US Joint Helicopter Safety Analysis Team: Year 2000 Report

to the

International Helicopter Safety Team

IHST

September 2007

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Section 1 – Executive Summary

Long term helicopter accident rates have remained unacceptably high and trends have not shown significant improvement in the last 20 years on a U.S. or worldwide basis. The persistence of this issue and the need to improve this record was the central theme of the International Helicopter Safety Symposium (IHSS) in Montreal, Canada in September 2005. A call to action was unanimously accepted by those in attendance at IHSS 2005, indicating that the helicopter community at large recognized that improvement was necessary and that it was ready to accept the challenge to improve the safety of helicopter operations. Thus, the International Helicopter Safety Team (IHST) was formed to lead a government and industry cooperative effort to address the factors that were affecting the unacceptable accident rate. The IHST chose to pursue an aggressive goal of reducing the worldwide civil and military helicopter accident rates by 80% in 10 years by adopting a known process with a demonstrated track record. Great strides had recently been made by the Commercial Aviation Safety Team (CAST) to substantially reduce the worldwide fatal accident rate in the commercial air carrier community. This motivated the IHST to use the process developed by CAST and to set a similar goal for reduction of the worldwide helicopter accident rate. The process used by CAST was directly linked to real accident data, used a broad spectrum of industry experts to analyze it and had objective success measurements to ensure that the actions taken were having the desired effect.

Accordingly, the IHST chartered the Joint Helicopter Safety Analysis Team (JHSAT) to adapt the CAST process for use with helicopter accident data, conduct analysis of the accident data and to offer recommendations intended to reduce the accident rate, for consumption by the helicopter community, and for integration into planned implementation actions by the Joint Helicopter Safety Implementation Team (JHSIT), also chartered by the IHST. The JHSAT was comprised of industry helicopter safety experts representing operators, airframe and engine manufacturers, and regulators. Most of the JHSAT team members had substantial accident investigation or safety research experience.

Adaptation of the CAST process involved many changes to ensure that data unique to the helicopter community could be effectively analyzed; however, the basic tenants of the CAST process were preserved: the analyses would be performed by stakeholders, results would be data driven, and the results would be measurable.

The JHSAT chose to begin its analysis with 197 accidents from the U.S. National Transportation Safety Board (NTSB) calendar year (CY) 2000 dataset, which the JHSAT believed was representative of other recent years of U.S. helicopter accidents. The CY2000 accident dataset also had the advantages of being both complete and unimpeded by pending litigation that might restrict full participation by some of the JHSAT members. The dataset focused on U.S., N-registered aircraft; however, no accident data for kit or homebuilt helicopters was included in the analyses. This set of accidents was determined to be a good starting point for analysis and was also determined to be a representative sample when compared with 24 years of prior helicopter accidents and causal factors. Future JHSAT products will reflect analyses of more recent and worldwide helicopter accident data.

The analysis of the CY2000 accident dataset produced 1217 problem and intervention pairs. The problems and interventions were then categorized and further processed to develop safety recommendations. This report presents safety recommendations for the entire U.S. fleet in seven foundational areas: Safety Management, Training, Systems and Equipment, Information, Maintenance, Regulation, and Infrastructure. The JHSAT also produced 127 safety recommendations for 15 primary mission segments flown by the U.S. fleet. Although the data analyzed were from one year of accidents, examination of the recommendations presented in the body of this report reveals comprehensive coverage of the critical issues known to exist in the worldwide helicopter community. This assertion was corroborated by an exercise conducted early in the JHSAT process whereby ten prior helicopter safety studies were reviewed and summarized in *Interim Safety Recommendations to the International Helicopter Safety Team* [Reference 20 as cited in Appendix I: References]. Each of the foundational topics identified by these earlier reports is augmented by JHSAT recommendations.

Looking ahead, the JHSAT plans to continue to analyze accident data that will allow for development and refinement of its safety recommendations. When the helicopter community adopts these safety recommendations, the JHSAT will have the means to make rate-based measurements on the effectiveness of the safety recommendations and implementation plans and will generate future recommendations based on new accident analyses and refinement of previous recommendations, as justified by the feedback that it receives.

Section 2 – Background

The culmination of several important events in the aviation community in the last decade paved the way for the formation of the International Helicopter Safety Team (IHST) and broad agreement in the helicopter community that positive steps must be taken to improve helicopter safety. Most importantly, on September 26-29, 2005, the American Helicopter Society (AHS) International and the Helicopter Association International (HAI) with the AHS Montreal / Ottawa Chapter, hosted the first International Helicopter Safety Symposium (IHSS 2005) in Montreal, Canada. More than 250 people from thirteen countries and five continents attended, representing operators, manufacturers, maintenance organizations, regulatory and accident investigation agencies, associations and aviation press.

Understanding that helicopter accident trends were not improving, that the market place is adversely affected by such trends and that new analysis methods were available to improve safety, the participants endorsed the IHSS 2005 mandate to reduce helicopter accident rates by 80% in the next ten years. Accordingly, the IHST was formed and the JHSAT was chartered to develop data-driven safety recommendations that would be used to pursue this goal.

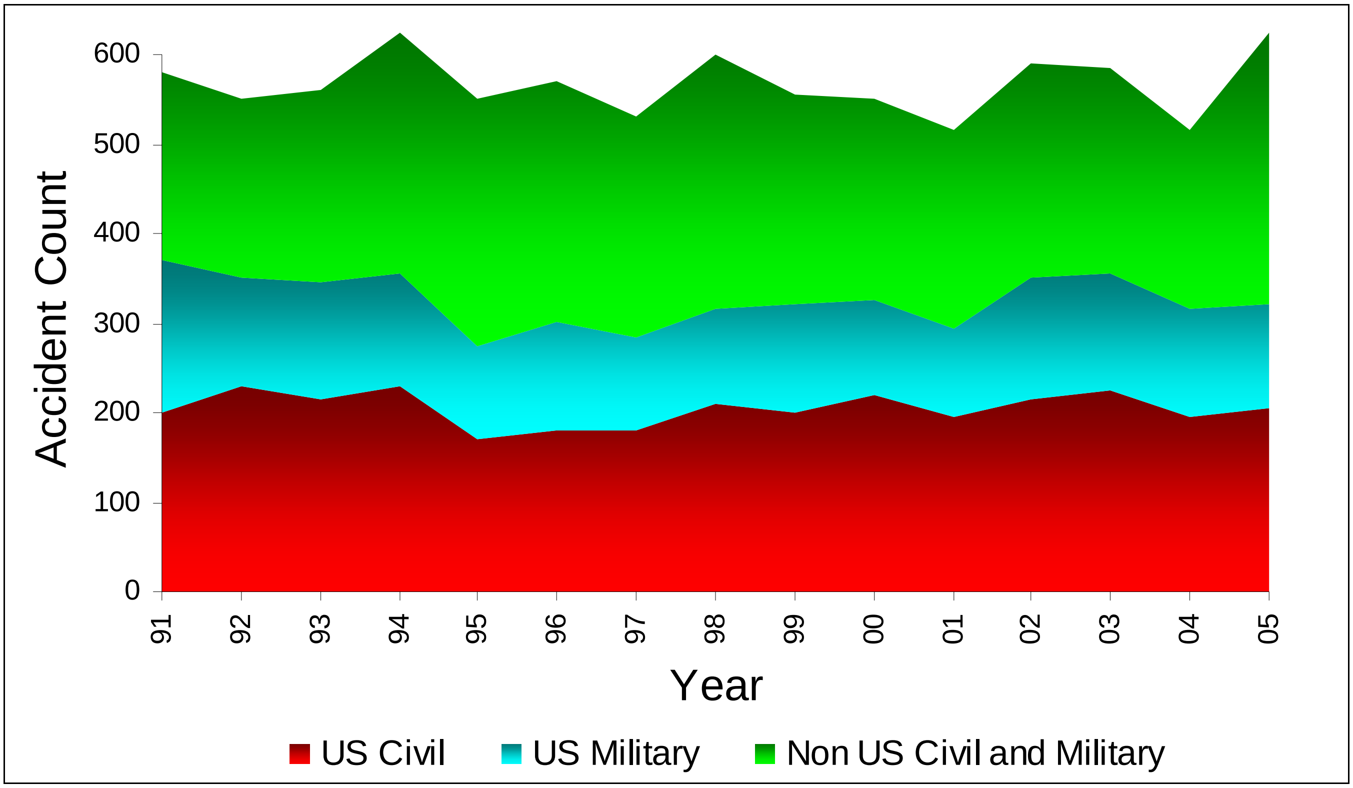


Figure 2-1.Worldwide Helicopter Accidents per Year: 1991 – 2005 (Source: Bell Helicopter)

Figure 2-1 shows helicopter accident trends for the 15 years leading up to IHSS 2005. The need for change is compelling: the U.S. civil, U.S. military, and non-U.S. civil / military helicopter accident count trends all remained relatively flat for the time period depicted. (Accurate fleet hour data was not available for the period; therefore, rate-based trends are not presented.) The U.S. civil helicopter accident count for the period is relatively constant at 180 to 200 per year. Figure 2-1 also shows the annual accident count contribution from the international and U.S. military (non-combat) communities. Likewise, these trends are flat for the time period. The worldwide civil helicopter fleet is estimated to be about 26,365 helicopters as of the end of 2006; a distribution of the fleet by country is shown in Figure 2-2. The U.S. comprises about 50% of the worldwide fleet of rotorcraft. Correspondingly, it also accounts for about 40% of the total accidents on a worldwide basis each year. Furthermore, it is easy to see that it is imperative for the international and military users of the remaining 50% of helicopters to participate in this initiative if the worldwide accident rate is to be successfully driven down by 80%.

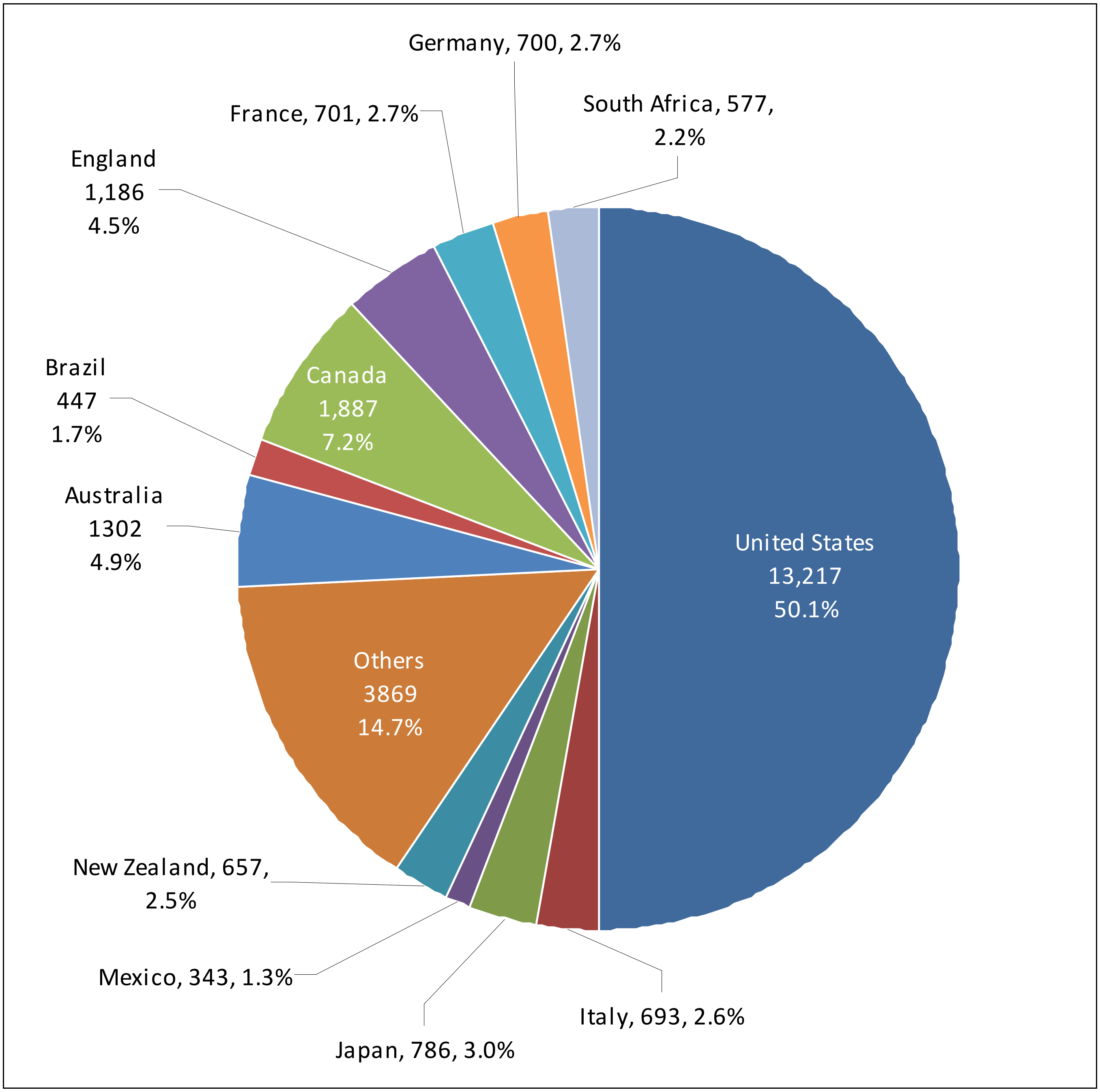


Figure 2-2. Worldwide Fleet Distribution by Country (Source: *Rotor Roster 2007*)

Figure 2-3 presents a 24-year look at helicopter accident primary causal factors. The figure shows that during this time period, no significant trend or change in primary accident causal factors can be identified. Human performance issues dominate all other categories. It should be noted that data for years 2004 and 2005 has an elevated unknown component; this is due strictly to the incomplete population of the NTSB accident report dataset as of the date of publication of this report. It is expected that these two years will still have the same accident cause distribution as prior years.

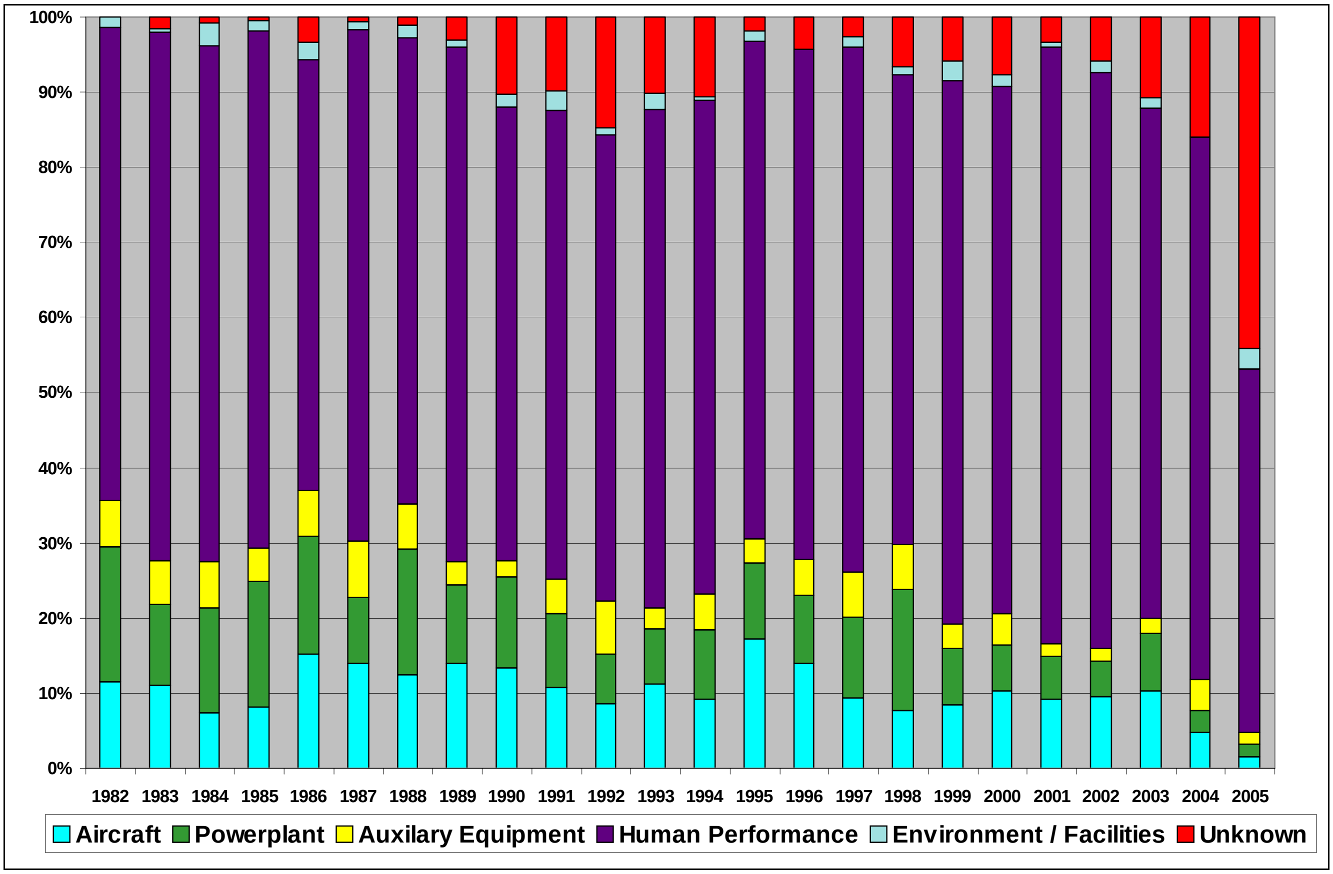


Figure 2-3. Civilian Helicopter Accident Primary Causal Factors, 1982-2005 (Source: Bell Helicopter)

In February 1997, the *Final Report to President Clinton by the White House Commission on Aviation Safety and Security* [Ref. 13 in Appendix I], set an aggressive national aviation safety goal to reduce fatal accident rates by a factor of five in 10 years. This was the origination of the 80% reduction goal. Also, during the mid 1990s, The Boeing Company, in collaboration with key members of the aviation industry and government organizations, initiated a process known as the Accident Prevention Strategy (APS). The large transport airplane industry took on that challenging goal by forming the Commercial Aviation Safety Team (CAST), which further developed the Boeing APS process. Aspects of the Boeing APS process were also used by the Helicopter Accident Analysis Team in 1998. CAST analyzed the leading safety issues in the large transport commercial aviation sector.

Each of the efforts referenced above engaged industry and government experts to analyze accidents to identify strategies to improve safety. The underlying assumption is that accidents are the result of a chain of events that could have been prevented by altering or eliminating one or more of the “links” in the chain. Instead of focusing on an accident’s primary cause, the process focuses on identifying and removing one or more links in the accident causal chain, which often initiate hours, days or even weeks before the accident. This analysis is accomplished by a team of subject matter experts “brainstorming” about what happened and why it happened (the chain of events), and what might have been done differently (interventions) to prevent a similar event in the future. By establishing potential interventions with which to break each link in the chain of events for individual accidents, concrete solutions can be identified that share commonalties across a group of accidents, missions, or aircraft types.

The JHSAT adapted the basic CAST process for use in analyzing helicopter accidents. Three basic tenets of the CAST process were maintained:

- solutions must be based on actual accident data (i.e., data driven)
- helicopter community stakeholders from the region must perform the analyses
- performance of the safety improvement recommendations must be measurable

The JHSAT adapted many other aspects of the process to better suit the unique needs of the helicopter environment. This adaptation accounted for the general lack of detailed root cause findings in helicopter accidents, accommodating the full range of helicopter design types analyzed from small reciprocating engine aircraft to large multi-turbine types, being able to address multiple and varied missions flown by helicopters and being able to address the spectrum of operators, from one person to large companies with substantial infrastructure.

An overview of the process is provided in Section 4 – JHSAT Process. A detailed process handbook, *Accident Analysis Process for a Joint Helicopter Safety Analysis Team* [Ref. 19 in Appendix I], dated September 2007, is also available.

Section 3 – International Helicopter Safety Team Overview

Following industry acceptance of the goal to reduce helicopter accident rate by 80% in 10 years presented at IHSS 2005 in Montreal, the IHST initiated several activities. The core IHST group was solidified by engaging key representatives from the Helicopter Association International (HAI), the American Helicopter Society (AHS) International, the Federal Aviation Administration (FAA), and the leading U.S. helicopter manufacturers.

The IHST also appointed co-chairpersons for the data analysis function conducted by the Joint Helicopter Safety Analysis Team (JHSAT). The JHSAT team was formed drawing from a spectrum of industry experts and stakeholders. It was staffed with manufacturers, operators, researchers, and regulators. Among the team members the following disciplines were targeted: engineers, pilots, crash investigators, trainers, type certification and powerplant experts, and persons experienced in helicopter safety research. The JHSAT initiated its effort of adapting the CAST process and analyzing helicopter accidents. The process used is discussed in Section 5 – Metrics. The Joint Helicopter Safety Implementation Team (JHSIT) was also formed with the same objective of staffing to meet the needs of successful helicopter safety recommendation implementation. It has a similar mix of manufacturer, operator and regulators, but with more emphasis on expertise in the international and operational sector since it will be the operators who ultimately adopt the JHSAT safety recommendations. The JHSIT will also be engaged in assessing the economic feasibility of the implementation activities, which will require expertise in cost analysis with company management and insurance entities. The JHSAT mission does not include consideration of the economic impact of its intervention recommendations, but the JHSIT charter does. Figure 3-1 shows the basic structure of the IHST and the U.S. stakeholders that participated in the first year of its JHSAT and JHSIT functions.

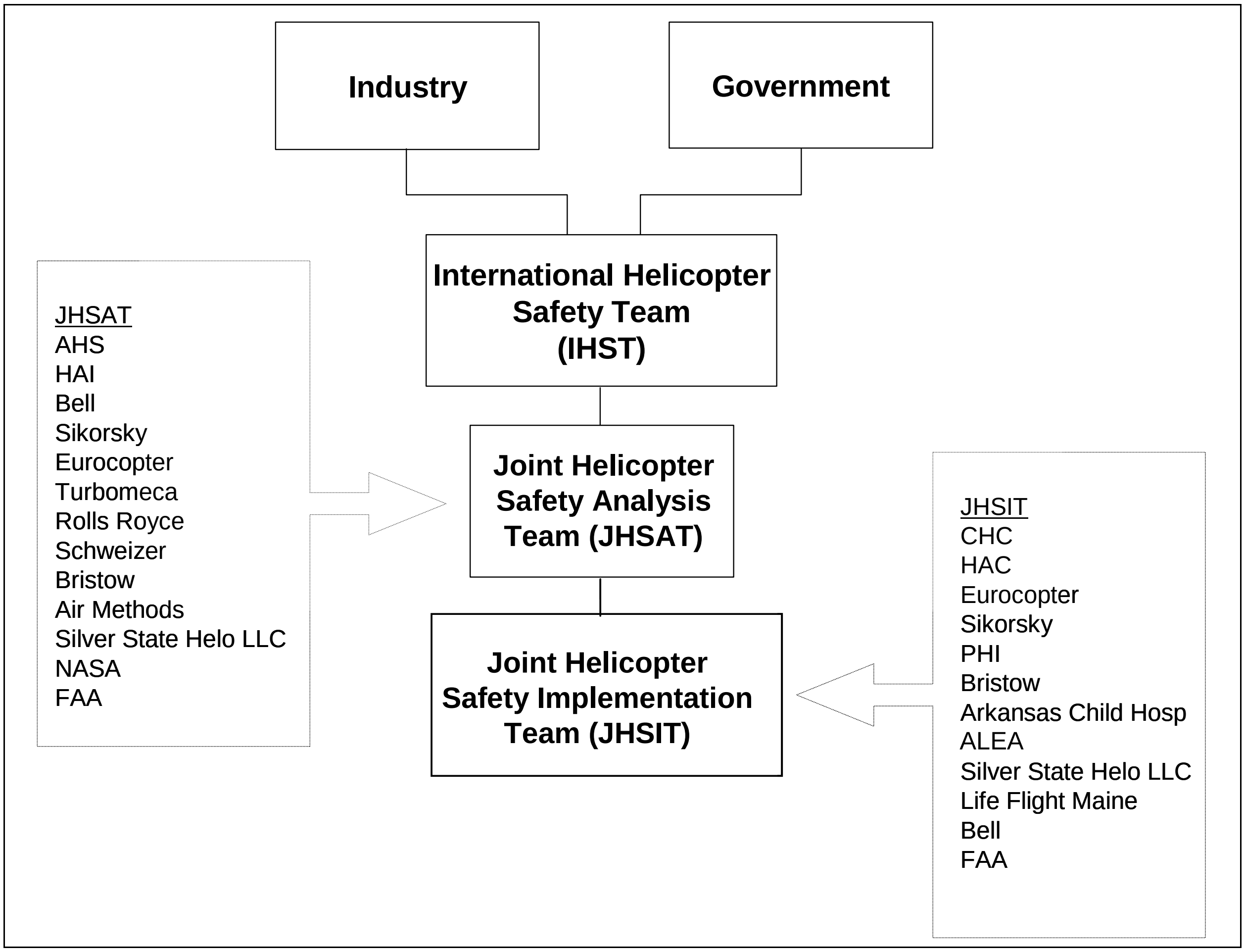


Figure 3-1. U.S. JHSAT and JHSIT Stakeholders

For the 2000 through 2005 time period, there were 3,344 helicopter recorded accidents worldwide. U.S.-Registered civil helicopters, U.S. military, and non-U.S. civil / military helicopters accounted for 36.7%, 22.0%, and 41.3% of the world helicopter accidents, respectively. The goals of the IHST can only be met by working with the international community to address the 41.3% of non-U.S. helicopter accidents. A strategy was developed to effectively coordinate international resources while attempting to maintain standardization of the key elements of the analysis process and have the means to measure and manage results. A basic structure, shown in Figure 3-2, was developed.

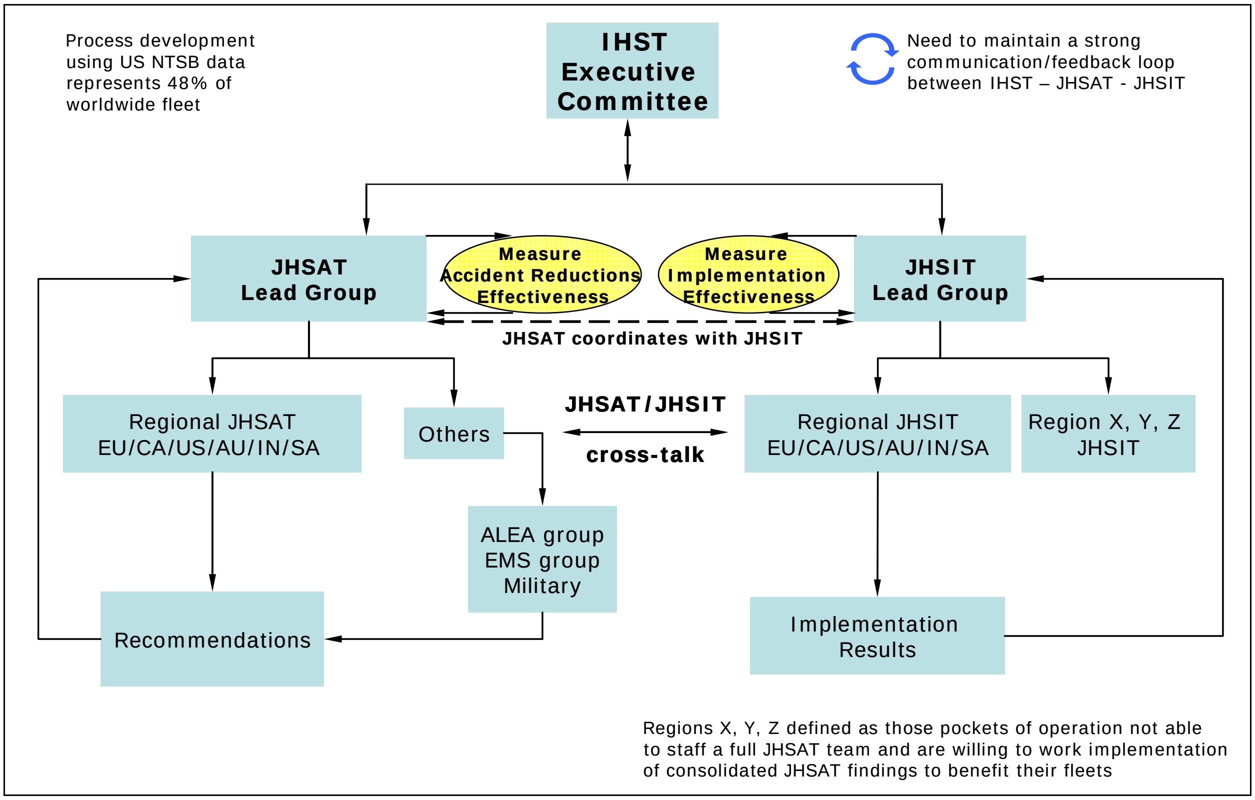


Figure 3-2. IHST International Resources (Analysis, Implementation and Metrics Management Structure)

The structure is constructed around three basic functions: the IHST Executive Committee providing leadership and exercising executive oversight; the JHSAT providing accident analysis and identifying risk reduction interventions; and the JHSIT evaluating feasibility and prioritizing implementation strategies.

The IHST is responsible for developing the strategy to accomplish our objective. It works to identify strategic international partnerships and acts to oversee and sponsor major elements of the analysis and implementation functions. The IHST is responsible for developing and overseeing communication strategies with those media sources best positioned to promote the initiative. It is also expected that any significant outputs passing between the JHSAT and JHSIT will be sent through the IHST for concurrence.

In the context of working the integration of international recommendation activities, the JHSAT function will be changing with time. The basic function of the regional JHSATs is to analyze data and pass recommendations to the regional JHSITs for implementation; all findings are passed from one team to the other with cognizance of the IHST. To date, the lead JHSAT function has been fulfilled by the U.S. JHSAT. This was necessary to initiate adaptation of the CAST process for helicopter use and generally define the detailed role of the JHSAT in this initiative. As the project matures, the U.S. team will move into a standard analytical function focused on the U.S. accident dataset. The JHSAT lead group will become a team, presumably with international representation, charged with evaluating recommendations emanating from national or regional JHSATs, each bringing expertise on the unique issues presented by their international / regional work. The lead JHSAT will be instrumental in advancing proposed recommendations for possible worldwide implementation, supporting measurement of safety recommendation effectiveness and ensuring standardization and use of the JHSAT process. When fully functioning, the regional JHSATs will feed the lead JHSAT data periodically, perhaps on an annual basis. The data supplied by the regions will provide the lead JHSAT the ability to develop rate-based metrics and determine the effectiveness of the regions' process-developed safety recommendations. The lead JHSAT will have access to worldwide fleet hour data and provide feedback to the regions, either validating their outputs or recommending that changes are needed.

Figure 3-2 also shows "other" groups working on analyses. At the time this report was published, the Airborne Law Enforcement Association (ALEA) and Emergency Medical Services (EMS) groups have expressed interest in the JHSAT analytical process. They intend to drill down into additional accidents in their mission types to produce a more detailed set of recommendations for their respective industries. Their results will also be tracked and measured by the JHSAT.

At the time of writing this report, the JHSIT process is still in a formative stage. The general function will be to act on the recommendations made by the JHSAT in a manner most likely to reduce accident rates to the desired level. Currently, the JHSIT is fully staffed with stakeholders as indicated in Figure 3-1. However, the JHSIT implementation process is still being developed. The JHSIT is working to adapt the CAST safety implementation process to meet its needs. Similar to JHSAT, the current tasks of the lead JHSIT are being fulfilled by the U.S. JHSIT. As this side of the management structure matures, the U.S. JHSIT will move into acting strictly as a regional JHSIT and a mix of international representatives will move into the lead JHSIT role. Again, similar to the JHSAT, this will empower the lead JHSIT with the necessary scope of understanding of regional limitations and challenges.

