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[66] Presently, the greatest accuracy in positioning can be obtained from the use of GPS augmented with Wide Area Augmentation System (WAAS) inputs that improve position accuracy.

[67] Glenn Connor. "From Air to Ground." Professional Pilot, April 2006, 54-60.