The lead JHSIT will have the responsibility of measuring and offering feedback to the regions on implementation effectiveness. Implementation effectiveness differs from intervention effectiveness in that it is an assessment of how well the JHSIT recommendations are being used by the targeted helicopter user communities. It may involve identifying roadblocks that must be addressed before implementation is possible or fully effective. Figure 3-2 shows a unique aspect of the JHSIT: it is expected that we will encounter pockets of the helicopter community that cannot invest the technical resources needed to field JHSAT and JHSIT teams. These pockets are identified as regions X, Y, Z. The IHST will work with these regions to develop agreements to adopt general consolidated recommendations developed by the other JHSATs. Similar to other implementation regions, these changes will need to be trended and tracked, normalized to rate-based results and the results fed back through the JHSIT to the affected regions.

To date, the IHST has had very good response to their request to engage with the international community. The following regions are ramping up activity:

- Europe – The European Aviation Safety Agency (EASA) has established the European Helicopter Safety Team (EHST), which will oversee the regional effort in Europe. The European Helicopter Safety Analysis Team (EHSAT) will analyze regional accident data; the European Helicopter Safety Implementation Team (EHSIT) will implement safety recommendations. The EHSAT has been meeting since Spring 2007.
- Canada – Has established a JHSAT (Canada) team, which had their initial meeting in June 2007. This included JHSAT process training.
- Australia / New Zealand (AU / NZ) – Identifying regional partners and resources.
- India – A JHSAT has been formed in India. A JHSAT workshop was conducted in March 2007, which included JHSAT analysis process training.
- South / Central America (currently consisting of Brazil, Columbia, Peru, Costa Rica and Mexico) – Identifying regional partners and resources. A JHSAT workshop was conducted in June 2007 and a Brazilian JHSAT meeting was held with JHSAT analysis process training.

The IHST is considering other regions based on helicopter fleet size and willingness to engage in the overall process. Discussions have been had with the U.S. military, but no firm commitments have been made to date. JHSAT is working with several U.S. and international military organizations to understand how best to engage. The Canadian Defense Force is participating in the JHSAT (Canada).

Each regional JHSAT has been invited to provide the status of their respective JHSAT activities at the IHSS conference in September 2007 (IHSS 2007); JHSAT lessons learned will be coordinated among the various JHSATs.

Looking ahead, the IHST will be taking an active role in overseeing the interactions between the lead JHSAT and the lead JHSIT, and in continuing to identify high-value regions with whom to partner. In turn, the lead JHSAT and JHSIT teams will be active in mentoring, monitoring, analyzing data from and providing feedback to the regional JHSAT and JHSIT teams.

Section 4 – JHSAT Process

The JHSAT created a handbook, entitled *Accident Analysis Process for a Joint Helicopter Safety Analysis Team* [Ref. 19 in Appendix I], also informally referred to as the "JHSAT Process Handbook," which details the process used to analyze helicopter accidents. Those seeking detailed process information should consult this document; however, a basic overview is provided below.

The U.S. JHSAT process was adapted from the Commercial Aviation Safety Team (CAST) Joint Safety Analysis Team (JSAT) process, and tailored specifically for analysis of helicopter accidents. An overview of the process is provided in Figure 4-1, below. The JHSAT recognizes that, since its analysis method is dependent on the quality of the data reports utilized, it is vulnerable to missing or incomplete data. Accordingly, the JHSAT has modified the original CAST JSAT process to better account for helicopter accident data, which is widely acknowledged to be considerably less detailed than commercial accident data. Several factors lead to this: lack of onboard digital or video recording devices; lack of investigative resources; inadequate documentation of the accident facts and circumstances; a pilot fatality or absence of witnesses or destruction of the evidence by fire, leading to loss of ability to reconstruct the event sequences leading to the accident; the wide range of helicopters and missions; etc. The JHSAT process now contains custom scoring criteria, helicopter specific problem categories and statements, and helicopter specific intervention categories and statements.

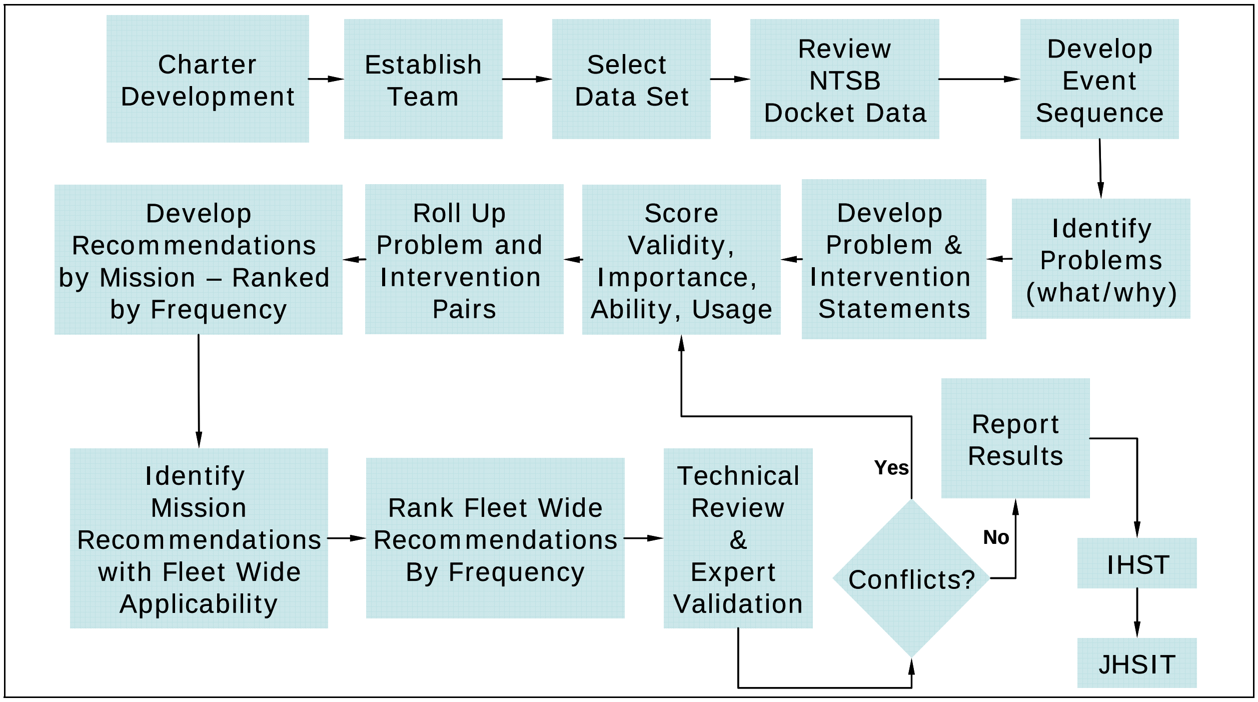


Figure 4-1. JHSAT Process Overview

Even accounting for these changes, the JHSAT process largely mirrors the CAST process, but with two significant exceptions: the IHST effort is much broader in scope by the analysis of all accidents (minor and major) in varied missions, including military, as compared to the CAST effort which focused strictly on fatal accidents of fixed wing commercial air transportation; also, the CAST process used an arithmetical relationship of the scoring components to prioritize the entire list of safety recommendations. The IHST / JHSAT process used frequency of problem occurrence as the primary factor to prioritize safety recommendations. The scoring elements of Validity, Importance, Ability and Usage (details described in the JHSAT Process Handbook), were used as secondary factors to make qualitative decisions about prioritization. This change was determined to be prudent by the JHSAT to maximize the payback on safety recommendations by targeting the most common problems across the broadest sectors of the subject fleet and missions early in the 10 year window to reach an 80% reduction. Lower frequency problems will be addressed, but later in the 10 year time period. Economic feasibility was not considered by the U.S. JHSAT, it is however a key consideration for the JHSIT.

The data set of accidents of the U.S.-Registered helicopter fleet for the year 2000 were analyzed per the process described in the JHSAT Process Handbook. The data source used was the National Transportation Safety Board (NTSB) database, including all information and photographs contained in the NTSB public docket. Accidents of kit-built helicopters and foreign registered helicopters were eliminated from this study. The 195 accidents of N-registered aircraft analyzed included those that occurred in the United States, offshore, and in foreign countries. For CY2000, there were two foreign registered helicopters that had accidents in the United States. Those two accidents were investigated and reported by the NTSB; thus, these accidents were analyzed for potential intervention recommendations and were included in the analysis data set. However, these two accidents were not used for U.S.-Registered helicopter accident rate determinations. This resulted in the analysis of 197 helicopter accidents by the U.S. JHSAT.

Section 5 – Metrics

Safety is defined as freedom from occurrence or risk of injury, danger or loss. Thus, to improve safety, one must reduce the level of risk or manage the existing risks. The term "safety" has no metrics inherent in it and therefore has little meaning unless metrics can be added. Since safety results from either absence of risk or successful management of risk, one actually measures safety by measuring risk and risk management failures, i.e. accidents. For example, one does not state, "In our city, 234,456 buildings did not burn last year," but rather, "In our city, 20 buildings burned last year," or, in terms of risk, "20 out of 234,456 buildings burned last year." We need to measure risk management failures to determine how our efforts are affecting the level of safety.

Safety metrics are needed to determine what progress has been made towards the IHST goal. One cannot expect to just establish a goal and wait 10 years to see if that goal is met. Progress must be measured often and course corrections made as needed. Therefore, the JHSAT will aggressively measure risk and changes of risk on an annual basis. This will provides a timely means to:

- Determine progress toward meeting the 10-year goal
- Identify successes and obstacles to success early in the effort
- Refocus efforts on problem areas
- Allow new information gained during those years to be used to reduce the risk of additional accidents.

5.1 80 Percent Accident Rate Reduction Goal

The IHST primary goal is to achieve an 80% reduction in helicopter accident rates by 2016. Achievement of this primary goal will be determined by calculating a worldwide accident rate using accident count and worldwide fleet hours. Additionally, as the JHSAT function matures, it is expected to continue to conduct accident analyses, develop safety recommendations and ramp up in its ability to provide measurements of the effectiveness of the safety recommendations and implementation levels in all regions. This will require development of secondary metrics that will give the JHSAT, JHSIT and IHST better ability to understand and manage the results of the recommendations and implementation actions.

Secondary metrics used to monitor annual progress toward that goal will include regional accident rates and the individual helicopter occupant risk of fatal injury. Other measures may be developed as the program progresses.

To add increased understanding of the results of our actions, the JHSAT will establish regional metrics. If each region establishes an 80% accident rate reduction goal and meets that goal, the worldwide goal is also met. Some regions may decide not to participate in the IHST effort. The safety metrics of regions that participate in IHST will be compared to the metrics in regions that do not participate. Such comparisons will show the effectiveness of the IHST effort. This particular report is specifically for the U.S.-registered helicopter portion of the worldwide fleet. The starting point and the target goal to achieve an 80% reduction in U.S.-registered helicopter accident rate is established below. The worldwide starting point and target goal will be established as soon as the worldwide flight hours have been developed; secondary measures by region will follow.

The number of military and civil helicopter accidents worldwide, shown earlier in Figure 2-1 illustrated that each area has basically the same number of accidents each year. There is no apparent improvement shown here despite the introduction of new aircraft, new generation avionics, and other equipment improvements. Although it is acknowledged that flight hours have increased, bringing the accident rate downward, the helicopter industry must try a different approach to bring the accident rate down substantially. This is the essence of the IHST effort.

5.2 IHST Goal Setting

The measurement of a goal requires a starting point, from which the future target goal is then measured. For example, a starting point metric such as 200 accidents in a year requires the future goal metric to be 80% less (i.e. there will be no more than 20% of the number of accidents occurring). For the U.S.-registered helicopter goals of the U.S. JHSAT, the starting point was the average of the last five years (2001 through 2005) before the IHST effort began in January of 2006. The IHST clock started in January 2006.

Using NTSB and FAA data presented on the HAI website, the accident rate of the U.S. JHSAT starting point and the target goal rate by 2016 are shown in Table 5-1. During the 2001 through 2005 period, there were 984 accidents in 2,132,600 flight hours with 53 fatalities of the 412 occupants onboard.. These data are the best available to establish a starting point, which is needed now. Accuracy will be improved by the JHSAT metric process over the next few years.

Table 5-1. U.S.-Registered Helicopter 80% Reduction Target Goals

	Annual Average Starting Point (2001-2005)	**80% Reduction Target Goal by 2016**
Accidents/100,000 flight hours	9.1	1.8

As they are developed, worldwide metrics will be handled in an identical manner, taking the same averages of the 2001-2005 period to develop the same information as in Table 5-1. Work is underway to ensure the JHSAT has all worldwide accidents in the count before establishing the worldwide 80% reduction goal. Regional JHSATs should use the same criteria and format, as their data will be folded into the IHST progress tracking around the world. For those countries that do not participate, the U.S. JHSAT will develop the hours and track progress (or lack of progress) to report to the IHST and regional JHSATs and JHSITs.

5.3 Metrics Calculation

Accident counting cannot be used effectively for fleets of different sizes and different amounts of exposure (e.g. flight hours flown). The metric for aircraft damaged per hour of exposure is the most common metric of the accident rate. The helicopter accident rate is typically expressed in number of accidents per 100,000 flight hours within a given year. Accident rate per 100,000 flight hours is the primary IHST metric, as its use is universal and started with the beginning of aviation. The use of accident rate is primarily a measure of risk of damage to the aircraft itself. Accident rates per 100,000 flight hours are calculated as the number of fleet accidents in a year divided by the number of fleet flight hours flown that year expressed in hundreds of thousands of hours.

The risk of harm to an occupant is different than the risk of damage to the aircraft (e.g. accident rate). An individual occupant risk can be calculated to determine that person's risk of a fatal injury (RFI) per 100,000 hours of occupant exposure. This allows the individual to determine his / her risk flying in different types of aircraft because it is based on the amount of personal exposure time. The RFI is the likelihood of an accident occurring (e.g. accident rate) multiplied by the likelihood of receiving a fatal injury given that you are involved in an accident. The last term is actually the ratio of number of fatal injuries that occurred in all accidents to the number of occupants in all accidents that were exposed to a potential fatal injury. Thus the RFI per 100,000 occupant hours metric is calculated as:

$$\text{RFI} = \frac{\text{Number of accidents}}{\text{Number of flight hours}} \text{ X } \frac{\text{Number of fatalities in all accidents}}{\text{Number of exposed occupants onboard all accidents}}$$

5.4 Flight Hour Exposure

The amount of exposure to any concerns in a helicopter fleet is the amount of flight hours for the period (typically a calendar year). Accurate flight hours are needed to correctly calculate safety rates regardless of the type of concern. The FAA has for years used sampling techniques in a voluntary survey of U.S.-registered aircraft owners to estimate airplane and helicopter aviation activities including flight hours, avionic usage, fuel usage, state aviation activities, etc. There has been considerable variability on small fleets like helicopter models.

The IHST effort requires significantly more accuracy in flight hours flown than is available in the annual FAA survey data [see, for example, Ref. 24 in Appendix I]. This accuracy is needed for tracking and analyzing the effects of many individual safety interventions. The annual effects of an individual intervention will be difficult to detect unless accurate flight hours are available. If an intervention is not having a measurable effect on the rate, IHST has to re-look at that intervention, and perhaps take a different approach. This must be done every year until 2016. The JSHAT will likely redirect and try new initiatives where interventions do not show enough effect on rates. Accurate flight hour information is crucial. Over a period of several years, some of the errors using

FAA annual flight hour estimates cancel each other out. The IHST used the averages of the last five years prior to IHST initiation (2001 through 2005) to establish the starting points for measuring progress as discussed in Section 5.3 Metrics Calculation. Going forward, the JHSAT is developing more accurate flight hours that will be used to measure progress.

For years, Bell Helicopter has tracked individual turbine-powered civil certified aircraft manufactured by Bell by serial number, allowing them to determine accurate flight hours. This has allowed accurate flight hours to be determined. Started in September 2006, to support the JHSAT effort, this process was expanded to achieve the goal of including all helicopters on civil registries (piston, turbine and military surplus) worldwide. This process includes helicopters produced by all manufacturers. It does not include kits or homebuilt helicopters / gyrocopters, so it will be consistent with JHSAT analyses. Each helicopter serial number is tracked individually. Annual flight hours are rolled up for reciprocating, single-turbine and twin-turbine engine types; data for individual aircraft models will be used internally for the study but will not be released publicly. Since the registry number is part of the tracking, flight hours flown can be determined in a particular country registry for a given year. This allows individual aircraft hours to be rolled up to hours flown under a country's registry. Knowing the accidents on a country's registry for a given year and the hours flown with that registry allows the calculation of accident rates with that country's registry. The vast majority of countries do not have or do not release their helicopter flight hours. Government regulatory authorities worldwide concentrate on the large commercial transport airplanes where reporting of flight hours may be required by their regulations. The overall flight hour process is shown in Figure 5-1.

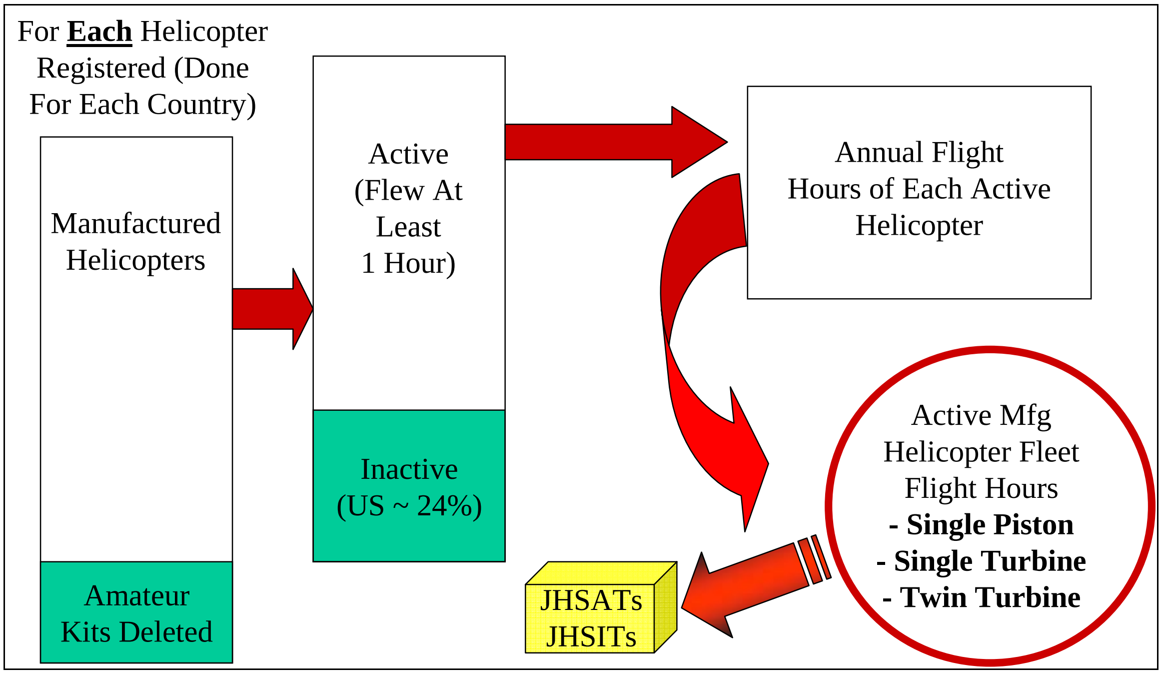


Figure 5-1. Flight Hour Process

The flight hour process involves recording model, manufacturer serial number, registry number, total airframe hours and the date of those total airframe hours. If the aircraft is exported / imported (e.g. changes country registries), a data point is generated to stop accumulating hours under the old registry and start accumulating hours under the new registry. Aircraft that crash and are destroyed do not accumulate additional hours after that date. The computation interpolates between the airframe total time data points for specified dates (e.g. the first of the year and the first of the next year) for that specific aircraft serial number. The difference in aircraft total times is the hours flown that year on that aircraft in that country registry. An example of an individual Bell 206B tracking is in Figure 5-2. Note that the aircraft left the U.S. Registry, was on the British Registry for some time and then returned to the U.S. Registry. So the annual flight hours can be rolled up under the appropriate registry.

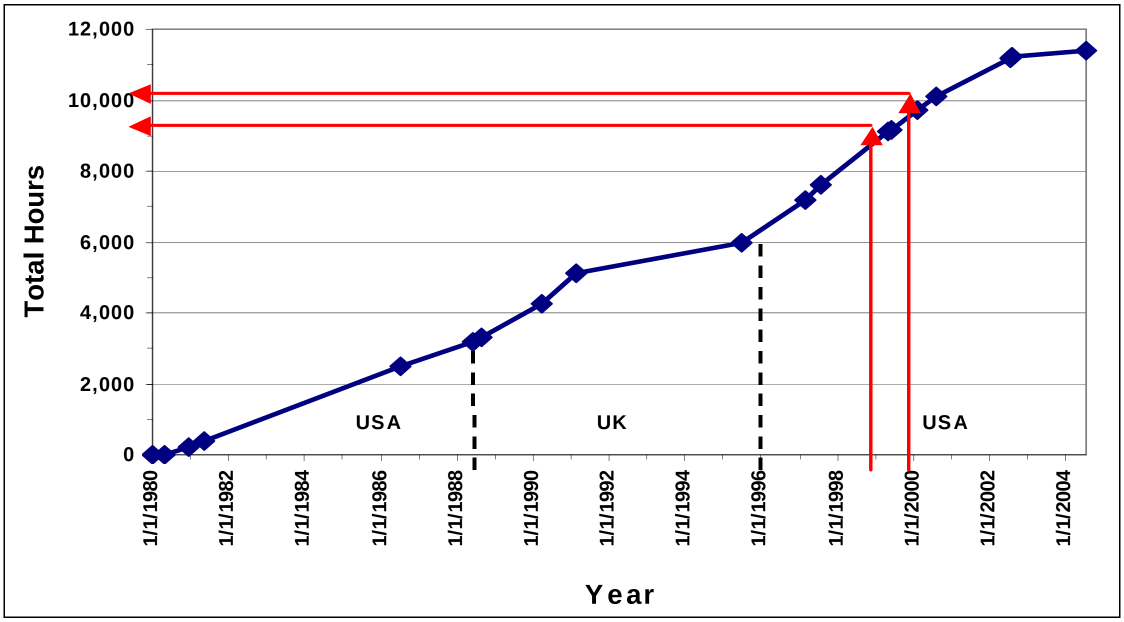


Figure 5-2. Example of the Flight Hours Tracking Process

This "data mining" process extracts data from any credible source of information rather than relying on responses from operators, which have proven to be difficult to obtain in the past. Registries on the Internet have been very helpful. The first data point is typically the date of manufacture, which is typically found on registry information. Data points can be found at such mundane places as Internet sites of helicopters for sale or helicopter clubs that track individual helicopters of a certain model for fun. A discrepancy report or accident report are also sources. HAI's web-based Maintenance Malfunction Incident Reports (MMIRs) are primarily for reporting helicopter discrepancies which then go to the FAA Service Difficulty Report (SDR) system. Figure 5-3 is the flight hour information gleaned from MMIR data of a Eurocopter EC 135. Note that although no usage was reported for about three years, the usage rate (slope of the line) was the same as the previous three years. Individual aircraft flight hour tracking has shown a remarkably constant helicopter usage rate for an individual operator as long as there is no accident or sale of the aircraft.

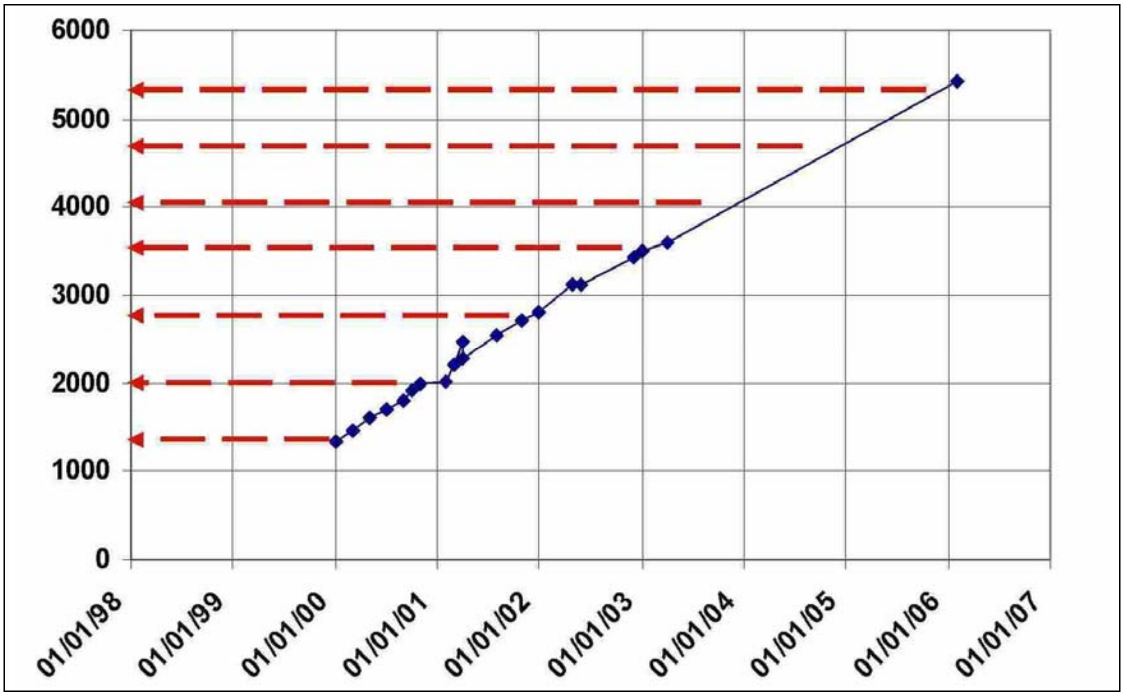


Figure 5-3. Example of Flight Hours from MMIR Data

In addition to the FAA survey, which has a confidentiality guarantee, data mining of other FAA data systems is being pursued. The FAA has supported this effort with known dates of registry changes. Assistance from other agencies is being pursued to identify registry changes that would improve accuracy of flight hour reporting in all countries.

At the time this report was published, flight hours had been obtained for about half of all civil registered helicopters worldwide. It will be included in the next JHSAT interim report and will present the IHST goals progress metrics available at that time. The flight hour information that will be released to the JHSATs, JHSITs, and IHST annually by country and worldwide will be:

- Single piston (reciprocating) family
- Single turbine family
- Multiple turbine family
- All helicopters (sum of the above three categories)

Other regional or country JHSATs are in the process of forming and will be using the IHST analysis process on their accident data. If they have accurate flight hours, it is expected they will use them. If not, the U.S. JHSAT will work with that regional JHSAT group to provide flight hours developed as noted above. Together, the JHSATs should be able to improve the accuracy of flight hours flown under registries of those countries. Accuracy of flight hour reporting is critical for every JHSIT as they determine how interventions can be implemented and how long that might take.

The JHSATs do not yet have the capability to break flight hours down to the mission-level. That refinement will be addressed in subsequent years after the all-mission effectiveness measurements are firmly in place.

Section 6 – General Results

Analysis of 197 accidents allowed the JHSAT to develop problems and interventions associated with each accident, and safety recommendations that are based on the frequency of categorized problems and interventions. The following hypothetical example illustrates the process:

Two helicopters are in flight on an observation mission. During the mission the two aircraft are flying several hundred feet from one another. One of the pilots says, "watch this" and initiates a 45-degree nose down dive. Subsequently, the aircraft impacts terrain, there is a post-crash fire resulting in the fatality of both on board. Post-crash investigation reveals that the accident pilot had a history of aggressive flying and risk taking and had a prior felony drug conviction.

Problems associated with an accident relate to what went wrong and why:

- Management policies and oversight were inadequate
- There was an apparent failure to observe and / or enforce company SOPs
- No evidence of crew hiring / screening criteria
- Evidence of pilot disregard for rules and SOPs
- No evidence of a formal, threat free, safety reporting system
- Post-crash fire

Interventions are team derived means to mitigate the problems cited.

- Management should develop and adopt a formal risk assessment / management program
- Include helicopter pilot histories in Pilot Records Information Act (PRIA)
- Develop hiring screening criteria for new hire pilots
- Conduct Procedural Intentional Non-Compliance (PINC) training
- Develop and implement a company non-punitive safety reporting system
- Use crash resistant fuel systems

Since the JHSAT developed over 1200 interventions from the accidents analyzed, a means to deliver useful recommendations was needed. Safety recommendations were developed by the JHSAT based on the frequency of like interventions, knowledge of the helicopter industry at large and knowledge of the specific type of mission being performed when an accident occurred. Given the problems and interventions used in the example above, several safety recommendations for this mission segment such as these might follow:

- Adopt SMS methods to assess and manage operations risk in general and specifically for
  - Hiring screening
  - Non-punitive safety reporting system
  - Training – Aircraft limitations and SOPs
- Augment existing PRIA system with helicopter pilot data
- Use crash resistant fuel systems

Combining the problems and recommendations from all 15 missions was also conducted to produce recommendations applicable to the entire U.S. fleet.

Below, Sections 6.1 (Factual Information) and Section 6.2 (Full Accident Set Analysis Results) provide a detailed discussion of the problems and interventions by most frequent category. Subsequent sections – 6.3 (Mission Specific Results), 7.1 (Safety Management) and 7.3 (Systems and Equipment) – present the safety recommendations developed by the JHSAT from the intervention data.

6.1 Factual Information

6.1.1 Mission Environment

Type of Operation. Most of the accidents occurred while the pilots were operating under FAR Part 91 – General Operations (71% of the accidents). This is not a surprising finding, as most helicopter missions are performed under Part 91. The next most common types of operations with accidents were conducted under Part 137 – Aerial Application (13%), Part 135 – Air Taxi (9%), and Part 133 – External Load (6%). Two accidents involved a Public Use (PUBU) operations helicopter. Two accidents involving non-U.S.-Registered aircraft were included in our database as both accidents occurred in the U.S. and were investigated by the NTSB. One involved a Non-U.S. Scheduled Commercial (NUSC) flight and the other a Non-U.S. Non-Commercial (NUSN) flight. The same information is shown in Table 6-1 by Primary Mission.

Although some public use operators operate aircraft to civil standards, an analysis of NTSB accident code designators (those containing "GA" and "TA" per Appendix G) indicate that some of the accidents analyzed were designated as public use.

Table 6-1. Mission Type vs Number of NTSB Accidents

Primary Mission	**Part 91**	**Part 133**	**Part 135**	**Part 137**	**NUSC**	**NUSN**	**PUBU**	**Total**
Aerial Application	3			25				**28**
Aerial Observation / Patrol	10							**10**
Air Tour	5		5					**10**
Business	9							**9**
Commercial	9		6		1			**16**
Electronic News Gathering	4							**4**
Emergency Medical Services	10		2					**12**
External Load	2	3				1	1	**7**
Firefighting	4		1				1	**6**
Instructional / Training	37							**37**
Law Enforcement	13							**13**
Logging		4				1		**5**
Offshore	6		3					**9**
Personal / Private	25				1	1		**27**
Utilities Patrol / Construction	3	1						**4**
Total	**140**	**8**	**17**	**25**	**2**	**3**	**2**	**197**

Weather Condition. Of the 197 accidents in the CY2000 dataset, 13 (7%) occurred in reported Instrument Meteorological Conditions (IMC). The remaining 184 (93%) occurred in Visual Meteorological Conditions (VMC). This balance between IMC and VMC operations is typical of helicopters operations in general. For many types of missions, all of the accidents occurred in VMC, possibly because most helicopter missions cannot be effectively conducted in IMC (Table 6-2). It is noted below that 1 of 4 Electronic News Gathering (ENG) accidents (25%) occurred in IMC; that flight's encounter with IMC was not mission-related. Only 1 of 12 Emergency Medical Services (EMS) accidents occurred in reported IMC (8%). This is a lower percentage of IMC encounters on EMS accident flights than has been found in previous studies. Most of the IMC encounters in this dataset were inadvertent and unnecessary or improper for their respective missions.

Table 6-2. Primary Mission vs Visual Conditions

Primary Mission	No. of Accidents	IMC	IMC%
Aerial Application	28	4	14%
Aerial Observation / Patrol	10	0	
Air Tours	10	1	10%
Business / Company Owned	9	0	
Commercial	16	1	6%
Electronic News Gathering	4	1	25%
Emergency Medical Services	12	1	8%
External Load	7	0	
Fire Fighting	6	1	17%
Instructional / Training	37	1	3%
Law Enforcement	13	2	15%
Logging	5	0	
Offshore	9	0	
Personal / Private	27	1	4%
Utility Patrol / Construction	4	0	

Time of Day. Most of the accidents occurred during daylight hours (165 accidents, 84% of the total). The remainder occurred at dawn (2), dusk (2) or night (19). This is similar to a previous finding that 89% of all helicopter accidents between 1990 and 2000 occurred during daylight hours (Ref. 26 in Appendix I). Of the accidents that occurred at night, the moon provided considerable illumination (Night-Bright) in 5 of them. There was no celestial illumination in 14 of the accidents (Night-Dark). Proportionally more of the accidents that occurred under reported IMC occurred at night (6 out of 14 or 43%) than during the day (5 out of 165, 3%). Interestingly, the number of accidents that occurred under Night-Dark conditions was roughly the same for IMC (6) and VMC (8). Even though only 1 of 12 EMS accidents occurred in IMC, 75% of the EMS accidents occurred at night (Table 6-3). Furthermore, 6 of those were under Night-Dark conditions, presenting the pilot with visual conditions that were not much better than IMC. The only other type of Mission in which a significant number of accidents occurred between dusk and dawn was Law Enforcement. These types of missions share a degree of unpredictable scheduling, perceived urgency and round-the-clock operations in a wide range of environments.

Table 6-3. Primary Mission vs Lighting Conditions

Primary Mission	Not Reported	Day	Dusk to Dawn
Aerial Application		25	3
Aerial Observation / Patrol		9	1
Air Tours		10	
Business / Company Owned	1	8	
Commercial	1	15	
Electronic News Gathering		2	2
Emergency Medical Services		4	8
External Load	2	5	
Fire Fighting		5	1
Instructional / Training	1	35	1
Law Enforcement		8	5
Logging	1	4	
Offshore		8	1
Personal / Private	3	23	1
Utility Patrol / Construction		4	

6.1.2 *Phase of Flight*

Overall. Accidents occurred during every phase of flight, but the most frequent were: Maneuvering (25%), Cruise (18%), and Landing (19%). Hovering (12%) and Takeoff (10%) were the next most frequent (Figure 6-1). Although these results are typical of helicopter accidents in general, they differ markedly from the pattern that is typical of fixed-wing accidents in that hovering is unique to helicopters, and helicopter accidents occur more often in the maneuvering phase than do airplane accidents.

By Primary Mission. The distribution of accidents by Mission and Phase of Flight are shown in Table 6-5. To a great extent, the different Phase of Flight patterns found across Missions reflects the flight regimes typical of each Mission and highlight the difficulty of identifying "one-size-fits-all" solutions. For some Missions (Aerial Application, Fire Fighting and Law Enforcement), accidents occurred during maneuvering more frequently than during any other phase of flight. For other missions (Air Tour, Offshore, and Personal / Private) accidents occurred most often during the Cruise phase of flight. For External Load and ENG, accidents sequences were initiated most often when the helicopter was in a hover. The vast majority of Instructional / Training accidents occurred during Approach, Landing and Hover. More than 50% of all of the Landing accidents that occurred during 2000 involved Instructional flights – most likely because autorotations are considered a landing phase maneuver and Instructional accidents frequently involved practice autorotations (13 practice and two emergency full-autorotations of the 20 "landing" accidents in the Instructional accident group).

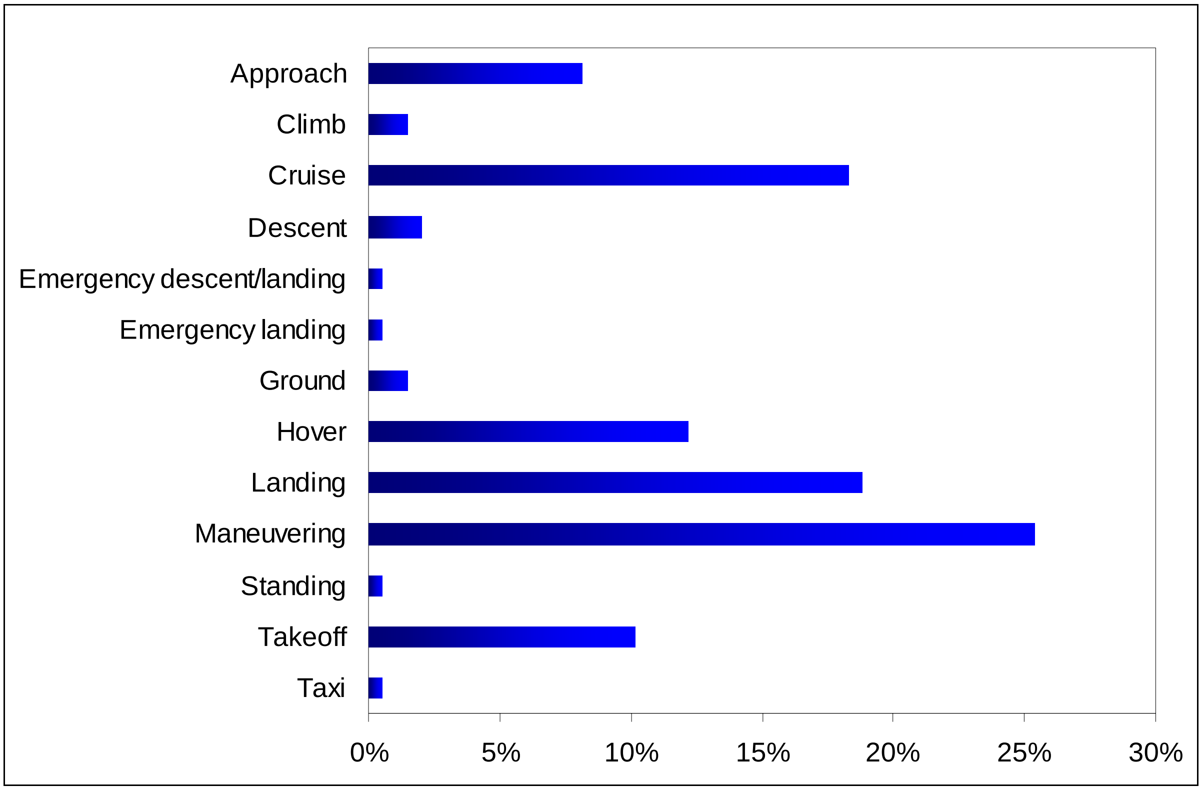


Figure 6-1. Phase of Flight in Which the Accident Occurred

Table 6-4. Frequency of Accident Occurrence by Mission and Phase of Flight

Primary Mission	Approach	Climb	Cruise	Descent	Em Descent	Em Landing	Ground	Hover	Landing	Maneuvering	Standing	Take-Off	Taxi	Total
Aerial Application	1		4	1	1			1	1	15		4		**28**
Aerial Observation / Patrol	1		2						1	4		2		**10**
Air Tours	1		5	1						2		1		**10**
Business / Company Owned	1		1	1		1	1		2	2				**9**
Commercial	1		3					2	4	4		2		**16**
Electronic News Gathering			1					2		1				**4**
Emergency Medical Service	2		4					1	1	2		2		**12**
External Load		1						4		1			1	**7**
Fire Fighting								1		3	1	1		**6**
Instructional / Training	4		1				1	6	20	2		3		**37**
Law Enforcement			3				1		2	6		1		**13**
Logging	2							2		1				**5**
Offshore	1	1	3						2	1		1		**9**
Personal / Private	1	1	8	1				4	4	5		3		**27**
Utility Patrol / Construction	1		1					1		1				**4**
Total	**16**	**3**	**36**	**4**	**1**	**1**	**3**	**24**	**37**	**50**	**1**	**20**	**1**	**197**

6.1.3 Pilot Hour Demographics

Total Flight Hours. On the average, the pilots involved in the 197 accidents that were analyzed for this report were quite experienced; their average reported total flight time exceeded 6,000 hours. However, total flight hours across all accidents ranged from a low of 13 hours to a high of 30,000 hours. The distribution of total pilot experience in all aircraft types is shown in Figure 6-2. In 154 of the accidents, the pilot in command had at least 1,000 hours of flying experience, and as many as 25% of the pilots had more than 10,000 hours of flying experience. In 43 accidents (21.8%), the pilot-in-command had fewer than 2,000 hours total flight experience.

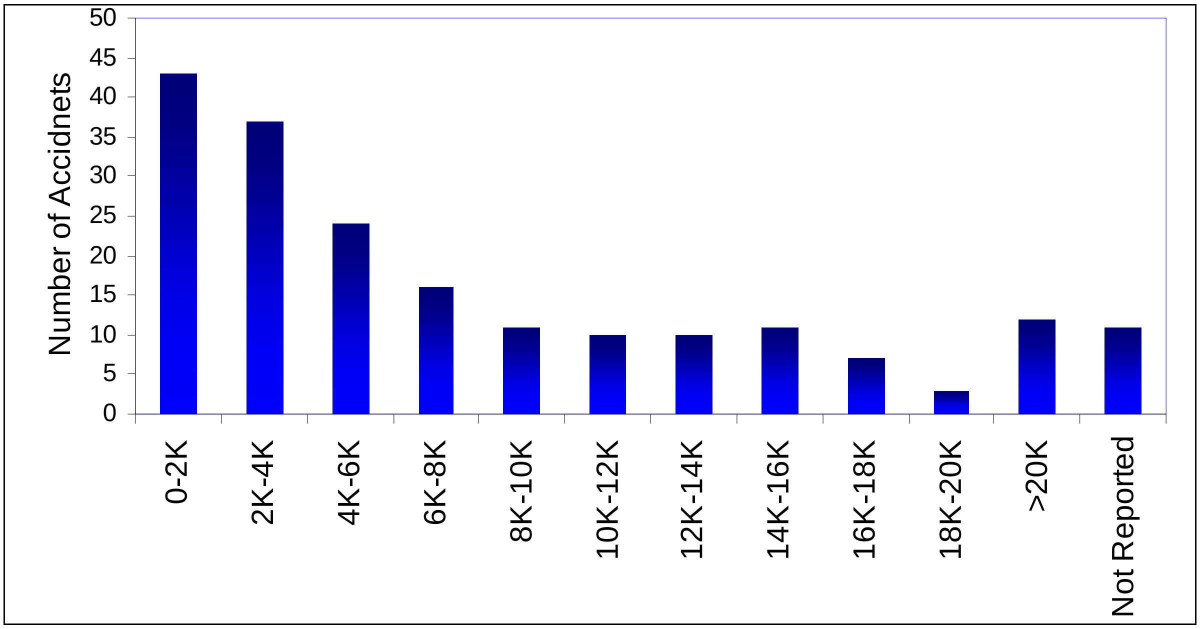


Figure 6-2. Distribution of Total Reported Pilot Hours Across All Missions

Helicopter Flight Hours. The average reported helicopter hours for the pilots in command for these accidents exceeded 4,600 hours, although the range extended from a low of 13 hours in helicopters to a high of more than 23,000 hours; 24 of the pilots had in excess of 10,000 hours. The majority of the pilots had flown both fixed-wing and rotary-wing aircraft, although for 40 of them, all of their flight experience was in helicopters. The largest experience category for these pilots was between 1,000 and 5,000 hours of helicopter experience (Figure 6-3). Figure 4 indicates about 37 accident reports (18.8%) did not report pilot time in rotorcraft.

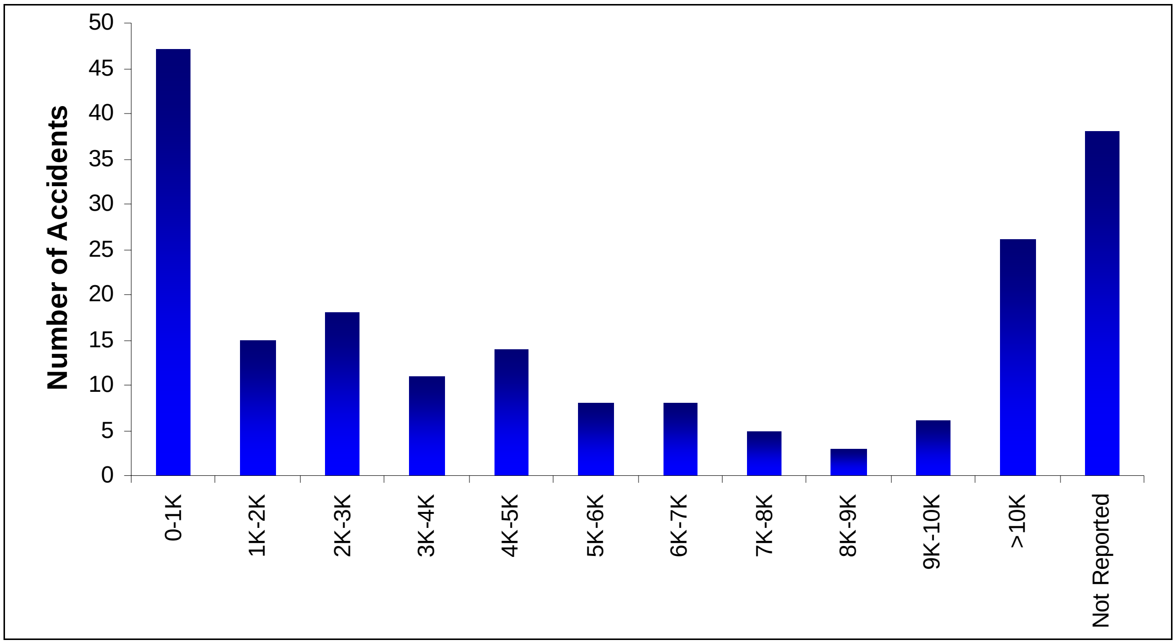


Figure 6-3. Distribution of Pilots' Total Reported Rotorcraft Hours

Hours in Make and Model. Approximately 50% of the pilots (for whom flight hours were reported) had less than 1,000 hours of experience in the make and model of helicopter in which the accident occurred. The average reported experience in the accident make and model exceeded 1,700 hours, although the range extended from a low of 6 to a high of 14,500 hours. Nearly 30% of the pilots had between 1,000 and 5000 hours of time in the make and model of helicopter in which the accident occurred. Only a few had more than 5,000. Hours in make and model was underreported; about 80% of the reports analyzed did not have this data.

Table 6-5. Average Reported Flight Hours by Primary Mission for the Pilots in Command

Primary Mission	Average Total Pilot Hours	Average Rotorcraft Hours	Average Make & Model Hours
Aerial Application	11,493	6,758	2,894
Aerial Observation / Patrol	4,850	2,956	1,428
Air Tours	6,644	5,729	1,656
Business / Company Owned	9,643	3,875	1,299
Commercial	6,783	5,870	1,504
Electronic News Gathering	5,027	3,589	902
Emergency Medical Services	4,873	4,795	538
External Load	14,182	12,447	7,532
Fire Fighting	6,872	6,183	2,582
Instructional / Training	4,572	2,923	1,495
Law Enforcement	7,379	2,694	1,004
Logging	10,369	10,143	2,652
Offshore	6,382	6,319	1,166
Personal / Private	5,486	1,940	193
Utility Patrol / Construction	8,873	8,210	3,428

Flight Hours vs Primary Mission. There were significant differences among missions with respect to average pilot experience. For example, the pilots who were involved in Aerial Application, External Load, and Logging missions had more than 10,000 hours total flying experience, on the average, and more than 6,500, 12,000, and 10,000 hours (respectively) in helicopters. These three groups of pilots also had the most experience in the accident helicopter make and model of any other type of operation except Utility Patrol / Construction. For four groups of pilots (EMS, Fire Fighting, Offshore, Utility Patrol / Construction) most of their total flying experience was in helicopters. The other notable finding was that average time in make and model for the pilots of EMS (538 hours) and Personal / Private (193 hours) missions that ended in an accident were considerably lower than the overall average of 1,708 hours. As one can see in Figure 6-4, the group of pilots who had the least amount of total flying experience were the pilots in command of the Instructional / Training flights that were involved in an accident, since flight instructors typically have just received their own flight training.

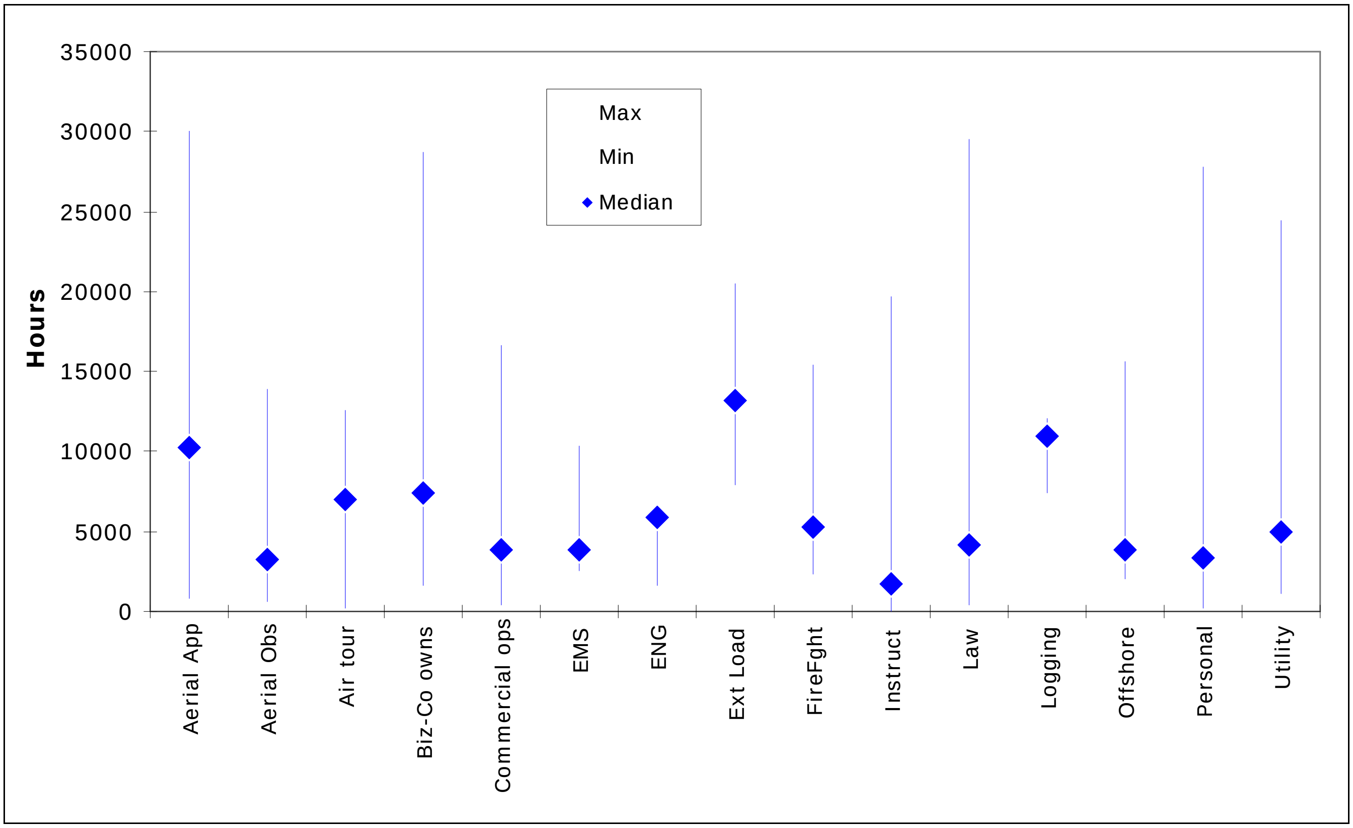


Figure 6-4. Pilot Experience for Different Missions (Median, Max and Min Total Hours)

6.1.4 Helicopter Demographics

Of the accidents investigated, 40% involved helicopters powered by reciprocating engines and 60% by turboshaft engines. Certified maximum gross weight of the helicopters in the "normal" category (less than 7,000 lb maximum gross weight) accounted for 169 accidents (86% of the total). Transport category helicopters (over 7,000 lb) accounted for the remainder (28 accidents, 14%). Table 6-6 illustrates the breakdown of helicopter type by primary mission.

Table 6-6. Primary Mission vs Certification Category (Based on Aircraft Maximum Gross Weight)

Primary Mission	Normal	Transport	Total
Aerial Application	22	6	**28**
Aerial Observation / Patrol	10		**10**
Air Tours	9	1	**10**
Business / Company Owned	8	1	**9**
Commercial	14	2	**16**
Electronic News Gathering	4		**4**
Emergency Medical Service	6	6	**12**
External Load	6	1	**7**
Fire Fighting	2	4	**6**
Instructional / Training	36	1	**37**
Law Enforcement	13		**13**
Logging		5	**5**
Offshore	9		**9**
Personal / Private	26	1	**27**
Utility Patrol / Construction	4		**4**
Total	**169**	**28**	**197**

6.1.5 Accident Severity

Most of the 197 civil helicopter accidents that occurred in the CY2000 dataset resulted in either no injuries (91 accidents, or 46%) or minor injuries (45 accidents, or 23%). The remaining accidents resulted in serious injuries (14%) or fatalities (17%).

Injuries by Primary Mission. Figure 6-5 and Table 6-7 break out accident severity by the Primary Missions that were being performed. It is interesting to note that the three most common types of accident missions – Aerial Application, Instruction and Personal / Private – were somewhat less likely to involve a fatality than were other, less frequently occurring types of accident missions. On the other hand, accidents that resulted in at least one fatal injury were significantly more common in Fire Fighting and Electronic News Gathering missions; however, analysis of several years of data will be required to more fully characterize these findings. Of the accidents that occurred in high-visibility segments of the industry (EMS, Air Tour and Law Enforcement) a third of the accidents involved at least one fatality. Of the 34 fatal accidents in 2000, 4 were EMS, 4 Law Enforcement and 2 were Air Tour. Another large and visible segment of the industry, offshore oil operations, contributed proportionally few accidents overall (9) and even fewer fatal accidents (3) to the total, an excellent record considering their number of operations and the challenging environment in which they fly.

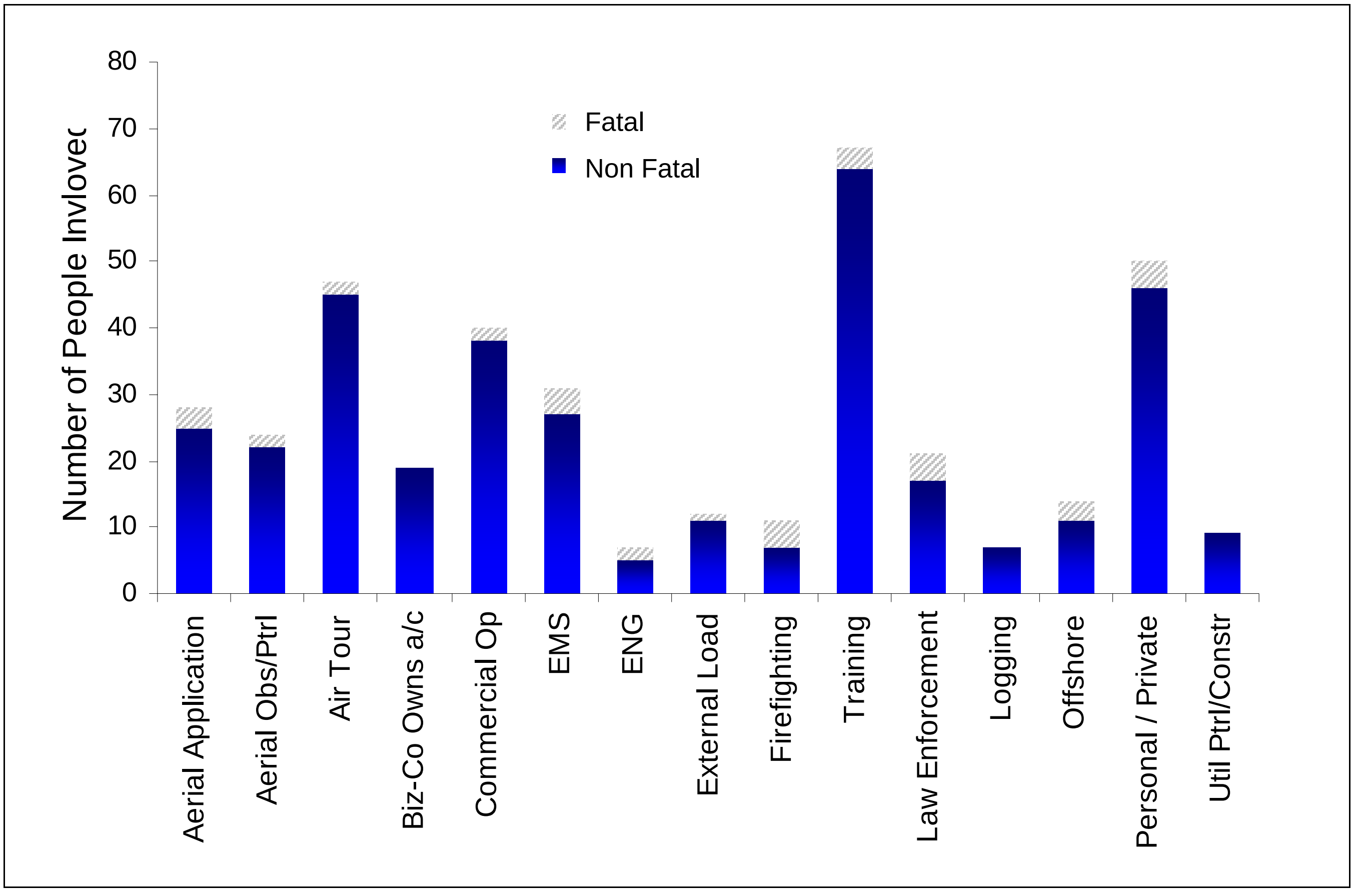


Figure 6-5. People Involved in Accidents / Fatalities by Primary Mission

Table 6-7. Severity of Accident by Primary Mission

Primary Mission	Number of Accidents	% Accidents with At Least 1 Fatality	Total Number of People Involved
Aerial Application	28	11%	28
Aerial Observation / Patrol	10	20%	24
Air Tours	10	20%	47
Business / Company Owned	9	0	19
Commercial	16	13%	40
Electronic News Gathering	4	50%	7
Emergency Medical Service	12	33%	31
External Load	7	14%	12
Fire Fighting	6	67%	11
Instructional / Training	37	8%	67
Law Enforcement	13	31%	21
Logging	5	0	7
Offshore	9	33%	14
Personal / Private	27	15%	50
Utility Patrol / Construction	4	0	9

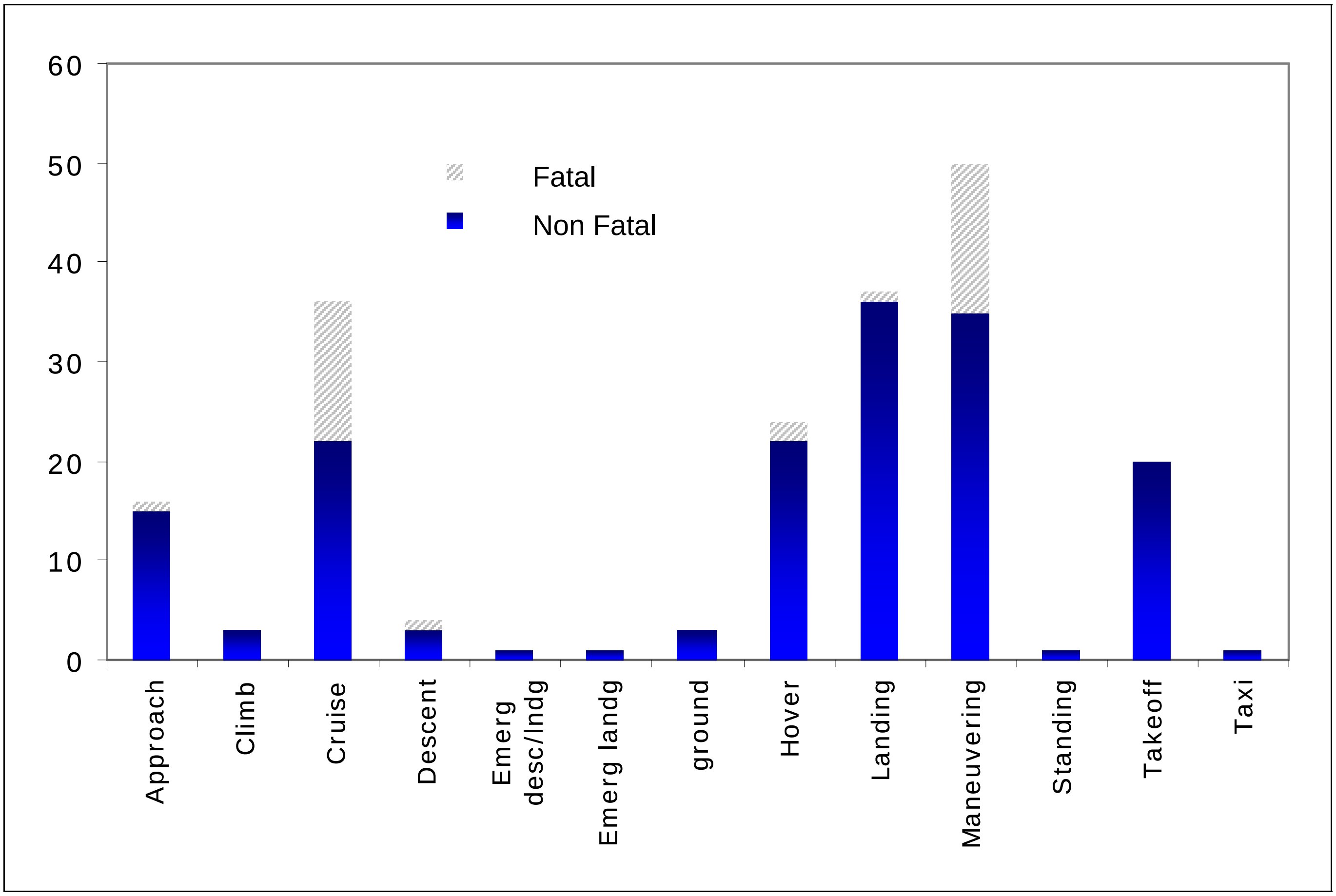


Figure 6-6. People Involved in Accidents / Fatalities by Phase of Flight

Injuries by Initial Phase of Flight. Figure 6-6 shows the numbers of occupants in accidents and their injury severity by phase of flight at time of the emergency. More people were involved in accidents that began while the helicopter was Maneuvering, followed by Cruise and then Landing. However, the fatality ratio (number of fatalities vs the number onboard) followed a different pattern. Fatality ratios for people onboard for Cruise, Maneuvering and Descent were 39%, 30% and 25%, respectively. Fatalities in the remaining flight phases were rare. It is interesting to compare these results to the frequencies with which accidents actually occurred during the different flight phases. In contrast, 18% of the accidents occurred during Landing, but the fatality ratio was only 2%, most likely due to low speed and relatively low impact forces compared to high speed impacts of Cruise, Maneuvering and Descent.

6.2 Full Accident Set Analysis Results

Figure 6-7 shows how many accidents were analyzed in each mission category and the resulting count of Standard Problem Statements (SPSs) generated by accident analysis in each mission. For example, in the Training Mission, 37 accidents were analyzed and 189 SPSs were identified. This chart helps orient the reader to which missions dominated the analyses both from accident count and SPS standpoints. A complete list of problem statements developed by the JHSAT is provided in Appendix C. Standard problem statements were used to help develop common problem areas during accident analysis and are more fully explained in the JHSAT Process Handbook [Ref. 19 in Appendix I].

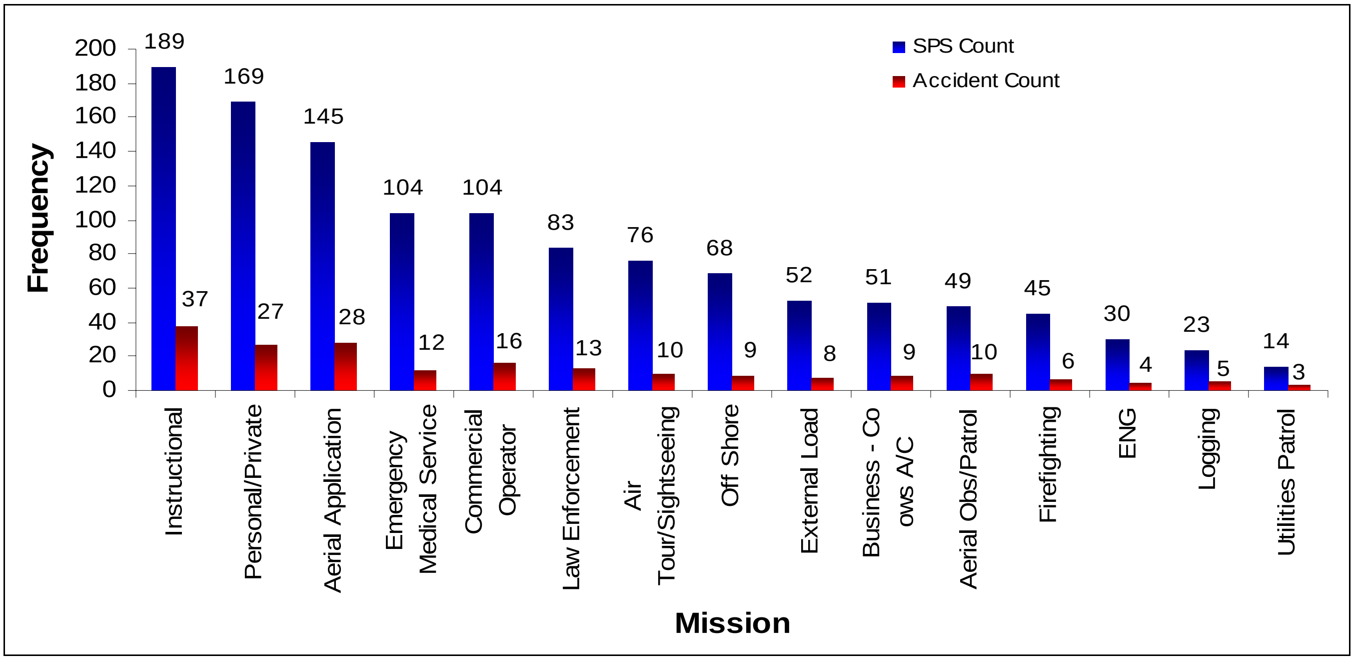


Figure 6-7. SPS and Accident Counts by Mission

During the analysis of the 197 accidents that occurred during 2000, 1,110 problems were identified. In some cases, these problems were directly and immediately related to the accident and were the proximal cause (e.g., “Fuel Starvation”). In others, the identified problems were related in time (e.g., “Aircraft preflight process inadequate”) or position in the causal chain. Many of the identified problems were related to actions that the Pilot in Command did (e.g., “Pilot disabled a warning system”) or did not perform (e.g., “Inadequate response to loss of tailrotor effectiveness”). Yet other problems targeted the pilots’ working environments (e.g., “Mission involves flying near hazards, obstacles and wires”).

Problems associated with a part or system failure (e.g., “Electrical system component failure”) were often easier to identify than problems associated with the mission (e.g., “Mission requirement places pressure on crew to fly”), organization (e.g., “Lack of local supervision of remote operations,” or infrastructure (e.g., “Weather information for flight inadequate or unavailable”). On the other hand, these less concrete factors tended to repeat in accident after accident. They seemed to be the factors that set up a situation in which one or more additional problems with a human, the helicopter or the mission resulted in an accident. There was another group of problems that were identified at least once in 62% of the accidents that were related to insufficient information in the report. However, since this Data Issues Category focused on the difficulty of obtaining complete data with which to investigate past accidents or prevent future accidents, it will be treated somewhat differently than problems that are more closely tied to the causal chains of the accidents.

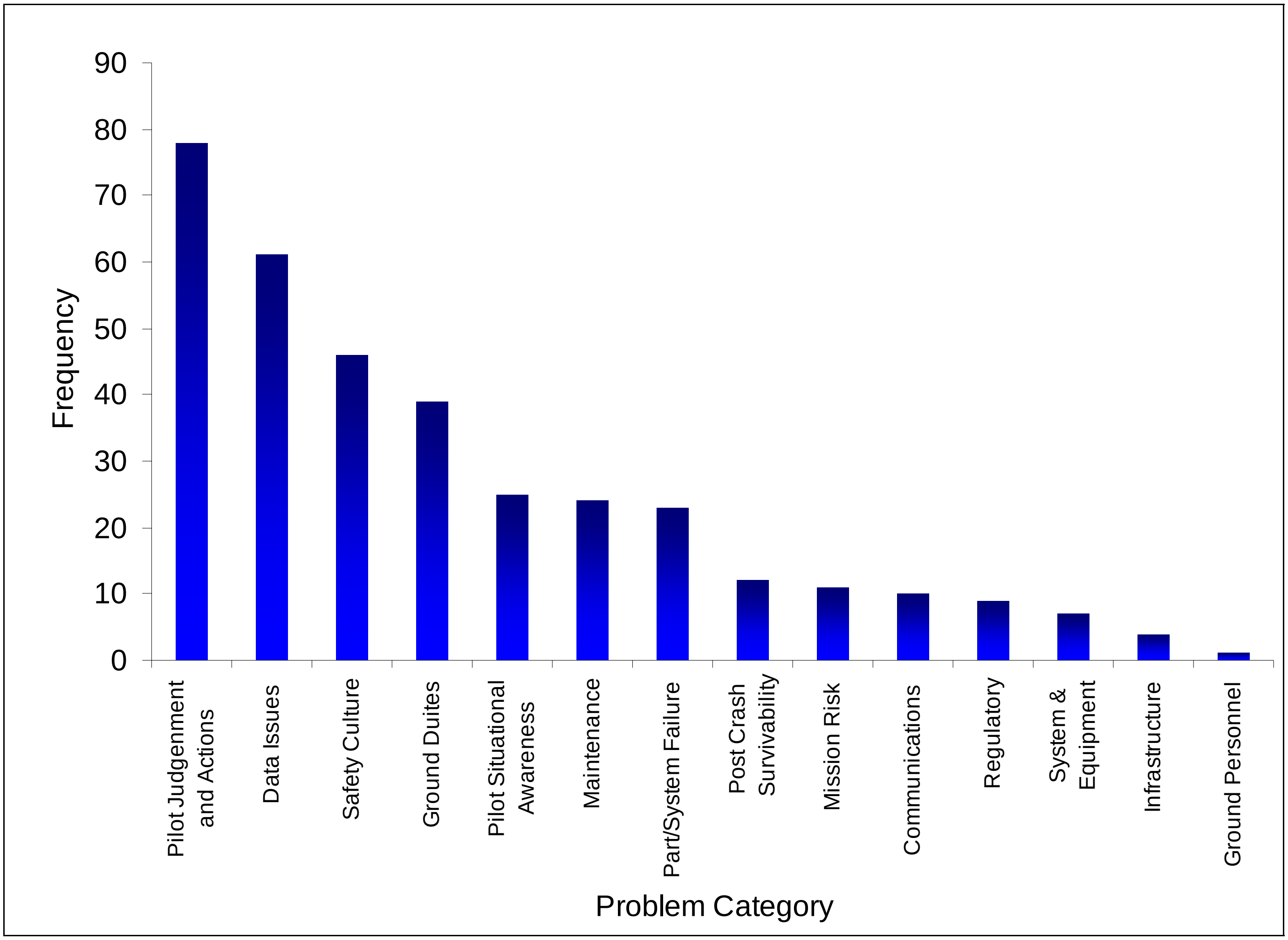


Figure 6-8. Percent of Accidents in which Problem Categories were identified at least once

The JHSAT grouped these 1,110 problems into 14 Categories and 50 sub-Categories (see Appendix D). Not only were different types of problems identified from one accident to the next, but their numbers differed as well. There were only four accidents in which just one problem was identified. In most cases, the team found a number of problems that in some way contributed to the occurrence of an accident. However, when information about the mission, operation, flight, pilot or helicopter was insufficient, the depth of the team's analysis was necessarily limited. Thus, the number of problems identified per accident was limited by the quality of the investigation and report and the materials available in the full docket to at least some extent. Furthermore, instances of one type of problem could occur more than once within an accident. For all of these reasons, the summary data for problems, problem sub-categories, and problem categories are expressed as the number (or percentage) of accidents in which it was identified at least once; the raw number of times each problem (or sub-category or category) was identified is a less meaningful measure. Figure 6-8 presents a high-level, graphic summary of the frequencies with which different types of problem were found.

The most frequently occurring category of problems involved Pilot Judgment and Actions. At least one of the problems represented by this category (e.g., Crew Resource Management (CRM), Human Factors and Procedure Implementation) was cited in 78% of the accidents. This finding is completely consistent with most previous analyses of aircraft accidents. The next most frequently occurring category of problems also revolved around the human: Safety Culture-related problems were found in 46% of the accidents. This category included such subcategories as Management, Pilot Experience, Training, Dispatch and Safety Equipment. Ground Duties were next, occurring in 39% of the accidents. This category included Mission Planning, Preflight briefings, Aircraft Preflight and Post-flight duties. This was followed in frequency by Pilot Situation Awareness (25%), Part / System Failure (23%), Mission Risk (11%) and Communications (10%). The following sections summarize the key findings for each Problem Category, starting with the most frequently occurring category and moving in order to the least. Table 6-8 is a summary of the number of times a problem category or sub-category was identified and the percent of accidents in which they were identified at least once.

Table 6-8. Problem Frequency

Problem Category	Problem Sub-Category	Total Count	No. of Accidents	% of Accidents
Pilot Judgment and Actions	Procedure implementation	93	74	38%
	Human Factors-Pilot's decisions	93	65	33%
	Landing Procedure	68	60	30%
	Flight Profile	59	52	26%
	Human Factors – Pilot / Aircraft Interface	28	26	13%
	Crew Resource Management	20	20	10%
	Total	**361**	**154**	**78%**
Data Issues	Inadequate info in report	148	122	62%
	Inadequate information in report	1	1	1%
	Total	**149**	**123**	**62%**
Safety Culture / Management	Management	50	35	18%
	Inadequate Pilot Experience	25	22	11%
	Safety Program	24	22	11%
	Transition Training	18	16	8%
	Training Program	16	16	8%
	Pilot	10	10	5%
	Flight Procedure Training	6	6	3%
	Scheduling / Dispatch	5	5	3%
	Ground / pax training	3	3	2%
	Safety Equipment	2	2	1%
	Total	**159**	**91**	**46%**
Ground Duties	Mission Planning	60	54	27%
	Aircraft Preflight	30	24	12%
	Preflight Briefings	3	3	2%
	Postflight Duties	1	1	1%
	Total	**94**	**76**	**39%**
Pilot SA	External Environment	40	33	17%
	Visibility / Weather	21	16	8%
	Internal Aircraft Awareness	4	4	2%
	Crew Impairment	3	3	2%
	Total	**68**	**50**	**25%**
Maintenance	Performance of MX Duties	37	27	14%
	MX Procedures / Mgmt	37	26	13%
	Aircraft Design	19	19	10%
	Quality of Parts	8	7	4%
	Total	**101**	**47**	**24%**
Part / System Failure	Aircraft	36	27	14%
	Powerplant	20	20	10%
	Operational FOD	2	2	1%
	Total	**58**	**46**	**23%**

Table 6-8: Problem Frequency (Continued)

Problem Category	Problem Sub-Category	Total Count	No. of Accidents	% of Accidents
Post-Crash Survivability	Crash-worthiness	16	16	8%
	Safety Equipment	6	6	3%
	Delayed rescue	4	4	2%
	Total	**26**	**25**	**13%**
Mission Risk	Terrain / obstacles	19	18	9%
	Pilot Intensive	3	3	2%
	Aircraft Intensive	1	1	1%
	Total	**23**	**21**	**11%**
Communications	Other Crewmembers	17	14	7%
	Controlling Agencies	4	4	2%
	Inadequate Procedures	3	3	2%
	Total	**24**	**19**	**10%**
Regulatory	Oversight	14	10	5%
	Safety System	4	3	2%
	Accident Prevention	4	4	2%
	Total	**22**	**17**	**9%**
Systems & Equipment	Systems & Equipment	15	13	7%
	Total	**15**	**13**	**7%**
Infrastructure	Equipment	6	5	3%
	Oversight	2	2	1%
	Oversight / Regulation	1	1	1%
	Total	**9**	**7**	**4%**
Ground Personnel	Ground Personnel	1	1	1%
	Total	**1**	**1**	**1%**
Grand Total		**1,110**	**197**	**100%**

In the following sections, each problem category will be considered individually and compared to other variables such as mission and pilot characteristics, phase of flight and the interventions that the analysis group suggested in the order of frequency with which they were found in the helicopter accidents for 2000. Again, please note that identification of problems was not exclusive; more than one type of problem was identified in most accidents with the result that 1,110 problems were identified in the 197 accidents analyzed by the team. For this reason, results are usually presented as the percent of accidents in which a problem (or Problem Sub-Category or Problem Category) was cited at least once. For a summary of the results, see Table 6-8, above. For a higher-level summary of the results by Primary Mission, see Table 6-9, below.

In addition to identifying problems in each of the accidents that were analyzed, the team also suggested interventions that might either decrease the likelihood that a particular problem will happen in the future or change the circumstances so as to decrease the likelihood of such an accident. The JHSAT team developed 532 distinct interventions associated with 180 different problems. Each of these problems was defined by a Standard Problem Statement (Appendix C). Because multiple interventions were suggested for some SPS, a total of 1,217 interventions were included in the analysis. The four interventions that were cited most often are described below.

Table 6-9. Percent of Accidents in Which a Problem Category Was Identified at Least Once, by Mission

	Aerial Application	Aerial Observation / Patrol	Air Tours	Business / Company Owned	Commercial	ENG	EMS	External Load	Firefighting	Instructional / Training	Law Enforcement	Logging	Offshore	Personal / Private	Utilities Patrol / Construction	Average
Communications	4%	10%	20%	11%	0%	0%	42%	29%	0%	16%	0%	0%	11%	0%	0%	9.5%
Data Issues	50%	70%	50%	67%	63%	25%	58%	43%	67%	84%	69%	40%	78%	56%	50%	58.0%
Ground Duties	50%	50%	50%	44%	44%	50%	25%	43%	33%	16%	54%	0%	22%	56%	25%	37.5%
Ground Personnel	4%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.3%
Infrastructure	0%	0%	10%	0%	6%	0%	17%	0%	0%	3%	0%	0%	11%	4%	0%	3.4%
Maintenance	25%	10%	40%	67%	0%	25%	17%	29%	33%	3%	46%	60%	44%	30%	0%	28.6%
Mission Risk	25%	10%	10%	11%	6%	0%	0%	14%	17%	0%	8%	40%	11%	7%	50%	13.9%
Part/System Failure	21%	10%	40%	44%	25%	25%	8%	29%	50%	8%	23%	60%	33%	19%	75%	31.3%
Pilot Judgment/Actions	64%	70%	70%	56%	94%	100%	92%	71%	100%	89%	77%	60%	89%	78%	25%	75.7%
Pilot Situational Awareness	43%	30%	10%	0%	31%	25%	67%	29%	33%	14%	23%	0%	22%	22%	0%	23.3%
Post Crash Survivability	14%	20%	30%	0%	13%	25%	25%	29%	0%	3%	15%	0%	44%	4%	0%	14.8%
Regulatory	4%	0%	30%	0%	0%	0%	8%	14%	50%	3%	8%	40%	33%	4%	0%	12.9%
Safety Culture	29%	20%	70%	22%	56%	75%	58%	71%	67%	59%	54%	20%	33%	41%	0%	45.0%
Systems & Equipment	18%	0%	10%	0%	6%	0%	0%	14%	17%	5%	0%	0%	0%	7%	0%	5.1%
Number of Accidents	28	10	10	9	16	4	12	8	5	37	13	5	9	27	4	

Dark Yellow = bottom third **Orange = middle third** **Red = top third**

The most prevalent intervention across accidents and SPS categories calls for the implementation, training, and enforcement of risk assessment and management programs (cited 181 times or 15% of the total interventions). Risk management was spread across SPS categories and was not confined to one specifically. The second intervention, installation of cockpit, data and / or video recording devices (cited 120 times, 10%) primarily targeted the Data Issues SPS category. Following recording devices, simulator training was mentioned as an intervention or part of an intervention 110 times (9% of interventions) across all SPS categories. The development, implementation, and enforcement of standard operating procedures (SOP) were mentioned in 95 interventions (8%). Related to SOPs were the development, implementation and use of safety management systems, particularly for risk assessment and management (cited 17 times, 1%). Finally, interventions involving quality assurance and maintenance appeared 59 times (5%).

6.2.1 Pilot Judgment and Action

Pilot Judgment and Action Problems: These were cited at least once in 154 (or 78%) of the helicopter accidents in 2000. This category included procedure implementation (in 38% of the accidents), pilot decisions (in 33%), landing procedure (in 30%), flight profile (in 26%), pilot / aircraft interface (in 13%) and CRM (in 10%). Since these types of problems were found in more than 75% of the accidents investigated, it is not surprising that they were found in every phase of flight, in VMC as well as IMC, in all lighting conditions and for high- as well as low-time pilots. Pilot Judgment and Action Problems were distributed across phases of flight as follows: maneuvering (21%), 17% landing (17%), Cruise (12%) and Hover (10%). The remaining phases of flight accounted for less than 10% each.

Pilot Judgment / Action-related Problems occurred in most types of missions, generally following frequency of occurrence of that type of mission in the 197 accidents analyzed. The notable Pilot / Judgment and Action results included: the percent of Pilot Judgment and Actions problems relative to the total number of problems identified for each type of mission was lowest for Logging accidents (cited in only 60% of the logging accidents). On the other hand, Pilot Judgment and Action Problems were found in all of the Logging and Firefighting accidents and most of the Commercial, EMS, Training and Offshore accidents. Finally, Pilot Judgment and Action problems comprised nearly half of the total number of problems found for Aerial Observation, Instruction / Training and Commercial Operator missions, suggesting at least one factor that these segments of the helicopter community might address to reduce their accident rates. For the remaining types of missions, Pilot Judgment and Actions accounted for approximately 25% of the total number of problems that the team identified.

Interventions for Pilot Judgment and Actions: There were 397 interventions suggested for Pilot Judgment and Actions problems. Of those, 92 (23%) recommended some sort of simulator training as part of a mitigation strategy. The two most frequent simulator interventions targeted problems with Autorotation (24 interventions or 6%) and Loss of Tail Rotor Effectiveness (LTE) (20 interventions or 5%). Model-specific simulator training was recommended 11 times (3%). The autorotation interventions targeted recovery from practice autorotations where the pilot misjudged aircraft parameters or did not initiate recovery in time. Table 6-10 lists the top interventions targeting Pilot Judgment and Action Problems.

Table 6-10. Top Interventions for Pilot Judgment and Action Problems (Cited 397 Times)

Intervention	Total	Percent of Pilot Judgment / Actions Category
Autorotation training aids, simulators, etc	24	6%
Ground and flight / simulator training for recognition and recovery from LTE and / or common aerodynamic conditions	20	5%
Risk assessment training	13	3%
Personal risk management training program	13	3%
Model-specific power energy / management simulator training	11	3%

6.2.1.1 Tools for Avoiding the Most Frequently Occurring Accidents

After more than a year of accident analysis, a quick review of the FAA's *Rotorcraft Flying Handbook* (RFH) – [Ref. 9 in Appendix I] – demonstrates that many of the keys to helicopter accident prevention are not only already known but also are readily accessible in one reference for those who would like to put into context accident data and practical helicopter operational guidance. For example, the RFH, after discussing rotorcraft theory, advances the discussion to inappropriate decision-making that impacts safety, operational tips, safety considerations, and common errors previously seen in the same flight phases and operational scenarios that the JHSAT saw in the accident data.

The CY2000 U.S. helicopter accident data illustrate disproportionate numbers of accidents involving dynamic rollover (12 accidents), loss of control or collision with objects while hovering (41), loss of tail rotor effectiveness (LTE) in maneuvering flight (14), loss of rotor rpm (28) and problems in safely completing autorotative landings (34) both in practice and secondary to emergency scenarios. Underlying many of these accidents was flawed preflight preparation and decision-making that contributed to an undesirable outcome that could have been avoided in most cases. Guidance addressing all of these topics is in the RFH. Clearly, the content of the RFH is equally useful to students and experienced helicopter pilots alike. Some of the most important keys to avoiding such accidents are risk assessment during preflight preparation, effective crew communications and coordination, and appropriate in-flight decision-making. Recognizing that each of these topics merits more discussion than can be provided here, it still may be important to address them while reviewing future accident data sets. Many of the tools to do so are already in place if the industry will use them.

6.2.1.2 Aeronautical Decision-Making

From Chapter 14 of the RFH: "Aeronautical decision making (ADM) is a systematic approach to the mental process used by pilots to consistently determine the best course of action in response to a given set of circumstances. The importance of learning effective ADM skills cannot be overemphasized. While progress is continually being made in the advancement of pilot training methods, aircraft equipment and systems, and services for pilots, accidents still occur. Despite all the changes in technology to improve flight safety, one factor remains the same—the human factor."

In an accident scenario described in the RFH, the pilot made a series of improper decisions, each one reducing the options that remained until the likelihood of an accident was greatly increased. Better planning and decision-making would have reduced that risk of the accident that resulted. "Making sound decisions is the key to preventing accidents. Traditional pilot training has emphasized flying skills, knowledge of the aircraft, and familiarity with regulations. ADM training focuses on the decision-making process and the factors that affect a pilot's ability to make effective choices."

"An understanding of the decision-making process provides a foundation for developing ADM skills. Traditionally, pilots have been well trained to react to emergencies, but are not as well prepared to make decisions that require a more reflective response. Yet during a flight, there are opportunities to examine changes that occur, gather information, and assess risk before reaching a decision. The steps leading to this conclusion constitute the decision-making process. Although a decision may be reached and a course of action implemented, the decision-making process is not complete. It is important to think ahead and determine how the decision could affect other phases of the flight. As the flight progresses, one must continue to evaluate the outcome of the decision to ensure that it is producing the desired result" – safely accomplishing the mission while reducing the risk of an accident.

A pilot's ability to appropriately apply ADM, starting with the launch / no-go decision, is related to the pilot's knowledge and willingness to assess and manage risk. In doing so, the pilot must continually consider and assess risks and make risk-based decisions regarding his own ability, the aircraft, the environment, and the operation. The self-assessment aspect relates to the pilot's training, experience, proficiency, familiarity with the mission, level of alertness, and physical and emotional state. Aircraft-related risk factors relate to its airworthiness, performance, fuel state, and how well it is equipped for the mission and environmental conditions. Environmental considerations are en route and destination weather, availability of needed weather data, availability of air traffic services, and terrain and obstruction issues. The operational factors put the pilot and aircraft to the test by introducing schedule, economic considerations, and other potential pressures on the pilot and company management. To apply ADM effectively, the pilot should be continually assessing the risks influencing anticipated operational decisions and using the resources available to him to reduce unnecessary stress and risks. Being well trained in the aircraft and mission and using equipment that would reduce pilot workload would reduce some of the stress and risk potentially associated with mission flight operations and allow better in flight decision-making. Control of fatigue, stress, and work overload allows the pilot to remain focused, to avoid distraction, and to maintain a high degree of situational awareness – all of which are potential contributing factors in accidents.

6.2.1.3 Helicopter Performance-Related Accidents

Although more than 65% of accidents are considered by previous studies to be the result of pilot error or inadequate human performance, a review of the CY2000 helicopter accident dataset revealed a higher percentage of accidents with problems involving flight crew performance and a higher percentage of accidents were considered preventable by putting in place mitigation strategies that would improve flight crew performance. Helicopter performance-related accidents such as takeoff and hover performance, autorotational performance, loss of rotor rpm, and loss of tail rotor effectiveness all could be prevented by improved pilot training, improved preflight planning, greater standardization and company operational oversight of crew performance and improved flight crew proficiency. All of the helicopter performance related accidents have in common demanding more power and performance than is available from the helicopter under the environmental circumstances of the accident. Thus, “any factor that affects engine and rotor efficiency affects performance” (RFH, Chapter 8). A reduction in rotor rpm, a reduction in airflow through the rotor system, severe environmental conditions and increased weight all affect helicopter performance negatively and could be factors in helicopter accidents.

6.2.1.4 Hovering Performance

Hovering Performance is affected most directly by density altitude, weight and wind. Density altitude is important because engine power, rotor efficiency and aerodynamic lift all decrease at higher density altitude. Unfortunately, higher temperatures and higher altitudes increase density altitude, thus decreasing rotorcraft performance and sometimes resulting in accidents when pilots do not adequately plan for higher density altitudes and expect higher rotor performance than the helicopter can deliver. Higher weight requires higher lift, thus reduction of weight of the helicopter would increase takeoff and hover performance. Wind across the rotor system contributes translational lift and a headwind provides more lift than a tailwind, in part because more anti-torque (a perpendicular lift vector generated by the tail rotor) is required when hovering with a tailwind component. A hover check is typically performed immediately after liftoff to determine whether the power delivered to the rotor system by the engine is producing enough lift to safely complete the takeoff and climb. Hovering out of ground effect, which is required in some mission profiles, requires higher power. Care should be taken not to inadvertently enter into hover out of ground effect situations where sufficient power is not available. Accidents that occur in the hovering phase of flight usually could have been avoided (if there was no engine power loss) if the pilot anticipated through preflight planning the hover limitations of the helicopter and planned the takeoff and departure accordingly. Inadequate planning can result in reduction of main rotor rpm and lift generated by the rotor system, leading to an unintended hard landing if the pilot attempts to demand more helicopter performance than is available during the takeoff or hover by increasing collective. Hover accidents can also be the result of inattention to small changes in attitude or altitude, followed by excessive or improper cyclic or anti-torque control inputs by the pilot.

6.2.1.5 Loss of Rotor RPM

Loss of Rotor RPM (excerpts below are from Chapter 11 of the *Rotorcraft Flying Handbook*) accidents are usually the result of inattention or improper operation of the flight controls secondary to conditions of high weight, temperature or density altitude. Such accidents may also be a consequence of a combination of powerplant or system malfunctions that necessitate an emergency landing and the need to trade rotor rpm for altitude or airspeed to avoid obstructions such as wires, poles, trees or terrain that could result in rotor system damage and total loss of control. Low main rotor rpm situations must be avoided because they can cause loss of lift needed to sustain flight as well as loss of directional control (because the anti-torque system speed is proportionate to main rotor speed), the combination of which can result in total loss of control of the helicopter.

In some cases, the physical evidence at the accident site will demonstrate the existence of a low rpm / coning condition, but in the absence of data recorders this condition may only be surmised from an overall examination of the accident circumstances. Thus, even though it is clear that too many accidents are the result of low rpm, the number of "low rpm" accidents in a dataset cannot be determined precisely. Low rotor rpm conditions can usually be avoided by alertly monitoring powerplant and rotor rpm cockpit indicators and by immediately adding "throttle, if available, while slightly lowering the collective. This reduces main rotor pitch and drag. As the helicopter begins to settle, smoothly raise the collective to stop the descent. At hovering altitude [it may be necessary] to repeat this technique several times to regain normal operating rotor rpm. This technique is sometimes called 'milking the collective.' When operating at altitude, the collective may have to be lowered only once to regain rotor speed. The amount the collective can be lowered depends on altitude. When hovering near the surface, make sure the helicopter does not contact the ground as the collective is lowered" unless landing is the desired outcome. "If [directional] control is lost and the altitude is low enough that a landing can be accomplished before the turning rate increases dangerously, slowly decrease collective pitch, maintain a level attitude with cyclic control, and land." Most of the above guidance is from the RFH; the reader should refer to the RFH or other training materials for further information about avoidance of low rotor rpm conditions.

6.2.1.6 LTE

Regarding Unanticipated Yaw / Loss of Tailrotor Effectiveness (LTE), the RFH (Chapter 11) states: "Unanticipated yaw is the occurrence of an uncommanded yaw rate that does not subside of its own accord and which, if not corrected, can result in the loss of helicopter control. This uncommanded yaw rate occurs to the right in helicopters with a counterclockwise rotating main rotor and to the left in helicopters with clockwise main rotor rotation. LTE is not related to an equipment or maintenance malfunction and may occur in all single-rotor helicopters at slow airspeeds near translational lift or less. It is the result of more anti-torque being demanded than the tail rotor can provide to maintain directional control. The high power demand of flight at speeds less than translational lift are present in all LTE accidents. Sudden initiators of uncommanded yaw are usually caused by certain wind azimuths (directions) that cause the need for additional tail rotor thrust beyond what is available. Although LTE events are avoidable, the accident data suggests that it is not adequately understood and frequently catches the unwary in accident scenarios.

The RFH and FAA Advisory Circular 90-95 on the same subject [Ref. 8 in Appendix I], and Original Equipment Manufacturer (OEM) guidance attempt to explain and provide useful tools for avoidance of LTE scenarios that can trigger loss of directional control accidents. This section of the JHSAT report is intended only to provide an overview of the problem and possible solutions that would reduce the risk of LTE events; the reader is encouraged to seek out more detailed source material to gain a fuller grasp of the subject. High gross weight and high density altitude conditions require more engine power thereby increasing the likelihood of conditions needed for LTE.

Regardless of the cause of the LTE, its effect is to produce a rapid loss of tail rotor thrust that, "if uncorrected, develops into an uncontrollable rapid rotation about the mast." The pilot must "be prepared to react quickly to counter this reduction with additional pedal…. When hovering at higher altitudes and high gross weights the tail rotor thrust may not be sufficient to maintain directional control." Thus, the hovering ceiling is limited by gross weight, density altitude, and limits of tail rotor thrust. The accident data show that pilots should be made more knowledgeable of the contributors to and signs of impending LTE, how to avoid it, and how to make an early recovery from LTE encounters. The onset of LTE can be reduced by maintaining maximum rotor rpm, avoiding operation in tailwinds, avoiding unnecessary out of ground effect operations at low airspeeds, being alert to airspeed inadvertently dropping below translational lift when flying in winds of about 8-12 knots, remaining alert to conditions requiring large pedal input, and being alert to changing wind conditions when flying along ridge lines.

The RFH suggests the following technique to recover from sudden unanticipated right yaw (counter-clockwise rotor systems): "Apply full left pedal while simultaneously moving cyclic control forward to increase speed. If altitude permits, reduce power. As recovery is affected, adjust controls for normal forward flight. Collective pitch reduction aids in arresting the yaw rate but may cause an excessive rate of descent. Any large, rapid increase in collective to prevent ground or obstacle contact may further increase the yaw rate and decrease rotor rpm. The decision to reduce collective must be based on an assessment of the altitude available for recovery. If the rotation cannot be stopped and ground contact is imminent, an autorotation may be the best course of action. Maintain full left pedal until the rotation stops, then adjust to maintain heading."

6.2.1.7 Autorotation

Autorotation theory and technique, although fundamental to helicopter pilots and practiced extensively in helicopter primary flight training, and to a lesser extent in other missions, apparently requires more highly focused training to avoid the high numbers of accidents that occur in the conduct of such maneuvers. Having said that, it is also appropriate to note that some of the "autorotation accidents" seen in the accident data occurred on flights operated unnecessarily at low altitudes above obstructions or unsuitable terrain (a preflight planning and operational risk acceptance problem) and others occurred secondary to power loss or system malfunction when mission requirements dictated flight at low altitude or in close proximity to high obstructions (mission risk). Notwithstanding those issues, this section will review some of the factors that should be considered when conducting practice autorotations or when they are necessitated by other circumstances. Most of the theory here is excerpted from the RFH (Chapter 11); readers are encouraged to consider other sources as well to maximize the effectiveness of their related SOPs and autorotation training programs.

It is important to note that an autorotation is not necessarily an emergency descent, but it is "a descending maneuver where the engine is disengaged from the main rotor system and the rotor blades are driven solely by the upward flow of air through the rotor." An autorotation may be used as a means of conducting a rapid descent with engine power available but not driving the rotor system, but it is most commonly used as a means of affecting a simulated or actual emergency descent following loss of engine power or loss of critical systems or to recover from settling with power. In an autorotation, "the freewheeling unit automatically disengages the engine from the main rotor allowing the main rotor to rotate freely. Essentially, the freewheeling unit disengages anytime the engine rpm is less than the rotor rpm….By immediately lowering collective pitch [after an in-flight emergency] lift and drag are reduced, and the helicopter begins an immediate descent, thus producing an upward flow of air through the rotor system. This upward flow of air provides sufficient thrust to maintain rotor rpm throughout the descent. Since the tail rotor is driven by the main rotor transmission during autorotation, heading control is maintained as in normal flight."

The pilot controls rate and angle of descent by using the cyclic to maintain a desired airspeed and rotor rpm is controlled in the descent by adjustment of the position of the collective. "When landing from an autorotation, the energy stored in the rotating blades is used to [stop] the rate of descent and make a soft landing [by flaring with the cyclic and increasing collective position to use rotor energy to stop the rate of descent and cushion the landing]. A greater amount of rotor energy is required to stop a helicopter with a high rate of descent than is required to stop a helicopter that is descending more slowly. Therefore, autorotations at very low or very high airspeeds are more critical than those performed at the minimum rate of descent airspeed…. When the helicopter is operated with heavy loads in high density altitude or gusty wind conditions, best performance is achieved from a slightly increased airspeed in the descent. For autorotations at low density altitude and light loading, best performance is achieved from a slight decrease in normal airspeed." Anti-torque pedals are used to prevent yawing and the cyclic is used to make turns and to flare / recover at the bottom of the autorotative descent. Collective pitch is used to manage rotor rpm in the descent, and it is important that rotor rpm is maintained within the green arc on practice autorotations. "The speed at touchdown and the resulting ground run depend on the rate and amount of flare. The greater the degree of flare and the longer it is held, the slower the touchdown speed and the shorter the ground run. The slower the speed desired at touchdown, the more accurate the timing and speed of the flare must be, especially in helicopters with low inertia rotor systems."

Autorotation accidents, other than those where there was simply no suitable place to land, are typically the result of initiation of the autorotation from a low altitude where few options for landing existed, failure to maintain appropriate rotor rpm and airspeed in the autorotation, and improper flare / recovery technique. In some instances, the JHSAT found that CFIs conducted high numbers of practice autorotations on training flights, with poor student performance, or the CFI was late to intervene when a student used improper technique. In most of these scenarios, the JHSAT concluded that better autorotation training – in simulators if they were available – would have prevented the accidents.

6.2.1.8 Dynamic Rollover

Dynamic Rollover is the result of the susceptibility of a helicopter to a lateral rolling tendency when the helicopter pivots about a skid or landing gear wheel until it reaches its critical rollover angle. Beyond this point, recovery is impossible, according to the RFH. Dynamic rollover occurs on level surfaces in both lateral directions, as well as on sloped surfaces. Dynamic rollover frequently is precipitated by a takeoff attempt or a landing when a skid or landing gear wheel becomes secured by a tie down or when its lateral movement is impeded by terrain or an obstruction such that the helicopter begins to pivot around the impeded skid or wheel. This rolling movement with the wheel or skid impeded causes the main rotor thrust vector and its moment to continue moving laterally, despite up to full opposite cyclic control input. As the roll rate increases, the critical rollover angle at which recovery is still possible is reduced.

Rollover occurs rapidly with improper (or the absence of correct) recovery technique. The most effective means of preventing dynamic rollover once the main rotor thrust vector begins movement toward the critical rollover angle is to smoothly lower the collective. Aircraft weight is far more effective in recovery than attempts to use cyclic controls. Heavy gross weight, a lateral center of gravity, crosswinds, and yaw inputs can increase the likelihood of dynamic rollover. Care should be taken on takeoffs to maintain proper cyclic position and trim, and to fly the helicopter into the air smoothly while keeping movements of pitch, roll and yaw small to reduce the likelihood of experiencing dynamic rollover. The CY2000 helicopter accident data demonstrate that dynamic rollover is a continuing and misunderstood problem. Greater familiarity with the guidance provided in the RFH and effective training for its prevention in primary helicopter training and periodically thereafter is critical to avoiding all too frequently occurring dynamic rollover accidents.

6.2.2 Data Issues

Data Issue Problems: These were found at least once in 123 (62%) of the accidents. The analysis team identified two primary types of Data Issues: inadequate information available to the investigators (in 45% of the accidents) and inadequate information in the investigation report (30% of the accidents). And, in five cases, it was felt that the investigation itself was inadequate. In many cases, it was impossible for the analysis team to discriminate between cases in which the information had never been available to the investigator from those in which it had been available but was not included in the narrative report. Since this category of problems is not directly related to the accident itself, it is not surprising that these are fairly evenly distributed across missions and follow the same pattern as the accident frequency by mission type. Data Issues were identified most often for accidents that occurred during Maneuvering (16%) or Landing (16%), but that is not surprising as they were the phases of flight in which most of the accidents occurred in 2000. The percent of "data issue" problems relative to the total number of problems found for each type of mission ranged from 3% (Electronic News Gathering) to 21% (Instruction / Training).

Data Issues Interventions: Interventions targeting Data Issues were the second most frequent. They primarily targeted the lack of information the team found in accident investigation reports. There are two data issues: (1) not having enough information to understand what occurred in the cockpit during the accident sequence, and (2) for the non-accident flights, the owner (chief pilot, etc.) not knowing how the helicopter is being flown – within flight manual limits, within company operations manuals, etc. The first issue is related to identification of the accident causes so specific design or procedures can be developed and fielded. The second issue relates to the owner's ability to monitor his pilots and aircraft, and make corrections before situations get to an accident situation. This second issue is an integral part of a company's SMS to monitor performance and adherence to company procedures.

The first two interventions ("Install cockpit recording devices" and "Install recording devices") provide both post-accident information and preventive safety management tools. One low-cost recording device that is currently being evaluated by a major U.S. operator has the potential to serve as a source of routine flight path operations data, which can be used to improve the focus and effectiveness of flight training and to standardize flight operations. Low-cost recording devices with additional features are being evaluated to provide similar capability of Flight Operations Quality Assurance quick access recorders used in air carrier operations.

Thus, these interventions, while addressing the dearth on information found in some accident reports, will also provide an opportunity to reduce accidents by improving company oversight and pilot performance. These first two interventions cited target actions and interactions between the pilot(s) and the aircraft, and devices that monitor and record aircraft systems parameters. Synchronized recorded information is expected such that pilot cues and actions are correlated with aircraft systems indications and responses. Until it is known and documented what actually occurred in the cockpit during an accident sequence, effective corrections related to design and procedures cannot occur. The IHST has already discussed methodology with the U.S. National Transportation Safety Board that might reduce the investigation shortcomings noted by the analysis team. Table 6-11 shows the top interventions targeting Data Issues Problems.

Table 6-11. Top Interventions for Data Issues Problems (Cited 154 Times)

Intervention	Total	Percent of Data Issues Category
Install cockpit recording devices	88	57%
Install data recording devices	23	15%
More comprehensive accident reporting / investigation / documentation	19	12%
Investigating authority to provide requirements and procedures to gather sufficient data to determine root cause of accident	7	5%
NTSB emphasis on obtaining root causes – Mx procedures	2	1%
Congress to provide adequate field accident investigation resources	2	1%

6.2.3 Safety Management

Safety Management Problems: These were found at least once in 91 (46%) of the accidents. This category of problems was one of the broadest categories and it included, in a broad sense, the operators' apparent attitudes toward assessing risk and managing safety as part of its business ethic. Grouped in this broad category are setting and providing oversight of operational standards, providing appropriate operational training, and safety management. The appropriateness and adequacy of training provided for the pilots and passengers were found deficient most often in this category (in 32% of the accidents), the way an operation was managed (in 18%), the company's safety program (in 11%), scheduling / dispatch (in 3%) and the type of safety equipment provided (in 1%). This group of problems focused on the tangible and intangible factors that ensure a safe operation or, when missing, create an environment in which an accident might be more likely. Perhaps because of the variety of helicopter operational missions and the greater risk of accidents occurring during operational missions that include low altitude maneuvering, Safety Management problems showed up most often in accidents that occurred in the maneuvering flight phase (14% of the accidents). Landing was the next most frequent flight phase that illustrated safety management deficiencies, followed by Cruise. Safety Management problems did not simply follow the same pattern as frequency of occurrence by primary mission: Safety Management problems were cited in less than half of the Aerial Application, Business, Offshore and Personal / Private accidents, in few of the Aerial Observation / Patrol, and none of the Utilities Patrol / Construction accidents. In some cases involving one-ship fleets, safety management was not cited because it wasn't expected to be present as a structured program. Some larger operators, with highly structured safety and operational management structures, were not cited because the safety attitudes and operational management of the company was not at issue in the accident. By contrast, it was noted that more than 70% of the Air Tour, ENG, and External Load accidents illustrated at least one Safety Management problem.

Safety Management Interventions: There were 171 interventions targeting Safety Management. Table 6-12 shows the top 5 of those interventions. Thirty-three of the interventions (19%) call for the development, implementation or enforcement of standards and SOPs. The SOP interventions range from industry standards ("…data collection and sharing of pilot history for hiring / screening") to specific operational control procedures ("…SOP for maintaining remote LZ and communicate with ground personnel."). Interventions calling for implementation of Risk Management as whole or part of Safety Management mitigations account for 25% (cited

44 times). Nine of the Risk Management interventions call for the use of a formal Safety Management System as a means to manage risk. The remainder span systemic to personal Risk Management Programs.

Table 6-12. Top Interventions for Safety Management Problems (Cited 171 Times)

Intervention	Total	Percent of Safety Management Category
Ensure SOPs address proper planning prior to instructional flights	8	5%
Develop industry standards for data collection and sharing of pilot history for hiring / screening	8	5%
SMS formalized risk management process and oversight	7	4%
Increased operational oversight for remote ops	6	4%
Personal risk management training program	6	4%

In 2006, the FAA issued Advisory Circular (AC) 120-92 [Ref. 7 in Appendix I], providing Safety Management Systems (SMS) guidance, rather than mandating safety programs for most operators. The guidance contained in this AC could be applied to improve the safety culture and to manage risk in any size operation. It would be wise for individual operators and company officers of larger operators to become familiar with its guidance. The AC can be used by any operator to transition from a "reactive" safety program – preventing the last accident – to a "proactive" program: i.e., committing to continuous safety improvement, a positive company-wide safety culture, programs that assess and reduce operational risk, non-punitive safety event reporting and safety education to continually reduce the risk of accidents. As the Transportation Safety Board of Canada advised as early as 2002, "A safety management system is a businesslike approach to safety. It is a systematic, explicit, and comprehensive process for managing safety risks." [Ref. 3 in Appendix I]

For a safety management system to be effective, it must be supported by a positive safety culture that is exemplified by the leadership of the chief executive and the management team, and have the full acceptance and participation of the non-management employees. In that culture, safety is part of the business plan, and safety concerns are not ignored. Safety is not what the company does when it is convenient, it is an attitude and awareness that permeates the operation. A healthy safety culture results in more proactive group behavior and non-tolerance of unwarranted operational risk. A top-down safety culture permeates the company's operational thinking, resulting in proactive corporate behavior and continuous reduction of accident risk. Safety there is a continuous process and the result of a team commitment and dedication. [See Ref. 4 in Appendix I]

AC 120-92 makes a compelling argument that safety management is most effective when integrated into normal business management practices and the way in which people approach their jobs. It includes the structured management of risk and integrates safety into program decision-making. Since most accidents involve human error and are the end result of a chain of events that can be interrupted by a systematic approach, SMS if properly adopted will significantly reduce the accident rate.

The FAA expects senior management to be responsible for safety management. "Management must plan, organize, direct, and control employees' activities, and allocate resources to make safety controls effective." Thus, the AC emphasizes the importance of a safety culture (the sum of the values, beliefs, goals, performance measures and the sense of responsibility for safety by individual employees). These attributes influence the way people think and behave on the job and are heavily influenced by the safety commitment communicated by management.

Safety Management programs can utilize manufacturer or industry advisories, audit reports, employee event or mishap reports, incident findings and digital data to identify hazards, the frequency and potential consequences of events and the probability of repeat occurrences. After using a risk matrix to determine the highest risks and priorities for safety management, the SMS provides insight into how a similar risk matrix can be used to evaluate the potential impact of risk mitigation strategies in preflight planning. Risk is described in terms of mishap likelihood and the potential severity of mishap consequences (see Figure 6-9 below). Such an approach routinely considers the experience and abilities of the flight crew, the capability and limitations of the aircraft, environmental considerations, and the relative difficulty of the mission. [See Ref. 5 in Appendix I]

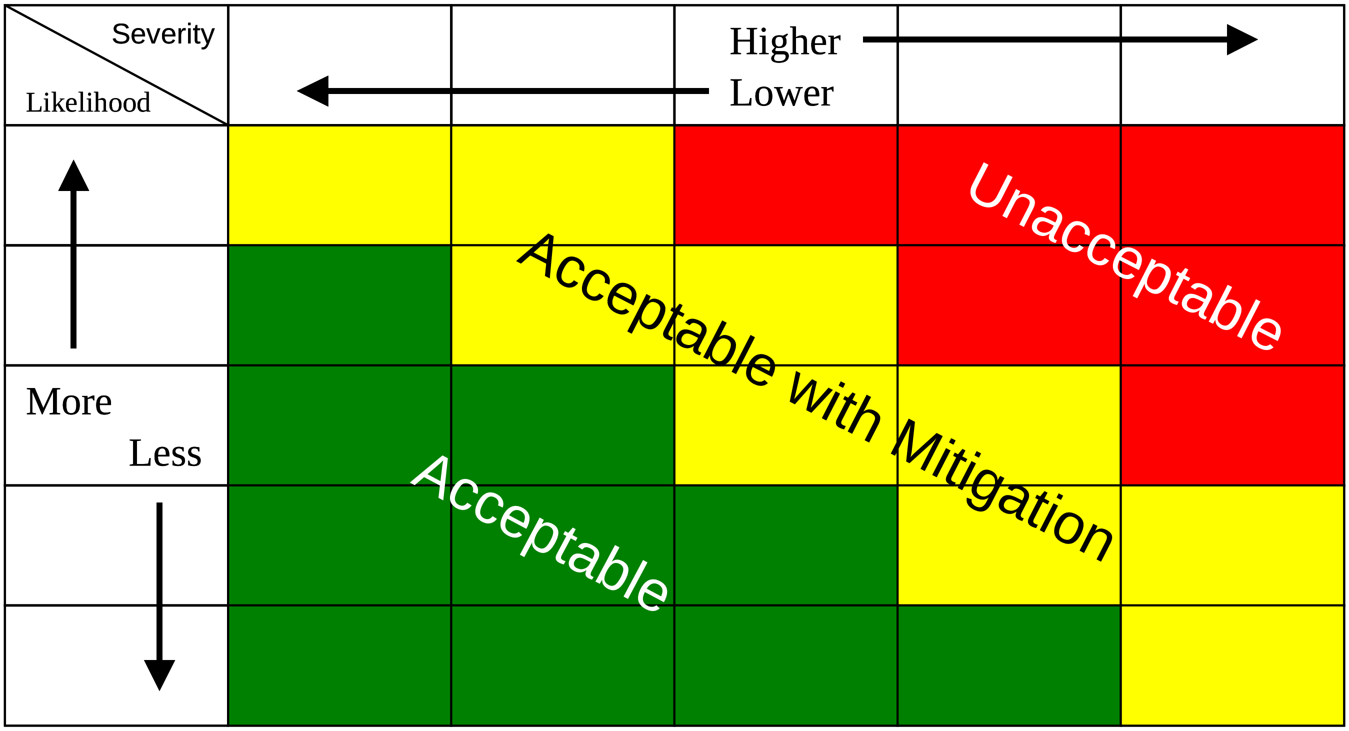


Figure 6-9. Safety Risk Matrix

The helicopter community needs to set a higher standard and manage risk through greater safety awareness, a proactive safety culture, non-punitive safety reporting, more effective data-collection and trending, processes that manage and reduce risk, audit programs that identify problems and verify the effectiveness of risk control measures, safety communications that reach every employee, and feedback loops to ensure all risks are identified and managed or eliminated. In short, operators should look forward to the introduction of safety management systems in all operations.

6.2.4 Ground Duties

Ground Duty Problems: Different types of Ground Duty-related Problems were identified at least once in 76 (39%) of the accidents. This type of problem referred to tasks pilots should perform before takeoff that could influence the safety of the flight itself or, in a few cases, duties pilots are expected to perform after a flight. At least one example of this category of problems was cited in 76 (or 39%) of the accidents. Mission planning was the largest sub-category of Ground Duty Problems. It was identified in 28% of the accidents. Aircraft Preflight also occurred relatively often (in 12% of the accidents), while Preflight Briefings and Post-flight Duties were cited in only 1% of the accidents each. Even though this category of problems focuses upon deficiencies during the pre- and post-flight phases of flight, the actual accident itself occurred most often during Maneuvering (12%), Cruise (8%) or Takeoff (6%). It is worth noting that this is the only problem category in which the landing phase of flight was not represented at all.

Ground Duty issues were identified in 50% of the Aerial Application, Aerial Observation, Air Tour, ENG, Law Enforcement and Personal / Private accidents. On the other hand, it was cited in less than a third of EMS, Firefighting, Instructional, Offshore and Utilities accidents. Either these types of missions are conducted so as to ensure that pilots perform their ground-based duties adequately or the nature of the mission does not depend on these duties as much as do other mission types.

Ground Duties Interventions: Table 6-13 provides the top interventions suggested to mitigate ground duty problems. When analyzed for patterns and aggregated, however, the majority of the intervention statements call for SOPs (cited 29 times), followed by implementing correct preflight procedures, and risk assessment and management (cited 23 and 19 times respectively). These concepts are distributed throughout the ground duties intervention set.

Table 6-13. Top Interventions for Ground Duty Problems (Cited 105 Times)

Intervention	Total	Percent of Ground Duties Category
Training in proper preflight procedures	13	12%
Training on proper fuel calculations and preflight procedures	5	5%
Improved power / performance margin planning for specific mission	5	5%
Preflight operational risk assessment program	4	4%
Emphasize training for carb ice and other performance limiters in RFM	4	4%

6.2.5 Pilot Situation Awareness

Pilot Situation Awareness Problems: These were cited in 50 (or 25%) of the accidents. It included problems associated with inadequate pilot knowledge about the external environment (in 17% of the accidents), and the visibility or weather conditions (in 8% of the accidents). The other two sub-categories were related to pilot impairment (in 2%) and awareness of internal aircraft state (also in 2%). Pilot Situation Awareness (SA) Problems occurred most often in accidents that took place during Maneuvering (8%) or Cruise (6%). Pilot Situation Awareness Problems were cited in only 2% of the Landing accidents.

This category of problems was found most often in Aerial Application (43%) and EMS (67%) accidents, and in a third or less of the accidents involving other types of missions. Of all of the problems identified in Aerial Application and EMS accidents, 14% and 11% of the problems, respectively, involved Pilot Situation Awareness. On the other hand, for Aerial Observation / Patrol and Law Enforcement, only 9% and 8%, respectively, of the total number of problems identified involved Pilot Situation Awareness. Perhaps this type of problem occurred relatively often in Aerial Application and EMS because the pilots are required to operate close to the ground above unfamiliar and unprepared locations when involved in Aerial Application activities or landing at a remote landing zone (LZ). On the other hand, no Pilot Situation Awareness problems were identified for Logging and Utilities Patrol / Construction, missions that also require operations close to the ground and from remote sites.

Pilot Situation Awareness Interventions: The intervention statements intended to increase pilot situation awareness predominantly targeted human interventions (e.g., training on topics other than risk management and risk assessment / management training were cited 20 and 16 times, respectively). Technology interventions were cited 17 times and primarily involved implementation of Enhanced / Synthetic Vision Systems (EVS / SVS) and/or Night Vision Goggles (NVG), and proximity detection (i.e., helicopter terrain awareness and warning systems (HTAWS) and other proximity sensors) systems. The remainder of the interventions ranged from SOPs to hazard awareness best practices. Table 6-14 shows the top interventions to help pilot situation awareness.

Table 6-14. Top Interventions for Pilot Situation Awareness Problems (Cited 86 Times)

Intervention	Total	Percent of Pilot SA Category
Personal risk management training program	5	6%
Install EVS / SVS	5	6%
Establish VFR into IMC recovery training / proficiency requirement	4	5%
Install EVS and / or NVG	4	5%
Install proximity detection system	4	5%
Mission specific risk assessment training - Ag Ops	4	5%
Ground and flight / sim training for recognition and recovery from LTE and / or common aerodynamic conditions	4	5%

6.2.6 Part / System

Part and System-Related Problems: Problems that involved failures or other issues with helicopter parts or systems were identified in 51 (26%) of the all accidents. Aircraft parts, systems and auxiliary equipment failures accounted for 33 (65%) and engine component or system failures were involved in 18 (35%) of the part / system failures. The primary area identified as leading to the part or system failures is maintenance problems, which were involved in 44 (86%) of the part / system related accidents. The remaining 7 (14%) of the accidents were part failures (3 OEM and 4 aftermarket) related to part quality and having no connection to maintenance problems. In 14 (27%) of the accidents it was determined that the condition of impending failure could have been detected by a thorough preflight by the crew. Non-compliance to the Aircraft Flight Manual (AFM) / Emergency Procedures was a direct contributor to 4 (8%) of these accidents. Also contributing to these accidents was the ability of the crew to handle the emergency presented by the part or system failure. In many cases, the crew did a reasonable job, considering the risk aspects of their particular flight circumstances. 13 (25%) of these accident flights involved inherent mission risk, such as Aerial Application or long line (External Load) operations at the time of failure.

Part and System Failures were from numerous parts and maintenance or operational causes. No two failures were on the same combined part, aircraft and root cause. Some however were from common causes such as fuel system contamination due to improper fuel cell sealant / installation. A listing of the system failure areas involved in this data set is presented below:

Table 6-15. System Failure Areas

Aircraft (33)	Engine (18)
12 – Tailrotor system	3 – Turbine overtemp
3 – Flight Control system	2 – Lube system contamination
2 – Hydraulic	1 – Fuel fitting non conform
2 – Rotor mast	1 – Fuel control pneumatic line
2 – Fuel system contamination	1 – Gear configuration non conform
2 – Fuel fittings	1 – Bearing retainer not installed
2 – Long line release	1 – Turbine disc mil surplus no record
1 – Skid	1 – FADEC failure
1 – Clutch cable	1 – Turbine FOD foreign material
1 – Sprag clutch	1 – PMA part design error
1 – Oil cooler fan	1 – Valve failure (recip.)
1 – Tailboom structure	1 – Cylinder retention (recip.)
1 – Transmission mount	1 – Oil jet loss (recip.)
1 – Transmission lubrication	1 – Magneto (recip.)
1 – Oil line	1 – Unknown

Part / System Failure Interventions: For accidents in which a part or system failed, the predominant interventions were associated with maintenance activity and are described in the next section. A second related tier was development, installation and use of Health and Usage Monitoring Systems (HUMS) on aircraft to monitor the status of the aircraft systems and their level of use, or equivalent Engine Monitor Systems (EMS). The JHSAT has identified 24 (47%) of the part / system failure accidents that may have potential for mitigation by monitoring systems. The third category, Production Approval Holder (PAH) Corrective Action, is one that describes mitigations and interventions that are already in the system (cited 11 times in 5 of the accidents).

6.2.7 Maintenance

Maintenance-Related Problems: Problems associated with Maintenance occurred in 44 (86%) of the 51 Part / System Failure accidents. This group of problems stemmed primarily from inadequate maintenance or maintenance error(s). In most accident cases, specifics about the maintenance that was (or was not) performed and by whom were simply not reported. The JHSAT did however reach conclusions and recommendations based on facts reported and assumptions regarding missing information. The most common problem cited in the 44 maintenance-related accidents was failure to follow proper maintenance procedure or published Instructions for Continued Airworthiness (ICA). This was cited in 27 (61%) of the maintenance-related accidents. The other major problem areas identified by JHSAT were issues with maintenance quality oversight, procedures and record keeping. This was cited in 26 (59%) of this accident group. In 6 accidents, use of bogus, unapproved, or military surplus parts was a factor in the accident.

Maintenance-related problems occurred in at least a few accidents of almost every mission type. No direct correlation with mission type was determined; however, it was noted that some operations may have experienced maintenance problems associated with remote location maintenance activity and limitations of quality oversight. Other findings were that *none* of the Instructional / Training, Commercial or Utilities Patrol / Construction accidents involved maintenance. It is possible that the helicopters used for these missions were generally based at a school or airport facility where maintenance facilities were co-located and used regularly. These types of missions are also less likely to involve flights in and out of remote locations.

Due to limitations of the maintenance database and lack of root cause maintenance data within many of the reports, it was not possible to make other significant findings.

Maintenance Interventions: There were 112 interventions suggested to mitigate Maintenance Problems. The top intervention areas are listed below. As mentioned above, Quality Assurance (QA) and Instructions for Continued Airworthiness (ICA) compliance constitute the majority of intervention targets. This points to the team’s assessment that in those accidents where maintenance of the aircraft was a factor, the maintainer was performing an insufficient job and the organizational safety net was either non-existent or insufficient to capture the low quality of work. Additional interventions were suggested, including the recommendation to install systems to monitor aircraft operation and performance.

Table 6-16. Top Interventions for Maintenance Problems (Cited 112 Times)

Intervention	Total	Percent of Maintenance Category
Improved quality assurance procedures / oversight	38	86%
Assure compliance with ICA	24	55%
Use of HUMS, EMS or impending failure detection equip.	24	55%
Improved record keeping	7	16%
Improved FCF procedures	4	9%

6.2.8 Post-Crash Survivability

Post-Crash Survivability Problems: This category of problems was found in 25 (13%) of the accidents. While these problems were not related to the *cause* of any accidents, they did pertain to the consequences of the accidents. Some of the specific problems identified included: post-crash fire (in 11 accidents, or 6%), vehicle sank or capsized (in 5 accidents or 3%), rescue delayed by inoperative Emergency Locator Transmitter (ELT), inadequate communications or flight following (in 3% of the accidents), and missing safety equipment (in 4% of the accidents). Post-Crash Survivability Problems were more common following several accidents that started during the Maneuvering (5%) and Cruise (4%) phases of flight. They occurred in most of the types of missions, but with low frequency. Post-crash problems were a particular problem for Offshore operations (44%). Even though the magnitude of the effect was not large, it is logical that for missions conducted over water and out of sight of land, post-crash rescue and survival is more difficult than it is for missions primarily flown over land and in less remote locations. No Post-Crash Survivability Problems were found for Business, Firefighting, Logging, and Utilities Patrol / Construction accidents.

Post-Crash Survivability Interventions: The predominant intervention recommended for post-crash survivability problems was use of crash resistant fuel systems (CRFS) to minimize the chance of life threatening post-crash fires. There have been significant changes to fuel systems over the years to improve crash survival, the CRFS was a major step forward. The intent was to design a tough puncture resistant fuel cell that could survive high impacts beyond human survivability levels. This was first produced by the U.S. military in 1970 and had a self-sealing feature for protection from incoming enemy rounds. In 1980, light-weight CRFSs were introduced on some civil helicopter models. In 1994, the FAA amended FAR Parts 27 and 29 to require CRFS for certification applicants. The fuel cell of a civil CRFS is tested to withstand a 50 ft free-fall of a cell 80% full of water (approximating the weight as a full cell of jet fuel), which results in an impact speed of 56 ft/sec. Such high impact speeds are in excess of human survivability in any civil or military helicopter with all of the latest safety features. Some military surplus helicopters from the U.S. military are flying on the U.S. civil registry and contain CRFS as well. Overall, 21.3% of the accident helicopters in this CY2000 study had the CRFS installed.

Table 6-17. Top Intervention for Post-Crash Survivability Problems (Cited 26 Times)

Intervention	Total	Percent of Post-crash Survivability Category
Crash resistant fuel systems	11	12%

6.2.9 Mission Risk

Mission Risk-Related Problems: This category focuses on factors that are intrinsic to the operating environment or requirements typical of a specific segment of the helicopter community. Mission Risk-related problems occurred in 22 of the accidents. Mission Risk problems included those associated with intensive requirements on the helicopter itself (1%), the pilot (2%), or the requirement to fly near hazards, obstacles or wires (5%), or over terrain unsuitable for an emergency landing (5%). Accidents in which Mission Risk problems were identified occurred most often during the Cruise (8%) and Maneuvering (5%) phases of flight. Mission Risk-related problems were identified in 50% of the Utilities Patrol / Construction, 40% of the Logging, and 25% of Aerial Application accidents, all of which require operating close to wires, other obstacles and the ground. For example, Aerial Applications require low-level passes and tight turns at the end of a row to avoid power lines that often follow the edges of a field. For all of the other types of missions, Mission Risk problems were found in one or two of the accidents. Another way of looking at this, however, is to calculate the percent of problems found within each type of mission due to a particular problem. A somewhat different pattern emerges when doing this: 17% of the total number of problems found for Logging accidents and 14% of those found for Utilities Patrol / Construction were attributed to the risks characteristic of that type of mission (e.g., flying close to hilly, wooded terrain and near power lines, respectively), while only 5% of the problems identified for Aerial Application accidents were in the Mission Risk category. Thus, Mission Risk was identified in a significant number of these accidents, but it was not a significant contributor to the total number of problems identified for those missions.

***Mission Risk Interventions*:** Twelve interventions target Mission Risk Problems. Two of the four interventions cited some form of risk assessment training, counting for 50% (6) of the number of interventions. The most frequently cited intervention specifically targets training to address risk in agricultural operations (Aerial Application). Installation of wire strike protection systems (WSPS) accounted for 20% of the interventions, the only technology-based intervention for this problem category. Table 6-18 shows the Top Interventions suggested for Mission Risk problems.

Table 6-18. Top Interventions for Mission Risk Problems (Cited 23 Times)

Intervention	Total	Percent of Mission Risk Category
Mission specific risk assessment training - Ag Ops	4	17%
Risk assessment training	2	9%
Mission specific training focused on wind, night, low, slow, at or near maximum gross weight and orbiting	2	9%
Install WSPS	2	9%

6.2.10 Communications

Communications Problems: This category of problems occurred at least once in 19 (or 10%) of the accidents. This group of problems included coordination with other crewmembers (in 5% of accidents), pilots (2%), ground or landing zone personnel (2%) or company dispatch / flight-following (1%). Unlike the other problem categories, the most frequent Phases of Flight in which Communications problems were found were Approach and Landing (2% of the accidents each), although the numbers are small. While only 7% of the problems identified in EMS accidents were related to Communications, at least one communications problem was identified in nearly half of the 12 EMS accidents.

***Communications Interventions*:** There were 14 distinct interventions targeting Communications Problems. Table 6-19 illustrates the five most frequent interventions suggested to mitigate Communications Problems. 80% of the interventions, not surprisingly, cite the need for increased communication and coordination between crewmembers (both aircrew-aircrew and aircrew-ground crew). The most frequently cited intervention calls for crew coordination training and use, as referenced in FAA AC 00-64 [Ref. 6 in Appendix I]. Two of the five interventions specifically call for establishing SOPs for crew briefings.

Table 6-19. Top Interventions for Communication Problems (Cited 24 Times)

Intervention	Total	Percent of Communication Category
AMRM training and utilization(AC 00-64)	5	21%
Establish preflight / maneuver briefings for training (including transfer of control commands and actions)	4	17%
Install cockpit recording devices	2	8%
Establish preflight maneuver briefings	2	8%
CFI training to take charge despite age or total exp differences	2	8%

6.2.11 Regulatory

***Regulatory-Related Problems*:** Problems related to regulatory issues were found at least once in 17 accidents (9%). These problems ranged from accident prevention (e.g., failure to require adequate data to understand what happened; in 2% of the accidents) to oversight (e.g., of military surplus parts; in 3%), development or application of standards and regulations (6%), and an inadequate safety system (e.g., to review, revise, oversee or disseminate pertinent flight safety information; in 3%). Regulatory Problems were found most often in accidents that occurred during the Cruise and Maneuvering phases of flight (in 2% of the accidents each), although the numbers were small. This type of problem was found in more than half of missions, but not often. For Air Tour, Firefighting, Logging and Offshore, more than 30% of accidents involved some sort of regulatory issue, usually related to cockpit recording devices, public use operations, oversight of maintenance and / or control of military surplus parts.

***Regulatory Interventions*:** The single most frequent intervention that addresses Regulatory Problems was the installation of cockpit recording devices. This intervention reflects the view of the team that if a recorder is installed, then the operators can use it to assess aircraft performance and pilot adherence to SOPs. It would also help maintainers trouble-shoot problems that are detected by the pilot but cannot be reproduced on the ground. Additionally, as in “Data Issues” above, a cockpit recorder will also provide an investigator with information on pilot responses. The major category of intervention relates to Oversight (cited 6 times): 40% of them target oversight of Part Manufacturer Approval (PMA) and applicants meeting Type Certificate (TC) holder design requirements, and 40% target operations regulation and oversight of Part 91 sightseeing operations. The remainder is a mix of suggestions directed toward the FAA to increase operational and maintenance oversight. There are four interventions targeting military surplus and restricted-category issues. These are cited four times. Table 6-20 illustrates the top interventions for Regulatory Problems.

Table 6-20. Top Interventions for Regulatory Problems (Cited 24 Times)

Intervention	Total	Percent of Regulatory Category
Install cockpit recording devices	5	21%
Easily accessed database of aircraft serial number, history, use, etc	3	13%
Increased FAA oversight of ops and Mx	2	8%

6.2.12 Systems & Equipment

Systems & Equipment-Related Problems**:** This category of problems was identified in 13 (or 7%) of the accidents. These problems were related to the design of the helicopter systems or installed equipment. The most common issue was the lack of wire strike protection (cited in nine accidents, or 5% of the total). The other factors (lack of annunciation / warning of a critical condition, a cockpit design that allowed critical controls to be selected inadvertently) were cited in two accidents each. All of the Systems & Equipment Problems were identified in accidents that occurred during the Maneuvering (in 4% of the accidents) and Cruise (2%) phases of flight. Systems & Equipment problems were cited most frequently in Aerial Application accidents (in 5 accidents, 18%) and in only 1 or 2 of the accidents for the remaining mission types. With the exception of a lack of adequate wire protection, no other design-related issues stood out.

Systems & Equipment Interventions**:** There are eleven interventions targeting Systems and Equipment problems. Three target wire protection / detection and proximity detection (65%, cited in 12 cases). The remaining eight interventions include two Rotorcraft Flight Manual (RFM)-based interventions and two cockpit annunciation changes. Table 6-21 illustrates the top interventions for Systems & Equipment Problems.

Table 6-21. Top Interventions for Systems & Equipment Problems (Cited 20 Times)

Intervention	Total	% of Aircraft Design Category
Install proximity detection system	5	25%
Install WSPS	5	25%
Wire detection system for low alt ops	2	10%

6.2.13 Infrastructure

Infrastructure-Related Problems**:** Problems related to the infrastructure were identified at least once in 7 (4%) of the accidents. Infrastructure Problems included those related to equipment (instrument navigation systems incompatible with the mission and unavailable weather information found in 1-3% of the accidents), oversight of training and operations, and regulations (in 3% of the accidents). This category of problems occurred so infrequently that it is difficult to draw any valid inferences. For EMS accidents, Infrastructure Problems were found in 17% of the accidents and 4% of the total number of problems identified were about Infrastructure. These percentages were higher than those found for any of the other types of missions.

Infrastructure Interventions**:** There were eight interventions that targeted Infrastructure Problems (Table 6-22). Specialized transition training and local in-flight weather updates (particularly targeting the tour industry) accounted for 40% of the interventions cited.

Table 6-22. Top Interventions for Infrastructure Problems (Cited 10 Times)

Intervention	Total	Percent of Infrastructure Category
Specialized training for pilots migrating from fixed to rotor wing aircraft	2	20%
Implement local Wx PIREP system for intra / inter company flights	2	20%

6.3 Mission Specific Results

During the course of analyzing the CY2000 accidents, the JHSAT determined that the data could be categorized into 15 basic missions: Instructional; Personal / Private; Aerial Application; EMS; Commercial Operator; Air Tour / Sightseeing; Law Enforcement; Offshore; External Load; Business – Company; Firefighting; Aerial Observation / Patrol; ENG; Logging; and Utilities Patrol. This is an important aspect to the analysis, since the initial set of safety recommendations from the SPS and interventions were developed in the context of specific missions. Interestingly, the JHSAT subsequently determined that, although the recommendations were developed in the context of individual missions, only 20% of the recommendations developed were purely mission related; i.e., 80% of the recommendations developed were determined to be applicable fleet-wide regardless of mission. It is this group of "generic or fleet-wide" recommendations that were further refined to develop the safety recommendations, presented in Section 7.

The following mission segments have been developed for use by the JHSIT for implementing industry change and for use by any entity interested in improving the safety of their operations. It should be noted that each mission section cites the number of accidents analyzed within that mission. Although the JHSAT believes each of these mission sections contains valuable general and mission-specific information, analysis of one year of accident data most likely does not offer a complete set of recommendations. Future JHSAT activity will add to the safety recommendations cited in this report.

Figure 6-10 depicts the process used by the U.S. JHSAT to develop mission recommendations from the accidents analyzed in the year 2000 NTSB dataset. Quantities quoted are hypothetical and for illustrative purposes only. The U.S. JHSAT analyzed 197 accidents. The process consisted of reconstructing the accident chain of events, determining what went wrong and why, assigning Standard Problem Statements (SPSs) and offering mitigating actions or "interventions" for the problems identified. This yielded about 1,200 problem / intervention pairs.

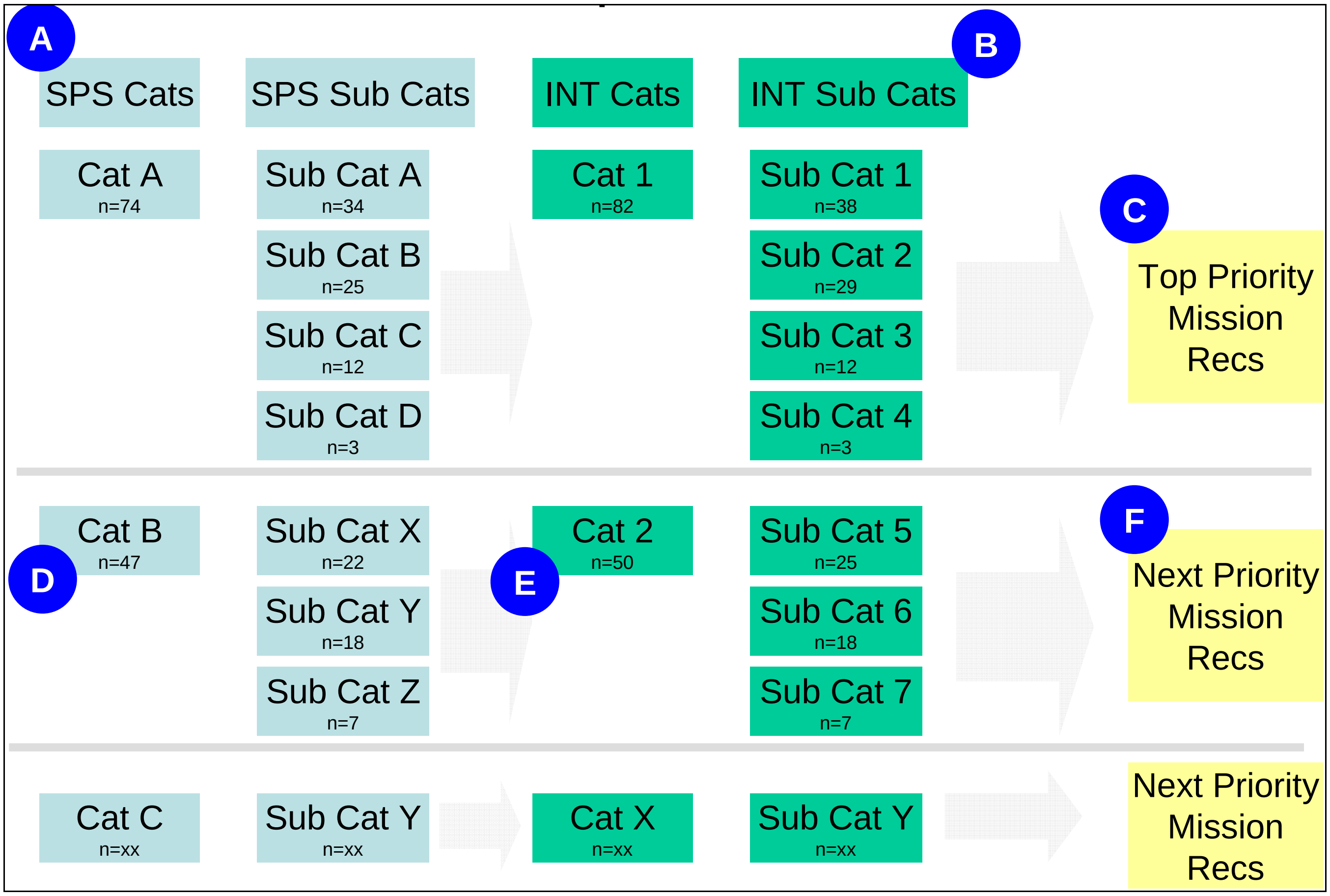


Figure 6-10. U.S. JHSAT Mission Recommendation Roll-up Schematic (Hypothetical Data)

Specific points of note, highlighted by the blue-circled letters, are addressed below:

- **A –** For a given mission (e.g., EMS, Logging, Aerial Application), the JHSAT ordered the data by most frequent SPS category and sub-category.
- **B –** Next, each of the corresponding Intervention categories and sub-categories in the top SPS category were ordered by frequency.
- **C –** The ordered intervention list was used as the basis for establishing the top recommendations for the given mission. The data analysts used judgment when developing and ranking the mission recommendations. Usually the most frequent interventions produced the highest priority

recommendations. However, the process used did allow flexibility to introduce a higher priority recommendation if it was deemed needed to affect other high priority change (e.g., Safety Management needed to bring about change to introduce new SOPs).

- **D**, **E**, and **F –** These used the same process except with the next less frequent SPS and Intervention categories and sub-categories.

Following are the recommendations for each of the 15 missions analyzed. Please note that the recommendations specified in each mission are ranked in order of importance as determined by the JHSAT.

6.3.1 Mission Specific Findings – Instructional / Training

6.3.1.1 Instructional / Training – Mission Definition

Instructional flying entails ground and flight training to accomplish a flight crew training goal. Primary and basic flight instruction (new student through commercial) is typically performed in small, light-weight helicopters that are powered by reciprocating engines and are less complex than those used for mission-specific training. Instructional training and light utility rotorcraft may have relatively low main rotor inertia and can carry less weight, particularly at high density altitudes. Thus, if not flown properly, such helicopters may be relatively unforgiving of operator error. The certified flight instructors (CFIs) who perform much of the primary and basic instruction mission are frequently low-experienced helicopter pilots themselves who may be recent graduates of commercial pilot and CFI training. They may be performing the CFI role as a means of building flight time to qualify for higher paying industry jobs that require more flight experience and may not have substantial industry experience outside the training environment on which to base in-flight decision-making. For this pilot to be successful, it is very important that instructional training be standardized, that risk be managed, and that clear communications occur during preflight preparation and throughout instructional flights. This advice is also important for very experienced instructors, and it is noteworthy that the instructional flight accident data included some very high-time pilots in addition to the student and low-time instructor accidents that were anticipated. This approach (standardized instruction, clear communication and risk management) is a safeguard to reduce the potential for students and instructors alike to make decisions that accept unnecessary risk. In that sophisticated training aids, like motion-based flight simulators, are frequently not available to supplement basic flight instruction, maneuvers like full-autorotations (autorotations to a landing) and some simulated emergencies that tend to be troublesome to new helicopter pilots but are important in developing needed pilot skills must be conducted in the helicopter. Instructional flying would involve less risk and likely have fewer accidents if sophisticated training devices could be made available for higher risk instructional flights.

By contrast, industry mission training is typically conducted by more experienced and industry-oriented pilots who are helping other pilots to transition from one make and model to another or are providing mission or proficiency flight training. These instructional training flights are more likely to be performed in turbine-powered helicopters that may be better equipped with workload reducing systems, more forgiving of human error, and very similarly configured to mission specialized aircraft. Flight simulators exist for some of these helicopters but are not universally available.

Both training categories are discussed in this section.

6.3.1.2 Instructional / Training – Synopsis of Accidents Analyzed

Of the 197 accidents analyzed in the NTSB year 2000 dataset, 37 accidents involved Instructional operations. This represented 18.8% of the accidents analyzed for the year. 199 interventions (some of which were found in multiple accident scenarios) for 189 problem statements were identified from analyzing Instructional accident data and are discussed in this section. In addition, it is noted that some training accidents are linked to specific mission groups and are discussed with the accident data from those groups.

6.3.1.3 Instructional / Training – General Characteristics of Accidents Analyzed

Because of distinctly different experience levels of the pilot-in-command (PIC), Instructional accidents are discussed here in three groups: Accident Group A – pilots with less helicopter flight experience (student pilots) conducting solo instructional flights; Accident Group B – dual-pilot flights operated with a relatively inexperienced helicopter flight instructor (CFI) as PIC; and Accident Group C – flights conducted by higher-time CFIs, or CFIs with unknown CFI hours. Collectively, the Instructional accidents occurred most often in the landing phase of flight (20 of the 37 accidents; 54%). Autorotations are considered landing phase maneuvers and were involved in 15 of the 20 landing accidents. Six accidents occurred during hover maneuvers (16%), four during the approach phase (11%), three during takeoff (8%), two in maneuvering flight (5%), and one each occurred in cruise or during ground operations (3% each).

Accident Group A. Ten accidents occurred on instructional flights conducted by student pilots (supervised student solo flights). Five of the 10 student flights were conducted in helicopters that are considered low rotor inertia helicopters. All 10 flights were conducted in day, VMC. The injuries from these accidents were: one fatal, one serious, one minor and eight no-injuries. For those accidents where this data was reported (and excepting one accident where a relatively experienced airplane-rated pilot was a helicopter student) these student pilots had flight experience that averaged 68 total flight hours (four had less than 40 hours) and 43 rotorcraft hours (two had 20 hours or less, and six had less than 40 rotorcraft hours). The average pilot-in-command time in the make and model of the accident helicopter (for the five accidents where this information was reported) was 4.8 hours; four of these very low experience student pilot accidents were in low rotor inertia helicopters. One accident occurred on the student's first solo flight.

Eight of the ten accidents in this group involved loss of control (LOC) at low altitude, usually with a rollover as a consequence of the LOC. The only fatal accident involved a loss of control in the traffic pattern, the cause of which was not determined. Other student LOC accidents occurred as follows: during an inadvertent takeoff during a ground magneto check; following improper operation of the flight controls (abrupt and excessive upward collective movement) during an intended takeoff; following an improperly conducted quick-stop maneuver; when experiencing a loss of directional control (low rotor rpm) during autorotation or on landing approach; while landing on a trailer (with one skid off the trailer); and while landing (due to medical factors). The other two student pilot accidents came as a result of a tail rotor failure on the ground; and while using the helicopter as an escape vehicle in a criminal activity.

Accident Group B. There were 12 dual instructional accident flights involving certified flight instructors (CFIs) with less than 1,000 hours as CFI. (There may have been more accidents in this category because when CFI hours were not known to be less than 1,000 hours, the accidents were placed in Accident Group C.) Ten of these 12 accidents occurred in low rotor inertia helicopters. Ten of the Group B accidents occurred in day, VMC; one occurred in VMC (light conditions not reported), and one occurred in night, IMC. These 12 accidents resulted in one serious, five minor and 18 no-injuries. The night IMC accident resulted in a crash in the ocean but had only minor injuries. The pilot (CFI) total flight experience for this group averaged 1,734 hours, of which 764 hours were in helicopters and 588 hours were in make and model (for those reporting). Seven of the 12 CFIs in this group had less than 1,000 hours total pilot experience, and five had less than 500 hours in helicopters. The 12 CFIs in this group averaged 404 CFI hours. Three (of ten reporting) had less than 50 CFI hours in the make and model of the accident helicopter.

The Group B accidents included two CFI-demonstrated full autorotations that resulted in noseovers, one accident where the CFI experienced a dynamic rollover on takeoff, and one accident where the CFI – because of self-induced pressure – inadvertently encountered IMC and crashed while attempting to return to base at night. Seven (total) of the accidents occurred during practice autorotations; one occurred when a student lost control in a hover; one occurred during a running takeoff on snow; and one occurred while practicing landings. The most common characteristic of the Group B accidents (eight of 12 accidents) was late or inadequate intervention by the CFI after the student had allowed the rotor rpm to become low or improperly operated the flight controls. All eight of the accidents where CFIs were late to intervene or intervened inadequately occurred in low rotor inertia helicopters. In five of those mishaps, the CFI had less than 200 hours experience as a helicopter instructor. In one of the mishaps, the student interfered with the flight controls (due to miscommunication) and over-powered the instructor when the CFI attempted to recover from a maneuver badly initiated by the student.

Accident Group C. There were 15 accidents in Group C, and these accidents were more varied in aircraft types and training missions than were the Group A and B accidents. Group C included six single turbine and one twin turbine-powered helicopter accidents; these accidents frequently occurred during mission qualification training and check flights. Group C also included light reciprocating engine-powered helicopters in traditional instructional training roles. All 15 accidents occurred in day VMC, resulting in three fatal injuries, two serious injuries, six minor injuries and 21 no-injuries. All but one of the turbine-powered helicopter accidents resulted in no injuries. The following average flight experience was reported for the pilots-in-command in Group C: 9,784 hours total flight experience, 8,106 hours in rotorcraft and 3,041 hours in the make and model of the accident aircraft (for those accidents where this information was reported). This data was skewed by eight very high time pilots (all more than 10,000 hours) who averaged 14,841 total flight hours. Three pilots (of five reporting) reported 200 hours or less of instructor time in the make and model of the accident aircraft.

The Group C accidents included two Part 135 or company flight checks (one with an FAA inspector observing from a non-pilot seat), three accidents involving "differences" or emergency training for Part 135 operations, factory flight training given by an OEM instructor, three accidents involving training or checking of CFI candidates, one training flight with a commercially-rated student, one evaluation of the skill level of a new student and four instructional flights with students. The student flight accidents occurred during hover practice (abrupt and unanticipated control movement), maneuvering at low altitude (struck a rock), autorotation training from a hover, and maneuvering during a demonstration flight (mast bumping and main rotor mast failure). The single turbine helicopter accidents involved: (1) a student inadvertently selecting the manual overspeed flight stop switch during a power recovery autorotation, causing an engine over-temperature condition and precipitating a tailrotor output drive coupling failure, (2) two accidents involving practice with hydraulics-off, (3) a hard landing while practicing autorotations from a hover, (4) a hard landing following an improper / misjudged flare during autorotation recovery, and (5) a collision with an unseen obstacle during pinnacle landing practice. In 11 of the 15 accidents, inadequate intervention or supervision by the CFI after an error by the "student" was cited by the NTSB as a cause or factor.

6.3.1.4 Instructional / Training – Problem Areas Identified

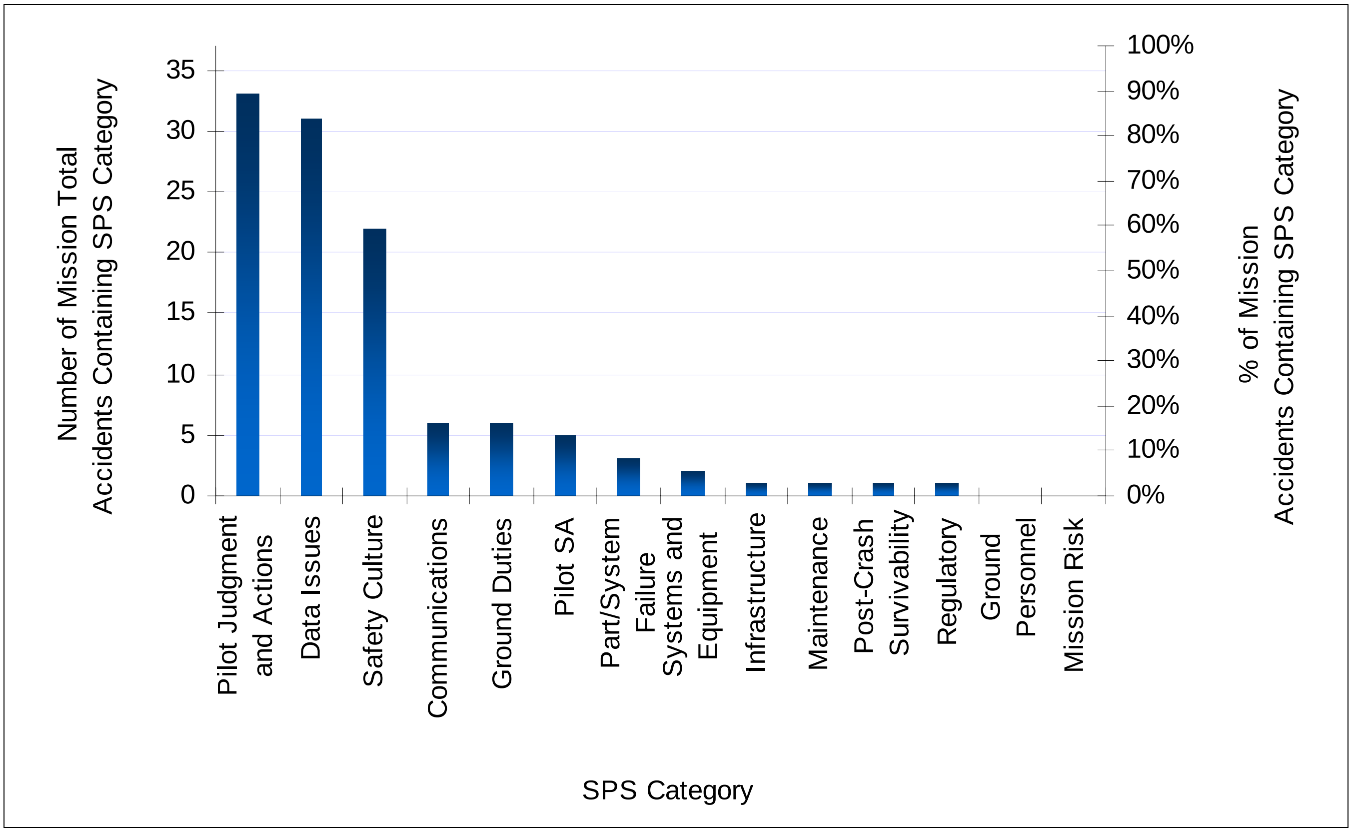


Figure 6-11. SPS Categories for Instructional / Training (37 Accidents Analyzed)

189 problems were identified in the ten primary areas for the 37 Instructional / Training accidents:

1. Evidence of inadequate Safety Culture was identified as a problem 34 times – in 22 (59%) of the 37 accidents – in the events leading to the Group A, B and C Instructional accidents. Crew performance issues, called Pilot Judgment and Actions, were identified 84 times, in 33 (89%) of the 37 accidents, and closely related Communications and Pilot Situational Awareness factors were identified nine times, in six (16%) of the accidents, and six times, in five (14%) of the accidents, respectively. Ground Duties were identified six times, in six (16%) of the accidents, and Aircraft Design was cited three times, in two (5%) of the accidents. Part Failure was cited three times, in two (5% of the) accidents, and Maintenance (the absence of optional vibration detection equipment) was identified just once. Infrastructure, Regulatory Issues, and Post-crash Survivability issues were cited once each. Lack of data (Data Issues) to adequately understand all of the important aspects of the accidents was identified 39 times, in 31 (84%) of the accidents.

2. The Safety Culture (34) issues in the Instructional accidents follow. Inadequate CFI preparation and training (cited 11 times) and inadequate pilot experience (11) were cited most frequently among training program problems. The latter category (inadequate pilot experience) includes student (5), PIC (4), inadequate pilot knowledge (1), and lack of experience in make and model (1). Other findings indicative of training program deficiencies were autorotation training inadequate (2), and emergency systems training inadequate (1). Findings pointing directly to the safety program were: “safety program inadequate” (1), “risk management inadequate” (1), and insufficient employee performance monitoring (1). A transition training program (to a new aircraft make and model) was cited twice, and pilots yielding to “self-induced pressure” was cited twice. Management policy / oversight and crew hiring practices were cited once each in this set of problem statements.

3. The collection of conditions and circumstances indicative of sub-standard pilot performance (frequently the CFI in Instructional accidents) were linked under Pilot Judgment and Actions. Most frequently cited among them were “procedural implementation” – pilot control / handling (14 occurrences), inadequate power / energy management (7), inadequate recognition and response to dynamic rollover (6), and inadequate response to loss of tail rotor effectiveness (2). Landing procedures were cited next most often – inadequate autorotation practice (13 occurrences), inadequate landing site reconnaissance (3), selection of inadequate landing site (2), autorotation forced (2), and misperception of stability and motion cues in a hover (1). Crew resource management deficiencies were noted 17 times – most often as “inadequate or untimely action” to correct student or second pilot action. Human factors related to pilot decision-making were cited seven times – disregarded cues that should have led to termination of current course of action (3), pilot decision-making (2), and willful disregard of rules / SOPs or limitations (2). “Human Factors – Pilot / Aircraft Interface” were cited five times – perceptual / judgment errors (2), diverted attention / distraction (1), and crew disregard for human performance limitations (2). An unsafe flight profile during approach, due to “conditions,” or due to unsuitable terrain was noted five times in Instructional accidents. (Dynamic rollover, LTE, and autorotation accidents occurred in other mission categories, in addition to those found in the Instructional category, and are discussed further elsewhere in this report.)

4. Pilot Situational Awareness was noted in the following circumstances – pilot failed to recognize the aircraft’s condition or aerodynamic state (3 events), pilot failed to recognize cues to terminate current course of action (2), and pilot impaired (1).

5. Communications difficulties included coordination with other pilots / crew (5 occurrences) and lack of positive transfer of flight controls (4).

6. Ground Duty deficiencies related to pilot preflight planning and preflight briefings. Noted deficiencies were inadequate consideration of weather / winds (2 events), aircraft performance / operational limitations (2), and inadequate flight crew briefings (2).

7. Aircraft Design was considered inadequate in two accidents. In one instance the cockpit design allowed critical controls to be selected inadvertently, and in both cases there was no provision for a caution / warning of a critical condition.

8. Part Failure / Maintenance Factors were cited infrequently in Instructional events. In a tail rotor tip weight separation accident, it was found that the tip weight installation did not conform to type design (OEM action was taken to address the problem). In the same event, it was noted that the aircraft was not equipped with

equipment (HUMS) to detect the impending failure. In another instance, the tailboom skin thickness was less than proscribed by the OEM, but this probably did not contribute to the accident.

9. Infrastructure, Regulatory and Post-Crash Survivability problems: “Infrastructure” was cited once when it was considered that the standards for transitioning a highly experienced airplane pilot to rotary wing flying were inadequate; the airplane pilot had 4 hours in helicopters when his abrupt and inappropriate control inputs in a 3-foot hover prompted a dynamic rollover accident in a light helicopter. The “regulatory” issue was lack of a requirement to install data recorders to better understand the accident causes; the event cited was one where there was a mast failure and main rotor separation, presumably because of improper maneuvering by the pilot, although there is no data to document what actually caused the mast failure. The survivability issue was a post-crash fire in an otherwise survivable accident (when the pilot died of burns).
10. Data Issues: While not part of the causal chain, it was considered that the root causes of numerous Instructional accidents would have been better defined and more definitively mitigated had the investigation gathered more data. A lack of data – either because information was not available to the investigator (26 events), information was incomplete in the report (10), the investigation was inadequate (2), or inadequate human factors information was collected (1) – was cited 39 times in 31 accidents in the Instructional dataset. Cockpit recorders (all recorder types were considered) offered the potential to gather most of the needed data.

6.3.1.5 Instructional / Training – Safety Interventions Identified

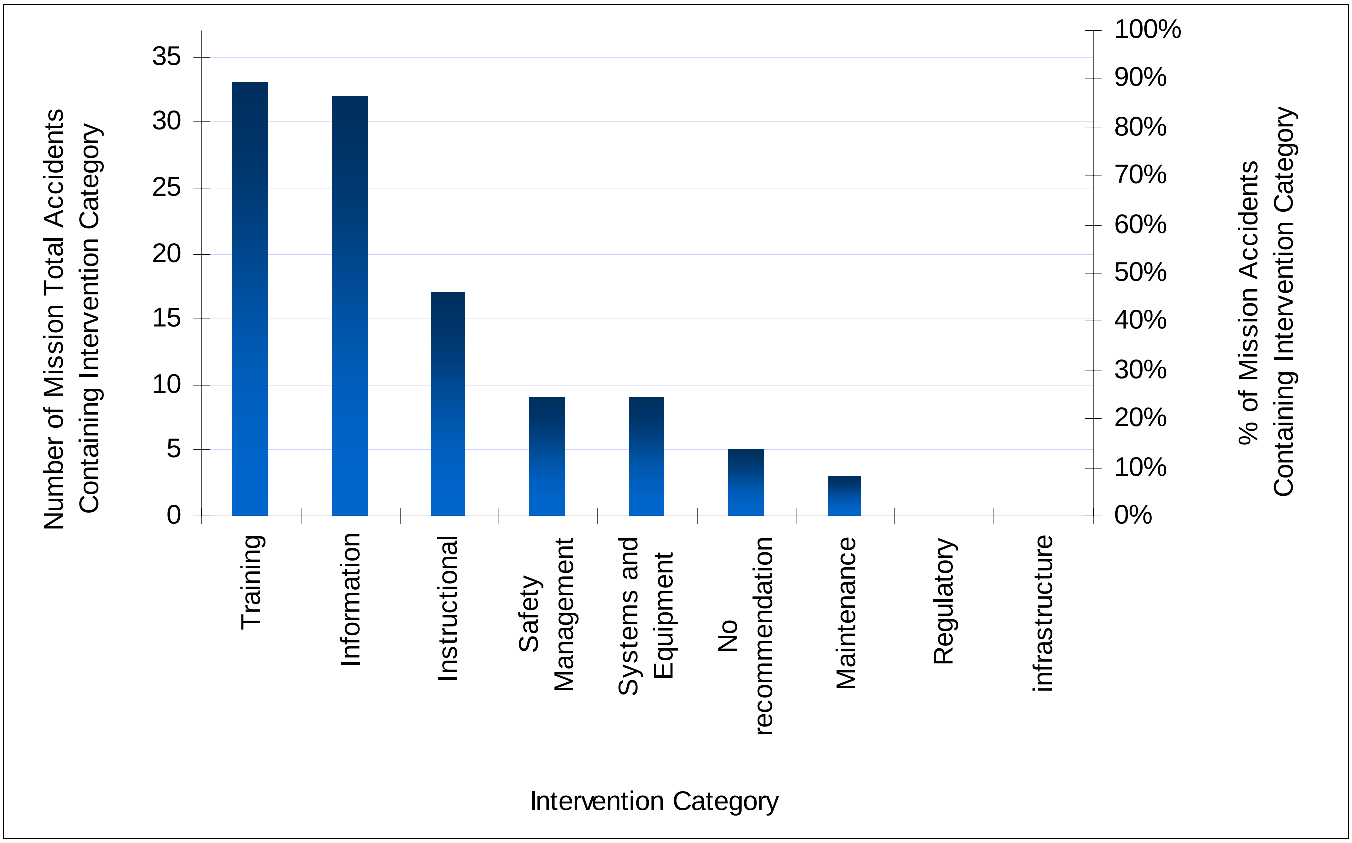


Figure 6-12. Intervention Categories for Instructional / Training (37 Accidents Analyzed)

1. Not surprisingly, the most commonly cited interventions for Instructional / Training accidents related to better training programs for instructors and students and establishing SOPS that would reduce risk of accidents on training flights; but that is an oversimplification of the intervention data. To get a better grasp of the data, intervention counts (for all 37 Instructional accidents) that relate back to “standard problem statements” identified for each accident will first be discussed. There were 199 interventions selected to correspond to the previously discussed problems; the corresponding intervention counts were: Pilot Judgment and Actions (95), Lack of Data (42), Safety Culture (31), Communications (9), Pilot Situational Awareness (4), Ground Duties

(6), Aircraft Design (4), Part / System Failure (4), Maintenance (1), Regulatory (1), and Post-crash Survivability (1). Almost all of these problems were considered to be factors in the accident sequence, with the notable exception that "lack of data" issues did not contribute to the causes of accidents but related to information that was needed to fully understand and mitigate the causal factors. Interventions to address these problems occurred in a few categories (numbers and percentage of accidents in parentheses) as indicated here: Training (33 accidents, 89%), Information (32, 86%), Instructional (17, 46%), Safety Management (9, 24%), Aircraft Design (9, 24%), and Maintenance (3, 8%).

2. Within the Pilot Judgment and Actions problem category, the following interventions were selected (frequency of use indicated in parentheses), with similar interventions grouped together:

    - Autorotation training (3); autorotation training aids and simulators (13); autorotation training aids and simulators to gain procedural skills coupled with knowledge of the aircraft performance characteristics (1);
    - Simulator training to gain procedural skill coupled with aircraft performance characteristics (3); simulator training (3); ground and flight / simulator training for recognition and recovery from LTE and / or common aerodynamic conditions (3); simulator training on quick-stop maneuvers (2); simulator training on dynamic rollover (2); simulator training in make and model before beginning flight instruction (1); and simulator training targeting approach procedures and practice in pinnacle approaches, unimproved landing areas, and elevated platforms (1);
    - CFI training / refresher training on advanced handling techniques and procedures (8); enhanced CFI training for simulated emergencies (4); CFI judgment and decision-making training to follow student more closely (3); increase CFI training on cues for low rpm, airspeed issues (2); improve CFI preflight briefing (1); CRM training and utilization (1); aeronautical decision-making (1); CFI training in judgment and decision-making in following the actions of the pilot being tested or taking the check ride (1); training emphasis for maintaining awareness of cues critical to safe flight (1); training emphasis on techniques for maintaining visual contact (1); develop SOPs for weather launch / abort criteria (2); company SOPs to minimize risk of repetitive maneuvers (1); establish SOP for autorotation training (1); ground survey of unimproved field sites before using it for autorotation training (1); establish SOP for selection of suitable autorotation landing sites (1); revise company checklist to be consistent with OEM checklist (1); preflight maneuver briefings for training flights (3); develop in-flight training techniques to familiarize student pilots with aircraft performance characteristics (1);
    - Training, recognition, and response to dynamic rollover (4); model-specific power / energy management simulator training (4); training on suitable landing site selection (1); increase student training on cues for low rpm airspeed issue (2); reinforce the importance of LZ recon (2); training in recovery from settling with power situations and the hazards of landing and or maneuvering in tailwinds and mountainous terrain (1); emergency procedures training (1);
    - Establish CFI Safety Management System (SMS) program to include transfer of control protocols while in stable flight condition (1); risk assessment training (3); provide risk assessment in training maneuvers (1); train for compliance to published aircraft performance specs (2); establish risk assessment program that addresses the potential for VFR into IMC (1); personal risk management program (1); training for enhanced awareness of hazard and handling while on ground (1); and aircraft equipment to include: in cockpit dynamic rollover alert system (1); short-term auto-hover recovery system (1); power available versus power required indicator (1); and installation of cockpit recording devices (1).

3. Interventions proposed to resolve Data Issues included: install cockpit or data recording devices (33); more comprehensive accident investigation, documentation, and reporting (4); investigating authority to provide more stringent investigation requirements and procedures to gather sufficient data to determine root causes of helicopter accidents (2); require investigators to assess adequacy of student training when student pilots are involved in accidents (1); require investigation authority to provide needed field investigating resources (1); require investigation of suspected ELT malfunctions (1); and require a standard format for recording pilot logbook / experience data (1). The JHSAT is recommending that cockpit recording devices be installed to provide additional data needed by crash investigators to understand system anomalies and pilot / crew performance that preceded an aircraft mishap. Such data, when used in routine operations – for example, data

collected in a Helicopter Operations Monitoring Program (HOMP) – also has great importance as a tool for monitoring aircraft system performance and quality of the flight crew training program, answering the question, “Do we fly like we train?” The JHSAT considered many alternative aircraft data recording devices (e.g., Cockpit Voice Recorder (CVR), Flight Data Recorder (FDR), HOMP, video recorders and other new technology recorders) for the wide range of helicopters and operations illustrated by the Instructional dataset and in the larger accident dataset discussed in this report. For the purposes of this report, it was considered that making an argument that more data was needed for root cause analysis and accident prevention was more important and appropriate than trying to suggest which recorders were most appropriate for specific helicopter models or mission categories.

4. Safety Culture interventions were similar to some of the Pilot Judgment and safety management interventions listed above; however, the focus of these recommendations was directed more to the operational philosophy and practices of the operator than affecting and improving pilot performance. Safety Culture recommended interventions that came from the JHSAT analysis of the Instructional cases included: Ensure SOPs address proper planning for instructional flights (7); establish SOPs for autorotation training (3); utilize HOMP-type data to verify employee flight performance (1); develop in-flight training techniques to familiarize student pilots with aircraft performance characteristics (1); enhance training for crew awareness of critical flight systems (1); enhance CFI training for simulated emergency training (1); provide aeronautical decision-making training (1); ensure use of an adequate transition training program (1); ensure the use of preflight / maneuver briefings for training flights (1); provide CRM / assertiveness training for pilots (1); provide training for pilots on common operational pilot errors (1); establish policy requiring the use of weather risk management tools (1); provide ground and flight / simulator training for recognition and recovery from LTE and other common aerodynamic conditions (1); establish risk-based solo flight release approval procedures (1); provide LTE recognition training before solo (1); provide policy that includes mission-specific risk assessment (1); ensure that CFIs evaluate the risk of operating in existing wind conditions and turn into the wind when appropriate for conditions (1); provide operational oversight to ensure the use of a risk assessment / management program (1); conduct preliminary pilot hiring screening in a flight simulator when available (1); require CFI endorsements for student operation from platforms (1); require proper training and proficiency before allowing pilots to operate from trailers / dollies (1); provide simulator training to allow pilots to gain procedural skill coupled with aircraft performance characteristics (1); provide simulator training in make and model before beginning flight instruction in the aircraft (1).

5. The following Communications interventions were suggested to address problems that resulted from inadequate communications on Instructional flights: provide preflight / maneuver briefings for training to include communications and procedures for proper transfer of control by pilots (4); establish policy to ensure CFI retention of PIC responsibility on dual flights regardless of the sometimes greater experience of the pilot receiving instruction (2); establish policy to ensure preflight briefings of all intended training maneuvers (2); and install cockpit recording devices (1).

6. The following interventions were suggested to improve Pilot Situational Awareness: provide standardized operational briefings and conditional situation checklists when warranted by mission requirements (1); install a low rotor speed warning when not already provided (1); provide ground and flight or simulator training for pilot recognition and recovery from LTE and other aerodynamic conditions (1); and provide operational risk management training to ensure appropriate preflight preparation (1).

7. The following interventions were suggested to improve Ground Duties when such deficiencies were noted in analysis of Instructional accident reports: establish preflight / maneuver briefings for training – to include transfer of control commands and actions (2); provide training for proper preflight planning for weather (1); emphasize training for performance limiters described in the rotorcraft flight manual (1); ensure CFIs use risk management techniques (1); and provide pilot training to ensure compliance with published aircraft performance limitations (1).

8. Aircraft Design: Interventions affecting aircraft design and OEM publications were referred directly to OEMs, as it was typically found that change could not be justified on the basis of individual accidents and in several incidents it was known that the risk of similar accidents had already been reduced by voluntary OEM actions.

9. Part / System Failure and Maintenance: An OEM Alert Service Bulletin and an FAA Airworthiness Directive had already been issued based on a tail rotor blade failure that was the subject of one recommended intervention (1). Install part failure detection system (HUMS) was recommended in one instance to detect vibration from an impending tail rotor failure (1); and improved OEM manufacturing quality assurance was recommended based on another accident (1). These and other recommendations based on apparently isolated events were referred to the OEMs for action, if warranted.
10. One Infrastructure intervention was recommended: provide specialized transition training requirements for airplane pilots transitioning to rotorcraft (1).
11. One Regulatory intervention was suggested: add guidance material addressing flight operations from trailers and dollies to the FAA *Rotorcraft Flying Handbook* (1).
12. One Post-Crash Survivability intervention was suggested: Install crash resistant fuel systems to reduce the risk of post-crash fires in otherwise survivable helicopter crashes.

6.3.1.6 Instructional / Training – Prioritized Safety Recommendations

Based on the accident data and the foregoing discussion, the following intervention recommendations were proposed:

1. Improve autorotation training by making greater use of training aids, training devices, and flight simulators to ensure students gain procedural skills coupled with knowledge of aircraft performance characteristics.
2. Provide enhanced training through greater use of coupled ground, flight, and simulator training for pilot recognition and recovery from LTE and other common aerodynamic conditions.
3. Improve training by using flight simulators for introduction to quick-stop maneuvers, recognition of and recovery from dynamic rollover, and for landing practice in unimproved areas, on landing platforms, and from pinnacle approaches.
4. Ensure that training programs provide a thorough understanding of recognition and recovery from dynamic rollover.
5. Ensure that training programs provide a thorough understanding of power / energy management; cues to avoid low rotor rpm, power, and airspeed conditions; training in recovery from power settling; the hazards of landing and / or maneuvering in tailwinds and in mountainous terrain; and emergency procedures training.
6. Use simulators to improve instrument and visual approach procedures training and model-specific power / energy management training.
7. Use simulators for introductory transition training in new make and models before beginning instruction in the aircraft.
8. Use simulators to provide enhanced CFI training on emergency procedures and conditions.
9. Provide advanced CFI training on judgment, risk management, and aeronautical decision-making to include preflight preparation and student / trainee mission briefings; cues for recognition and prevention of low rotor rpm and airspeed conditions; techniques for maintaining alertness to cues critical for safe flight; specific guidance regarding student monitoring and when intervention is warranted; and communications regarding transfer of control protocols and crew resource management.
10. Provide introductory and recurrent CFI training on advanced handling techniques and procedures to avoid LTE, dynamic rollover, and autorotation accidents.
11. Develop operator standard operating procedures (SOP) for preflight preparation and maneuver briefings for training flights, for weather launch / abort criteria, to minimize risks associated with excessive repetition of maneuvers, for autorotation training, and for selection and ground survey of remote or unimproved sites before using them for training.
12. Provide operator training on landing site selection and the importance and correct methodology for conducting landing site or LZ recon before landing.

13. Revise company operational checklists to be consistent with OEM checklists (except when differences are justified by unique mission or operational considerations).
14. Develop in-flight training techniques to familiarize student pilots with aircraft performance characteristics.
15. Establish for CFIs an "instruction" mission-specific Safety Management System (SMS) to include risk assessment and management training and protocols; transfer of control protocols; training to ensure compliance with SOP, regulations, and aircraft performance limitations; procedures to prevent Inadvertent Flight into IMC (IIMC) and provide for recovery from IIMC; personal risk management; and to provide the CFI with an enhanced awareness of hazards on the ground and on training flights.
16. Ensure that the company Safety Management System, through all of its elements, cultivates a culture of safety and regulatory compliance, risk assessment and management, and making proactive use of safety information to create safety awareness and reduce the risk of accidents. In a training environment, this program should provide operational risk management training and SMS policy that includes training mission-specific risk assessment.
17. Provide company operational oversight to ensure adherence to its SMS policies, including the use of risk assessment and management in flight operations.
18. Conduct preliminary pilot hiring screening in a flight simulator, when available.
19. Ensure that SOPs address the proper planning for instructional flights, including establishment of risk-based solo flight release approval procedures; provide for the use of preflight / maneuver briefings for training flights; provide policy to ensure that standardized preflight mission briefings will be conducted for all intended training maneuvers; provide CRM / assertiveness training for CFIs; provide policy to clarify CFI retention of PIC responsibility on dual flights, regardless of the sometimes greater experience of the pilot receiving instruction; provide procedures for proper transfer of control by CFIs and pilots receiving instruction; familiarize student pilots and CFIs with aircraft performance characteristics and limitations; establish policy for evaluating weather risk factors and use weather risk management tools; provide for enhanced CFI training for simulated emergencies; and provide training for pilots on common operational pilot errors.
20. Ensure that training policy and standardized operational procedures (SOP) enhance training for crew awareness of critical flight systems; provide for appropriate aeronautical decision-making training; provide an adequate transition training program; provide methodology that reduces risk of accidents in autorotation training; and provide ground and flight / simulator training for recognition and recovery from LTE and provide LTE recognition training before solo.
21. Require proper training and proficiency before allowing pilots to operate from trailers / dollies. Require CFI endorsements for student operation from platforms and trailers / dollies.
22. Use (HOMP-type) flight data to verify that employee flight performance meets training and operational standards.
23. Encourage development and use of optional aircraft equipment to include: low airspeed and low rotor speed warning systems; in-cockpit dynamic rollover alert systems; short-term auto-hover recovery systems; power-available versus power-required indicators; and cockpit recording devices.
24. Use crash resistant fuel systems for helicopters to reduce the likelihood of post-crash fires in survivable helicopter accidents.
25. To ensure that adequate data exists to provide for company operational oversight and standardization of flight operations and improved accident prevention through more in-depth analysis of accidents:
    - Install cockpit recording devices (video, audio or digital format as appropriate for the helicopter and mission).
    - Encourage accident investigation authorities to provide adequate staffing and conduct comprehensive investigation, documentation, and reporting to allow root cause analysis (and prevention) of helicopter accidents.

- Where student pilots are involved in accidents, require investigators to assess the adequacy of the student training.
- Require investigation of ELT malfunctions.
- Require a standard format for recording pilot logbook / experience data.

6.3.2 Mission Specific Findings – Personal / Private

6.3.2.1 Personal / Private – Mission Definition

Personal / Private operations fall into two main groups: privately-owned aircraft and rented aircraft. Aircraft in this mission are typically single engine light helicopters, powered by either turbine or reciprocating engines. This mission includes a wide variety of non-commercial flights operated under FAR Part 91 and receiving little regulatory oversight. Most of these accidents occurred on pleasure or personal transportation flights. Non-commercial flight operations conducted by a business and operated under FAR Part 91 are found in Section 6.3.8 Business / Company-Owned Aircraft.

6.3.2.2 Personal / Private – Synopsis of Accidents Analyzed

Of the 197 accidents analyzed in the NTSB year 2000 dataset, 27 accidents involved Personal / Private operations; this represented 13.7% of the accidents analyzed for the year. This mission ranks third in total accidents within the year 2000 data set, behind Instructional (37 accidents) and Aerial Application (28 accidents). 170 problem statements and 169 interventions were identified from analyzing Personal / Private accidents. Two accidents involved U.S.-Registered aircraft operating in other countries; reports of those accidents reflected little or no investigation and provided very little information with which to analyze the accidents.

Nine of the accidents involved power loss – four due to engine failure, three due to inadequate use of carburetor heat, and two due to fuel exhaustion. Seven accidents involved operation outside the aircraft performance envelope, two due to LTE, two due to weight and high density altitude operation, two due to winds / gusts and one due to ground resonance. Three wire strike accidents were reported. Three accidents related to aircraft mechanical failures were reported, one involving mast corrosion, one TR drive shaft failure, and one aircraft to engine oil supply line failure. Two accidents occurred during practice autorotations. One accident occurred in adverse weather, one was the result of dynamic roll over and one was a hard landing.

6.3.2.3 Personal / Private – General Characteristics of Accidents Analyzed

Four fatal accidents with 7 fatalities were noted in the accidents analyzed, or 15% of Personal / Private accidents. 31% resulted in serious or minor injuries and the remaining 54% produced no injuries. Seven (26%) of the accidents involved component and / or maintenance failures.

In the general analysis, the Personal / Private mission accident group was noted that:

- Operations were nearly all conducted under Part 91 and VFR.
- Helicopters were powered by reciprocating engines in 19 of the 27 accidents.
- One accident occurred under night IMC conditions.

21 (or 78%) of this mission's type accidents were related to errors in judgment and actions by the pilots. This mission group has the lowest average pilot experience (1,940 hours) and a significantly low average time in type of only 193 hours. This low experience level may account for the frequent number of accidents (7) where the pilot lost control of the helicopter due to operation outside the operating envelope.

Ground Duties Problems (15) were 8% of the total, second behind Aerial Application, but were 29% of this mission type.

Data Issues Problems were 8% of total, third behind Instructional / Training 16% and Aerial Application 11%, but were noted in 55% of mission type.

6.3.2.4 Personal / Private – Problem Areas Identified

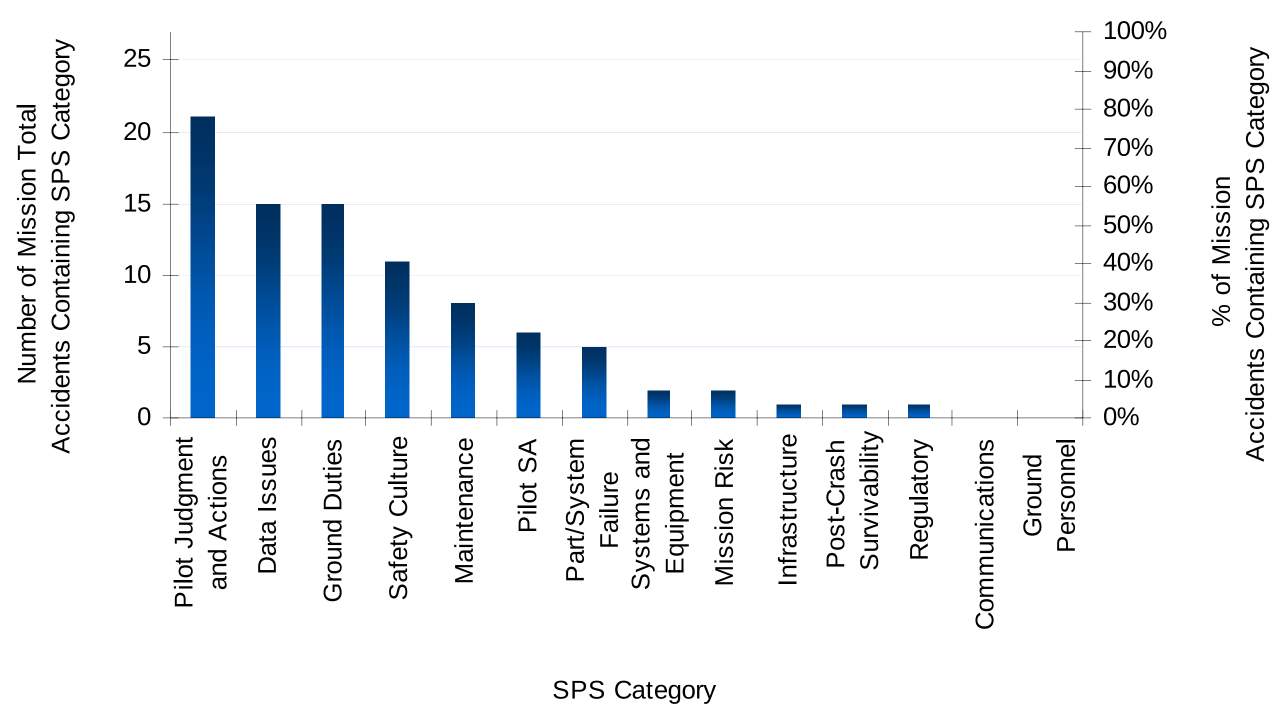


Figure 6-13. SPS Categories for Personal / Private (27 Accidents Analyzed)

169 problems were identified in 9 primary areas for the Personal / Private mission group:

1. Pilot Judgment and Actions category accounted for 53 of the SPSs for this mission group. In 14 accidents, pilot human factors played a part in the accident sequence. In most of these cases, pilots failed to follow procedures and in three accidents willful disregard for standard operating procedures was evident. In three events, cues were present that should have led to termination of activity precluding the accident. Another major contributing factor in 8 accidents was an unsafe flight profile, in most cases unnecessarily low altitude. Nine accidents involved landing procedures. Autorotations were the largest landing classification problem, with accidents involving 5 forced and 2 practice autorotations. Landing site selection / reconnaissance was a contributing factor in two accidents. Eleven accidents involved pilot procedure implementation or proficiency. This was primarily in the areas of power management, control / handling and in two cases failure to recognize and respond to loss of tail-rotor effectiveness.

2. Parts or System Failures were casual factors in 7 accidents. In 6 of these failures, maintenance error, omission or lack of following ICA procedures was apparent. In the one accident where maintenance casual factors were not directly identified, an aircraft oil line (flex hose) failed. It was not known what the design approval holder ICA requirements were for that part. Therefore a maintenance contribution determination could not be made. Maintenance was a significant factor and was identified in 26 of the problem statements for the Personal / Private accidents. Insufficient information was contained within the NTSB investigative documentation to ascertain details of the organizations performing maintenance and quality control or training levels. It can only be assumed that maintenance management was a significant issue as well as performance of the actual maintenance duties.

3. Data Issues made up 19 of the identified problems for the mission group. Although the accident reports had sufficient detail to make reasonable findings, they did not have data sufficient to develop conclusive assumptions that would allow investigators to make detailed root cause findings. In 10 accidents, data essential to conclusively determine crew actions was not available to investigators and in 9 accidents, available information helpful to understanding factors contributing to the accidents was not included in the report.

4. The Safety Culture problem group was identified as an issue in 15 accidents, with a significant percentage – 12 of the 15 – being either lack of experience in type, transition training or general inexperience. Of the 17 accidents with pilot rotorcraft flight experience documented, nine had less than 500 hours of rotorcraft time and only 5 were over 1,000 hours. Of the 24 with total flight time documented, 6 had less than 1,000 hours total time and 5 had over 10,000 hours.
5. Pilot Situational Awareness of the external environment was noted in two accident, one impacting power lines and a second controlled flight into the ground. These two accounted for 2 of the fatal accidents.
6. Regulatory problem statements were identified 3 times relating to FAA oversight and military surplus parts issues.
7. Systems and Equipment was identified twice with regard to absence of wire strike protection.
8. Mission Risk of flying too close to hazards was identified twice.
9. Post-Crash Survivability was identified in one post-crash fire.

6.3.2.5 Personal / Private – Safety Interventions Identified

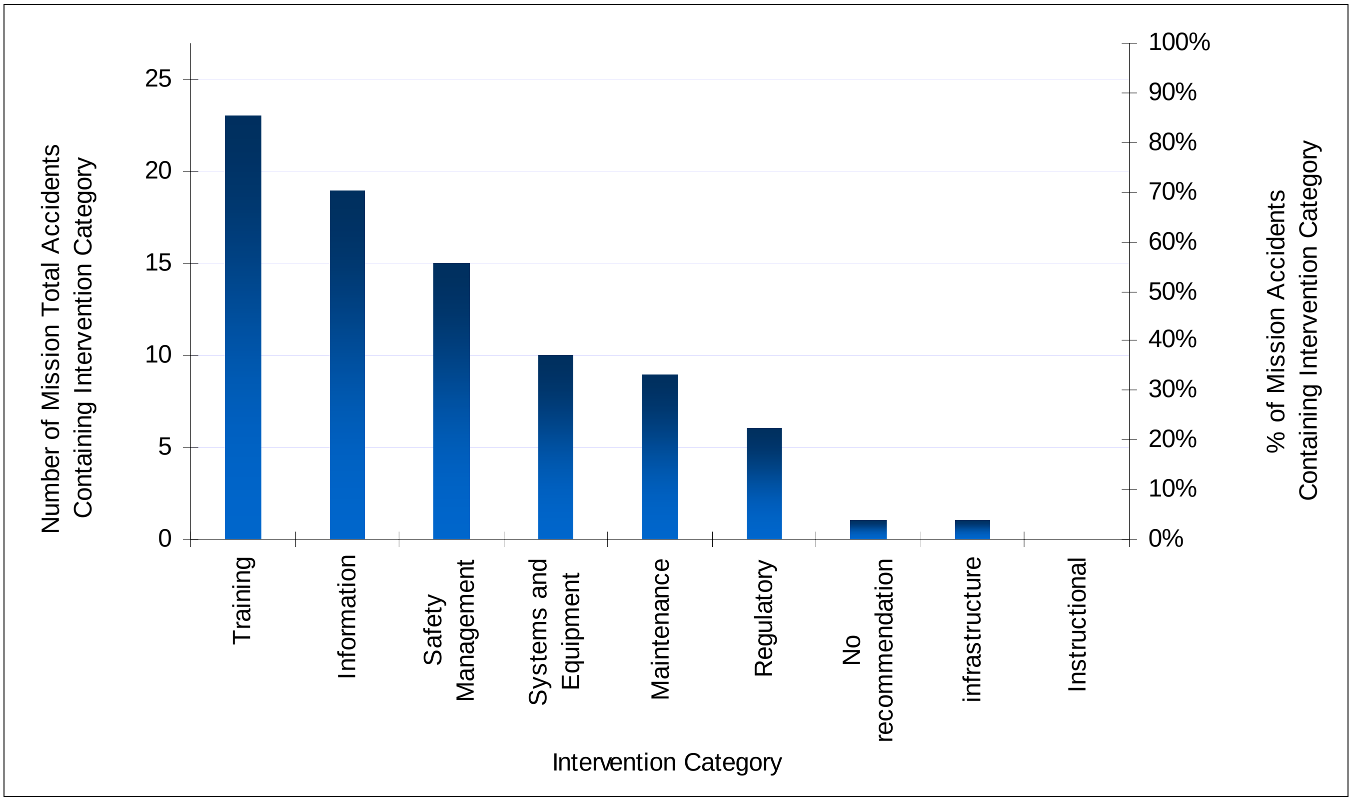


Figure 6-14. Intervention Categories for Personal / Private (27 Accidents Analyzed)

169 safety interventions were identified in 6 areas for Personal / Private operations:

1. Training accounted for 40.8% of intervention recommendations for this mission type. Increased knowledge of the aircraft, its performance limits and its systems were recommended a significant number of times. Training in awareness of various issues including mission risk, risk assessment, identification of critical cues and aircraft state with associated mitigation techniques is recommended. Improvement in basic and emergency maneuver skills was recommended as mitigation against a number of accidents.
2. Improvement in Maintenance (29 interventions) quality assurance and control should reduce the possibility of malfunctions that relieve the pilot of performing emergency maneuvers. Part / System Failure rates, at least in this mission, could also benefit from improved maintenance practices.

3. Increased emphasis on Safety Management (25 interventions), including risk assessment and management and adherence to SOP are necessary to improve accident rates in this mission group.
4. Install cockpit recording devices that will enable mishap investigators to understand cockpit indications and pilot actions prior to a crash. Cockpit imaging devices also provide information for company management to provide non-punitive corrective actions for pilot / crew performance anomalies. Informational issues were similar to the total for the year.
5. Improvements in Aircraft Design incorporating cockpit warnings in the area of aircraft performance monitoring and proximity detection are recommended. Wire strike protection may have reduced risk in one fatal accident and reduced injury in the other power line accident in this mission group.
6. Regulatory recommendations include better oversight by FAA of private operations.

6.3.2.6 Personal / Private – Prioritized Safety Recommendations

With a significant quantity of the accidents resulting from Pilot Judgment and Actions and from Training noted in a high percentage of interventions, each of the recommendations below will cross several causal factors. Increased knowledge of the aircraft and its performance, improved flying skills and better awareness of situational and risk factors should all have benefits in the reduction of this mission's accident numbers.

1. Establish a Personal / Private risk management training program and distribute through general aviation media or FAA safety programs.
    - Develop a stand alone risk assessment / management handbook for the Part 91 community (a fit to size SMS program).
2. Emphasize the importance of model-specific training on aircraft performance and systems to owners and rotorcraft CFIs; encourage more time be spent on this during biannual check-rides.
    - Include emphasis on carburetor ice and other performance limiters published in the Aircraft Flight Manual.
    - Increase use of simulator training on aircraft performance and emergency procedures. Desktop and software-based aides may be useful to increase rotorcraft knowledge.
3. Develop and integrate into training programs autorotation training aids, simulators, etc.
4. Encourage compliance with published preflight check procedures.
5. Increase training emphasis on maintaining awareness of cues critical to safe flight, including situational and proximity awareness.
6. Inform owners and mechanics of the importance of following the published maintenance or ICA procedures with confirmation of compliance. Increase awareness of proper records management and military surplus parts risks.
7. Consider requiring system data recording for new production aircraft (HUMS / Engine Monitoring System).
8. Increase awareness of common accident causes through publication of accident scenarios and root causes. Publish in general aviation media or the FAA Federal Aviation Administration Safety Team (FAAST) program.
9. Encourage the installation of cockpit recording devices.
10. Conduct more comprehensive accident reporting, investigation and documentation.

6.3.3 Mission Specific Findings – Aerial Application

6.3.3.1 Aerial Application – Mission Definition

Aerial Application involves use of rotorcraft to apply fertilizers, pesticides, herbicides, or other material to agricultural or forest land. These missions rely on pilots usually flying their helicopter lower than 50 feet above the ground and in close proximity to wires, poles and trees. Operations range from single aircraft, pilot / owner operations where pilots and one ground crewman load, fuel and service the aircraft (sometimes with rotors turning and from elevated platforms) to larger multi-aircraft and crew operations. The helicopters used in this environment are a combination of standard and restricted category-certificated helicopters. In the context of JHSAT, Aerial Application missions do not include firefighting, where helicopters are used to apply water or retardant to fires.

6.3.3.2 Aerial Application – Synopsis of Accidents Analyzed

Aerial Application operations accounted for the third highest number of accidents in the year 2000. Of the 197 accidents analyzed in the NTSB year 2000 dataset, 28 accidents involved Aerial Application operations, representing 14% of the accidents analyzed for the year. Restricted category / military surplus aircraft were involved in 25% of all of the accidents in Aerial Application. 145 problems with 142 interventions are identified for Aerial Application accidents.

6.3.3.3 Aerial Application – General Characteristics of Accidents Analyzed

The 28 Aerial Application accidents generally involved collisions with the ground or objects secondary to another event, usually not a mechanical failure. Nine of the accidents involved power losses, with four of those being triggered by inadequate planning and fuel starvation or exhaustion (three turbine powered and one reciprocating engine helicopter). The other powerplant failures (except one with an unknown cause) were triggered by fuel contamination, carburetor ice, FOD and a turbine failure. Six accidents involved collisions with wires; five of the six occurred during spray runs or while turning to begin a spray run and five involved reciprocating engine helicopters. Some of the accidents were initiated in low visibility conditions that contributed to the accident cause; one resulted from LTE during a turn to begin a spray run. Three occurred when pilots became distracted – two attempted takeoffs while still partially tied down or attached to a resupply hose, and one occurred when a pilot struck a wire during a spray run while referring to a map. Four accidents had non-powerplant related mechanical contributors: two tail rotor counterweight failures (one a suspected unapproved part), a main rotor pitch control component and an inadequately lubricated tail rotor drive shaft coupling.

Aircraft. Of the aircraft involved in Aerial Application accidents, 13 of the 28 had reciprocating engines. The remainder had turboshaft engines. Only one of the accidents occurred in a twin engine aircraft. Seven of the 28 aircraft were identified as restricted category / military surplus helicopters.

Accident Times. The Aerial Application accidents in calendar year 2000 occurred between January and October. There were no accidents in the months of November and December. A majority of the accidents (24) occurred between the hours of 0700 and 1630 local time. One accident occurred at 0430 in June and one at 1900 hours in May. Those two accidents occurred in the spring months where twilight conditions occur earlier in the mornings and later in the evenings.

Visual Conditions. NTSB data indicates that 4 of the 28 accidents occurred in IMC with 1 recorded during Night-Dark conditions. Two of the remaining 3 IMC accidents occurred in daylight, the other at dawn. Surprisingly, the number of accidents occurring in degraded visual conditions (IMC, other than daylight) is rather low considering that night, dusk and dawn are preferred times to spray in agricultural operations, due to low wind conditions. The majority of the accidents were reported in VMC, daylight.

Phase of Flight. The majority of Aerial Application accidents occurred during maneuvering flight (15 of 28; 54%). The NTSB considers maneuvering flight in Aerial Application to include spraying runs and the turn-around maneuvers that occur between spraying runs. The next two most frequent phases were takeoff and cruise: 4 (14%) each. The remainder was spread evenly among the remaining phases of flight. Two of the takeoff accidents occurred when the pilot and ground crew failed to ensure the aircraft was “disconnected” from the ground: supply hoses still in tanks or tie downs had not been removed. The remaining two takeoff accidents occurred as a result of power loss immediately after lift off.

Pilot Demographics. The Aerial Application missions analyzed involved highly experienced helicopter pilots. 13 of the 28 pilots (46%) involved in the analyzed accidents had greater than 10,000 hours of total pilot time. Nine of the 13 reported over 5,000 hours of rotorcraft time, with 5 of those reporting greater than 10,000 hours of rotorcraft time (18% of the analyzed accidents). Only eight of the pilots reported less than 5,000 flight hours total flight time, and only two of those reported less than 1,000 rotorcraft hours. Seven pilots reported fewer than 500 hours in the accident make and model helicopter. Two of the pilots involved in the IMC accidents had no flight hours reported. The remaining two pilots involved in IMC accidents had 22,900 total / 9,650 rotorcraft and 4,030 total / 2,225 rotorcraft hours respectively.

Injuries. The data showed that there was only one person on board each of the Aerial Application accident aircraft for a total of 28 persons involved in all the accidents. There were three fatal accidents involving Aerial Application missions, accounting for 2% of overall fatal accidents and 11% of the Aerial Application accidents. 53% of the Aerial Application accidents had no injuries reported; 21% had minor injuries reported; 14% involved serious injuries.

6.3.3.4 Aerial Application – Problem Areas Identified

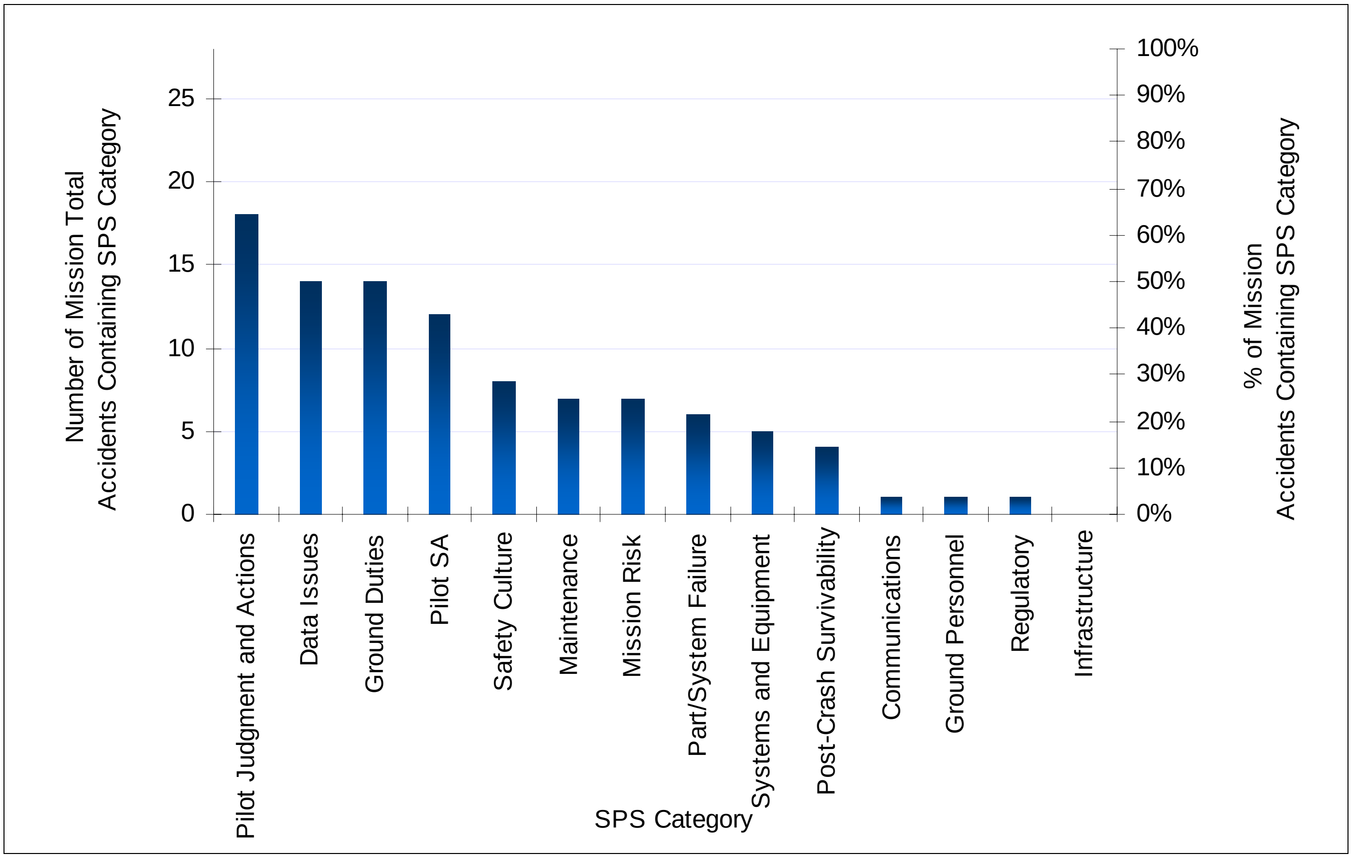


Figure 6-15. SPS Categories for Aerial Application (28 Accidents Analyzed)

145 problems were identified across 12 problem categories:

1. The Pilot Judgment and Actions category was the most frequently cited in the analysis results, appearing in 18 of the 28 accidents (64%). These problems ranged from disregarding cues and willful disregard for rules and standard operating procedures to inadequate landing procedures. Pilot Judgment and Actions issues are illustrated in Figure 6-15. Example events include apparent failure to properly plan flight time for the fuel on board, over-flying the fuel on board duration, or flying in a low altitude and low speed regime where an autorotation would not be successful. Additionally, there were instances of pilots not ensuring ground

equipment was detached from the aircraft after refueling or reloading operations or the aircraft was free of its tie-downs.

2. Data Issues accounted for 14 of the identified problems for the mission group. Although the accident reports had sufficient detail to make reasonable findings, they did not have data sufficient to develop conclusive assumptions that would allow investigators to make detailed root cause findings. In 14 accidents, data to conclusively determine crew actions was not available to investigators.

3. Ground Duty problems occurred in 14 of the Aerial Application accidents (50%). Figure 6-15 shows the breakdown of problem statements within the Ground Duties SPS category. There are eight distinct SPSs, primarily targeting preflight activities. For instance, the most frequently cited statements relate to issues where the pilot did not adequately assess mission needs or plan adequately to deal with an emergency or other contingency. Considering the low altitude and relatively low airspeeds that the mission requires, coupled with the desired environmental conditions (calm winds that are usually found in twilight conditions), the JHSAT found that the need for pre-planned contingencies procedures were too important to ignore.

   The remainder of the accidents reflect issues such as failing to have an adequate pre-flight or thru-flight process where the pilot and ground crew ensure the aircraft is ready for flight. Specifically, the aircraft has sufficient fuel on board, is still not tied down or does not have ground equipment (filler hoses, etc) still attached to the aircraft.

4. Pilot Situation Awareness was the fourth most frequent problem category, appearing in 43% of Aerial Application accidents (12 of 28). There are 10 distinct problem statements that address the external environment and visibility (7 of 10; 70%). Two of the problem statements correlate to the Ground Duties problem category in that they cite the pilot for being unaware that the aircraft was not ready for flight (i.e., still being tied down or attached to ground equipment). The one “global” problem statement (“Failed to recognize cues to terminate current course of action”) relates to an accident where improper maintenance resulted in the failure of the tail rotor drive shaft. In this particular accident, the JHSAT concluded that the pilot probably had indications of problems prior to the tail rotor drive shaft failure and either elected to fly the aircraft in an un-airworthy condition or neglected to land that aircraft immediately after experiencing anomalies.

5. Safety Culture is applicable to all operations regardless of size. The SPS sub-category titles such as “Management” and “Safety Program” have stereotypical meanings pointing to large organizations. However, any and all operators can have a safety culture that encompasses all of the hallmarks without a “large organization”-type program. Eight of the 28 Aerial Application accidents had Safety Culture cited as an issue (29%). There were seven specific SPSs cited. Four of the seven SPSs relate to managing safety and risk. Inadequate risk management and management policies / oversight indicate that the owner of the operation (whether a single owner-operator or a company) did not have adequate policies or programs in place to monitor and control risk. The SPS “Safety program inadequate” indicates that there was not a safety program in place in the one accident in which it appeared. The SPS “Lack of monitoring of flight operations data” directly relates back to management policies and oversight. Finally, there was a crew selection and training component in two SPSs that cited pilot experience coupled with the crew hiring criteria. In these accidents, pilots flew aircraft they were not familiar with – low time in make and model (153 hours and 10 hours respectively) – but had fairly high time overall or high time in rotorcraft.

6. Maintenance: Five of the 28 Aerial Application accidents had quality of parts issues. Four involved use of bogus, surplus or unapproved parts. One of the accidents involved contaminated fuel. Five of the accidents involved management of maintenance and maintenance procedures divided evenly between the standard problem statements. The two sub-categories are related in that the management of maintenance is the safety net for performance of maintenance. Improper maintenance and / or failure to detect impending failures were factors identified in 3 of the accidents. The nature of Aerial Applications operations, being a smaller independently owned and cost-driven community, is that it is subject to environmental and seasonal influences. These factors can lead to delaying necessary inspections and / or maintenance.

7. Part / System Failures were involved in 6 (21%) of the accidents. 18% involved the failure of the tail rotor drive system or tail rotor itself. One of the accidents involved the use of unapproved parts. One involved

failure of an engine component. Part / System Failure and Maintenance account for 46% (13) of the Aerial Application accidents. The correlation between the two is difficult to make statistically due to the lack of information in accident reports. The JHSAT consensus was that these two problems statements are interlinked and without significant improvement in both areas the accidents will continue.

The six failure areas identified all are dealing with highly loaded / stressed dynamic components. As mentioned above, the nature of the Aerial Applications mission can lead to delaying necessary inspections and / or maintenance. Inspecting and replacing – and identifying anomalies in dynamic components – is critical to the continued operational safety of all helicopters.

Another factor identified was higher usage of military surplus and restricted category helicopters for Aerial Application. When these aircraft are purchased, they are only supplied with the maintenance manuals up to the date of release from the military. The helicopter may or may not be included in a type certificate and may be limited to the distribution of airworthiness publications and revised maintenance manuals, some of which may be critical to the safe operation of the aircraft.

8. Mission Risk: Seven SPSs relate to the mission risk of flying low in obstruction rich / hostile environments, and operating continuously outside the height-velocity (HV) diagram, where likelihood of a successful emergency landing is greatly reduced. The requirement that Aerial Applications be conducted at low altitude can not alleviate some the involved hazards. The best opportunity for operator intervention is effective operator management and control of mission risk. As stated in previous problem statements discussions, “Inadequate risk management and management policies / oversight” indicate that the owner of the operation (whether a single owner-operator or a large company) did not have adequate policies or programs in place to monitor and control risk. A “Safety program inadequate” SPS indicates that there was not a safety program in place in the one accident in which it appeared.

9. Post-Crash Survivability: The helicopter community has adapted existing Part 27 and 29 civil helicopters and military surplus helicopters to the Aerial Application mission. All three cases of fires in Aerial Applications involved aircraft that were piston-powered and did not have a CRFS. There were only 7 aircraft that had CRFS and they were all military surplus helicopters. The JHSAT determined that Aerial Application mission risks are high, and incorporation of crash resistant fuel system features would greatly enhance the overall safety of the Aerial Applications community.

10. Communications: There are 2 standard problem statements, primarily targeting communication activities between the PIC and ground personnel. The two accidents cited statements relating to inadequate loading processes and coordination with ground personnel. As with any helicopter operation, the key to safety is developing a safe, consistent standard operating procedure / process. The term Crew Resource Management is not intended to deal just with operations and crew inside the aircraft, but should be applied to all operations and crew outside the aircraft as well. Communication is imperative to the success of any operation. The JHSAT found that the need for pre-planned / checklist procedures were important throughout the helicopter community.

11. Ground Personnel: There was one SPS targeting ground personnel’s “failure to disconnect.” This accident involved personnel on the ground failing to disconnect a loading hose from the nurse truck and the pilot failing to ensure the loading hose was disconnected. This accident highlights the importance of effective communication between the PIC and ground personnel. As discussed above, the key to safety is developing a safe, consistent standard operating procedure / process. The JHSAT found that the need for pre-planned / checklist procedures were important throughout the helicopter community.

12. Regulatory: The JHSAT spent considerable time discussing the role of bogus, surplus or unapproved parts use in Aerial Applications. There is currently no formal method for the FAA to track and / or control military surplus parts. Although one standard problem statement directly relates to regulatory oversight, the entire Aerial Applications accident data indicates 15% of the accidents involved the use of bogus, surplus or unapproved parts. Increased federal oversight of Type Certificate holders who rebuild military surplus aircraft and parts brokers critical to safety would reduce the use of unapproved parts and reduce the risk of accidents. With the predominate number of small operators involved with Aerial Application aircraft and the considerable cost of operating helicopters, the chances are likely of either knowingly or unknowingly using

un-airworthy parts is greatly increased. The JHSAT concluded that this is not solely an FAA problem and there is a need for the government agencies involved – General Services Administration (GSA), Department of Defense (DOD) and Federal Aviation Administration (FAA) – to develop a process to improve the tracking of surplus / military parts released to aviation community.

6.3.3.5 Aerial Application – Safety Interventions Identified

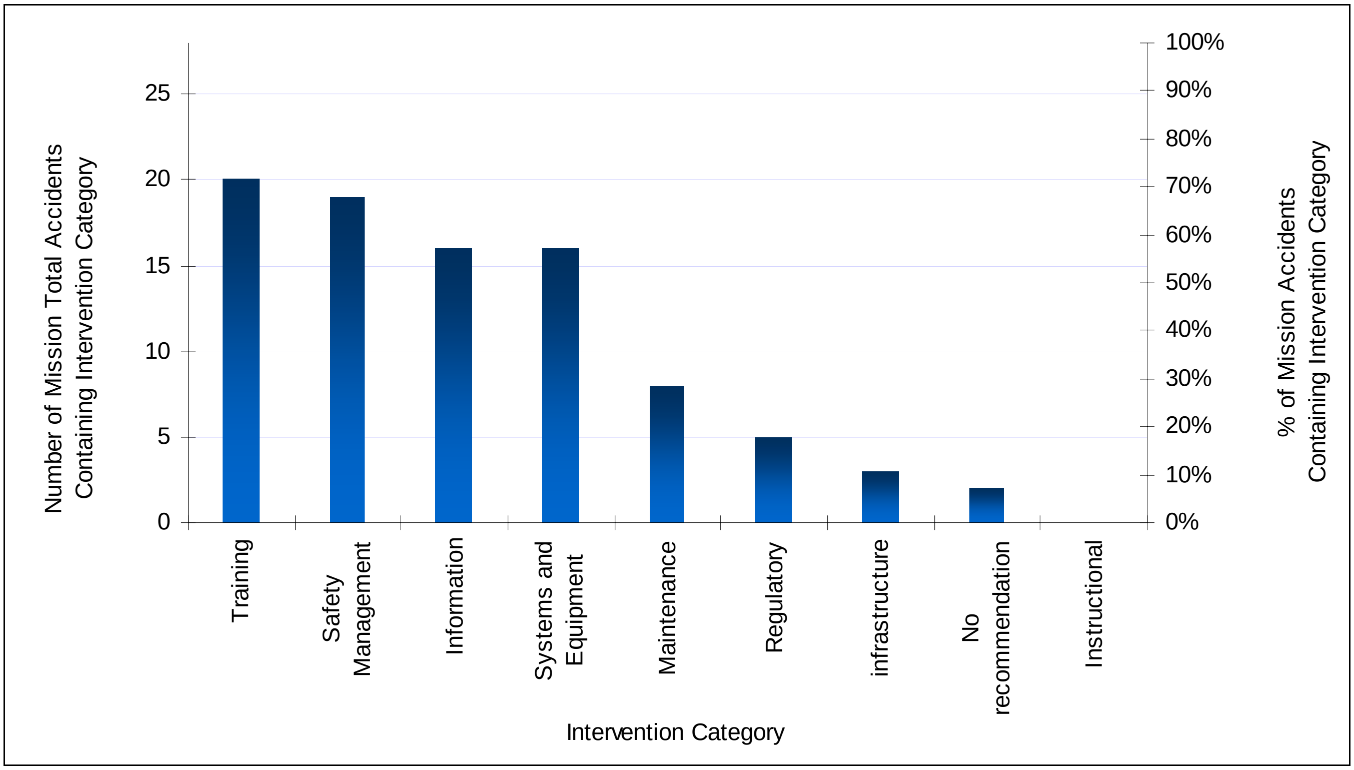


Figure 6-16. Intervention Categories for Aerial Application (28 Accidents Analyzed)

142 interventions were identified across seven intervention categories. The largest clusters of interventions in Aerial Applications are in Risk Assessment and Management, Standard Operating Procedures, Systems and Equipment, and Training.

1. Systems and Equipment: Four interventions target systems and equipment problem statements. Three of the interventions involve installing wire strike protection systems (WSPS) and / or proximity detection systems for low level wire detection. Work with the National Agricultural Aircraft Association (NAAA) to develop a Best Practices Guide for the design and modification of helicopters for agricultural use. Furthermore, with NAAA to ensure operators are aware of and capable of tracking component safe lives (airframe, drive train and power plant) are uniform and correctly applied by the operator community, ensure that the type design holder adequately applies lessons learned to those aircraft active in Aerial Application operations.
2. Communications: There are two interventions, primarily targeting communication activities between the PIC and ground personnel. The two accidents cited statements relating to inadequate loading processes and coordination with ground personnel. The term Crew Resource Management is not intended to just deal with operations and crew inside the aircraft but should be applied to all operations and crew outside the aircraft as well. Communication is imperative to the success of any operation. The JHSAT found that the need for pre-planned / checklist procedures were important throughout the helicopter community.
3. Data Issues: Install cockpit recording devices that will enable crash investigators to understand cockpit indications and pilot actions prior to a crash. Cockpit imaging devices also provide information for company management to provide non-punitive corrective actions for pilot / crew performance anomalies.

4. Ground Duties: The JHSAT identified 20 interventions targeting the ground duty problem category. 11 of the ground duties interventions (55%) are in the Safety Management category. Five of them recommend establishing standard procedures for departments, risk assessment and management, remote operations, and checklist usage. Four of them relate to improving or enforcing use of checklists. Two of the interventions call for establishing risk assessment programs and establishing training programs.
5. Ground Personnel: One accident involved ground personnel inadvertently leaving the loading hose attached to the aircraft. The pilot could not see the hose and was unaware that the hose was attached. The intervention dealt with possible cockpit indication when ground equipment is still attached to the aircraft. As with any helicopter operation the key to safety is developing a safe consistent standard operating procedure / process. The term Crew Resource Management is not intended to just deal with operations and crew inside the aircraft but should be applied to all operations and crew outside the aircraft as well. This particular intervention parallels Ground Duties, Communications and Safety Culture.
6. Maintenance: Improve critical aspects of maintaining the aircraft used in Aerial Applications. Given the severe usage environment of these aircraft, maintainers need the means to detect component problems prior to critical part failure in flight. This can be accomplished by simple trending equipment similar to HUMS. Cost effective solutions will be needed. Military surplus aircraft were also found to be used in Aerial Applications; maintenance standards equivalent to those expected for civil aircraft should be developed and adopted by these users.
7. Mission Risk: Lack of adequate mission risk assessment was also found to be present in the accident causal chains. Aerial Application operations carry inherent mission risk that compounds the consequences of poor pilot decision making and / or component failures. A significant part of the mission profile involves flying low, slow and heavy, often operating the aircraft in the shaded (keep-out) portion of the HV diagram, and in close proximity to obstructions. A formalized risk assessment tool developed specifically for and with the Aerial Application operators could assist operators in recognizing and consistently accounting for the risk on each Aerial Application flight.

   Analyzing mission risk as part of an overall risk assessment and management program is part of a larger safety management system imbedded within an operator's safety culture. Recognizing and consciously preparing for operations within the mission's required flight envelope should help minimize the risk of operating in that envelope.
8. Part / System Failures were also determined to be a part of accident causal chains. When operating in confined areas, the exposure to inadvertent contact with obstructions increases, which can lead to hardware / component failures, such as tail rotor drivetrain-induced failures from inadvertent FOD contact and failure to inspect engine components. Operating in the Aerial Application environment also tends to limit the pilot's available options in an emergency situation. Detail oriented pre-flight inspections can assist in detecting impending part failures. None of the accidents analyzed involved helicopters configured with equipment (e.g., HUMS-type recorders) to detect impending component or part failures. The use of military surplus helicopters or operating aircraft under restricted category enhances the need for stricter adherence to maintenance procedures and schedules. Coupled with the latter, ensure that parts used to repair military surplus and restricted category aircraft are not unapproved parts and have a pedigree to decrease risk of part failure inherent in the use of unapproved parts.
9. Pilot Judgment and Actions: 21 specific interventions were identified to help mitigate Pilot Judgment and Actions problem statements. 7 (33%) of the Pilot Judgment and Actions interventions relate to assessing and managing risk and were identified in 10 of the 28 accidents. In the Aerial Applications operating environment where most of the pilots are high time and can be considered "experienced," risk assessment and management was felt to be the most effective way to decrease Aerial Application accidents. The JHSAT felt that providing pilots and operators tools to help them identify hazards and develop mitigations will raise their awareness, leading to more informed decision making. 5 (23%) of the Pilot Judgment and Actions interventions relate to training outside of risk management and appeared in 5 of the accidents. Although training may not be considered the most effective mitigation for problems, in this case, training provides both the knowledge and motor-skill currency (i.e., recognition and actions for events that will result in an autorotation) that diminish

over time. Four of the interventions revolve around providing pilots cues to enhance their awareness of the aircraft's status. Increasing awareness of aircraft state particularly applies to the older aircraft that were not required to have certain equipment installed when they were certified. An example is a low fuel warning indicator or annunciator other than the fuel gauge. Another example would be a separate low airspeed alerting or warning system other than the airspeed indicator. Two of the interventions establish standard operating procedures for weather and checklist procedures.

10. Pilot Situational Awareness: The JHSAT identified 16 interventions for the Pilot SA problems found in Aerial Application accidents. Six of the interventions involve installing additional systems and equipment on the aircraft to help enhance the pilot's awareness of aircraft status and hazards. In this environment, most of the aircraft are older or are military surplus and do not have some of the equipment provided on newer helicopters to provide pilot with information beyond that presented on gauges. Five training interventions were identified, the most frequent of which was "Mission specific risk assessment training – Ag Ops" (4 accidents). This intervention is also identified in Pilot Judgment and Actions three times. The JHSAT thought that by providing the tools to assess and manage risk in Aerial Applications accidents, the pilots and crews may make a more formal and conscious assessment and plans for contingencies. The remaining training interventions relate to weather, IMC and recurring training.
11. Post-Crash Survivability: FAR Part 27.952 identifies the crash resistant fuel systems for helicopters. All three cases of fires in Aerial Applications involved aircraft that were certified and manufactured under the original Civil Aviation Regulation (CAR) 6 requirements. Since this time, many OEMs and STC houses have developed improved crash worthy fuel systems for those early aircraft. All three cases of fires in Aerial Applications involved aircraft that were piston-powered and did not have a CRFS. There were only 7 aircraft that had CRFS and they were all military surplus helicopters. Work with the National Agricultural Aircraft Association (NAAA) to develop a Best Practices Guide for the design and modification of helicopters for agricultural use, and encourage the use of current crash resistant designs where applicable by modification.
12. Regulatory: Make improvements to regulatory guidance, oversight and rulemaking. The regulatory agencies should offer more comprehensive guidance to augment FAA Advisory Circular 137-1, "Agricultural Aircraft Operations" [Ref. 10 in Appendix I]. Additionally, the FAA should increase oversight of facilities responsible for maintaining and supplying parts / components for helicopter operators. The FAA Rotorcraft Directorate should ensure timely correction of components not meeting type design supplied by the type design approval holder.
13. Safety Culture: Aerial Application operators should adopt basic Safety Management Systems concepts. Given the inherent risk in Aerial Application, the owners of these operations should develop and adopt policies and procedures that assess and minimize risk. Specific to the findings of the accidents analyzed, the policies and practices should include measures to address operational risk assessment methods, risks associated with improper maintenance, risks associated with inadequate hiring practices and methods to target pilot and crew training focused on operating within published aircraft limitations.

6.3.3.6 Aerial Application – Prioritized Safety Recommendations

Looking at the Aerial Application accidents and the interventions proposed, the JHSAT makes the following recommendations:

1. Develop and distribute "fit for size" Safety Management System development and implementation tools. The tools and systems should recognize the variability of size, types of operators, and fleets used in Aerial Application. A one-size-fits-all or a traditional safety management system template may not work. Developing a comprehensive safety management system will help address the following interventions:
    - Safety culture
    - Risk assessment and management
    - Training and communications (through CRM)
    - Maintenance
    - Some aspects of pilot judgment and actions

2. Develop and encourage implementation of best practices for development of standard operating procedures covering both operations and maintenance in the Aerial Application community.
3. Encourage installation of protective hardware like wire strike protection systems (WSPSs) or other proximity-obstacle detection systems that will enhance the pilot's awareness of hazards.
4. Encourage installation of annunciations and / or warning indications to help increase pilot awareness of aircraft state and assist in decision making.
5. Work with National Agricultural Aircraft Association (NAAA) to develop a Best Practices Guide that identifies:
   - The need for clear and concise communications between the pilot and ground personnel.
   - A means for operators to receive and respond to current safety information / issues.

6.3.4 Mission Specific Findings – Emergency Medical Services (EMS)

6.3.4.1 Emergency Medical Services – Mission Definition

The first civilian Helicopter Emergency Medical Services (HEMS) program was started in 1972. Since then, the industry has grown to approximately 792 helicopters transporting over 500,000 critically ill or injured patients a year. That's 1,500 flights per day or a little more then one takeoff every 60 seconds. The public sector (i.e., government sponsored EMS) accounts for 10% of the aircraft. The civilian sector (i.e., company / commercial owned and operated) accounts for the balance. In the civilian sector there are two basic business models. The traditional model and the community-based model. In the traditional, or hospital-based model, a hospital would contract an aviation vendor to supply the helicopter, mechanics and pilots, as well as all the support needed to maintain an operation, such as parts, insurance, etc. Aircraft supporting this model may be based at hospital helipads or at local airports. The second model is an independent provider, or community-based, model. In this model the aviation company in effect becomes the health care provider, providing the helicopter as well as the medical staff. Total responsibility is assumed by the operator, including the medical control, billing and collections. Many of these programs have no direct affiliation with the hospitals themselves, but are based within the community, often at local airports. Government-sponsored entities are normally funded by tax revenue or state automobile licensing fees. They are most often located at local airports or municipal helipads.

EMS operations entail providing pre-hospital, or out-of-hospital, acute medical care services to patients suffering injuries or illnesses. While fixed wing airplanes provide some of these transportation services, the majority, by far, are provided by helicopters. Requests for Emergency Medical Services are of two types – on-scene or inter-facility – and generally come from one of three sources. The sources most familiar to the average public citizen are the first responders (i.e., ambulance crews, fire fighters or police agencies), who, upon determining that an injured or acutely ill individual's physical condition requires faster transportation to a hospital than is available by ground ambulance units, will request a helicopter pick up at the site (on-scene) of the event. The second source of requests is a hospital emergency department, upon determining that an admitted patient requires services beyond the capability of that emergency department's and (by extension) that hospital's staff. Such inter-facility transports usually begin at the sending hospital's helipad and end at the receiving hospital's helipad. The third type of request (also an inter-facility transport) comes from one of a hospital's specialty departments having determined that an individual requires equipment or clinical expertise beyond the capability of that hospital.

The emergency nature of the three types of requests, coupled with the explosive growth in the EMS air ambulance industry country-wide, serve to apply both humanitarian and competitive pressures on the pilot to launch when risk factors may suggest otherwise. EMS helicopter pilots are routinely called upon to land in unfamiliar, unimproved, and hastily established landing areas, frequently at night. Though hospital helipads provide a more formalized landing area, these have little standardization, and are generally uncontrolled by air traffic (i.e., FAA) communications services. The distances between sites (scenes to hospitals and between hospitals), coupled with the limited availability of approved weather reporting services at hospital helipads and at remote landing zones (LZ), means that EMS helicopter pilots are forced to extrapolate much of their weather forecasting based on their own experience-gained familiarity with the areas in which they fly. Although company flight following is currently providing more operational oversight and risk management than existed in CY2000, most often in the dataset examined in this study, it was the EMS pilot (usually away from the support of his own home base) who assessed the risks of a particular flight (weather, landing site suitability, estimated power available to hover, fuel required to reach the various probable destination hospitals, etc.) and determined if the flight could be completed safely.

6.3.4.2 Emergency Medical Services – Synopsis of Accidents Analyzed

Of the 197 accidents analyzed in the NTSB year 2000 dataset, 12 accidents involved EMS operations. This represented 6.1% of the accidents analyzed for the year. 104 Interventions were identified from analyzing the CY2000 EMS accident data.

6.3.4.3 Emergency Medical Services – General Characteristics of Accidents Analyzed

All 12 accidents were in turbine engine powered helicopters. Three accidents (25%) were in single-engine helicopters and nine (75%) were in twin-engine helicopters. Four accidents (33%) took place during on-scene operations. Six accidents (50%) occurred after the patient had been delivered to the receiving hospital. One accident (8%) occurred during post-maintenance evaluation and one (8%) occurred while returning the aircraft to the hospital helipad after refueling.

Of the 12 accidents, four (33%) involved fatalities. In all, there were 11 fatal injuries, one serious injury, nine minor injuries and 10 non-injuries. Significantly, when there were fatalities, it included all occupants. The four fatal accidents all took place during cruise flight. Eight accidents (66.6%) occurred at night. Six of those – or 50% of the total HEMS accidents and 75% of the night HEMS accidents – occurred in Dark Night conditions. Dark night would provide conditions similar to IMC with little or no visible horizon. Seven accidents (58.3%) involved either Controlled Flight into Terrain or Controlled Flight into an Object. Loss of Tail Rotor Effectiveness was indicated in one accident (8%). Two accidents (16%) had maintenance errors as contributors. In one case, improper maintenance inspection resulted in a loss of aircraft control and in the other, improper troubleshooting, coupled with pilot disregard for the Aircraft Flight Manual (AFM) limitations, resulted in transmission seizure due to loss of oil pressure. Only one accident (8%) was the result of attempting to maintain visual reference in IMC. Two of the four on-scene accidents (16% of the total) were the result of striking objects while hovering in the landing zone during night. Three of the twelve pilots (25%) held Airline Transport Pilot (ATP) certificates. The remaining nine (75%) held Commercial Certificates with Instrument ratings. Instrument currency was not reported in the accident information. This becomes significant, considering seven of the 12 accidents (58.3%) occurred in either IMC or Dark Night conditions. Pilot flight experience ranged from a low of 2,500 hours to the highest time pilot’s 10,379 hours. The second least experienced pilot had 3,100 hours. Experience in make and model ranged from 28 hours to 1838 hours, with three pilots having less than 100 hours in the make and model of the accident helicopter.

6.3.4.4 Emergency Medical Services – Problem Areas Identified

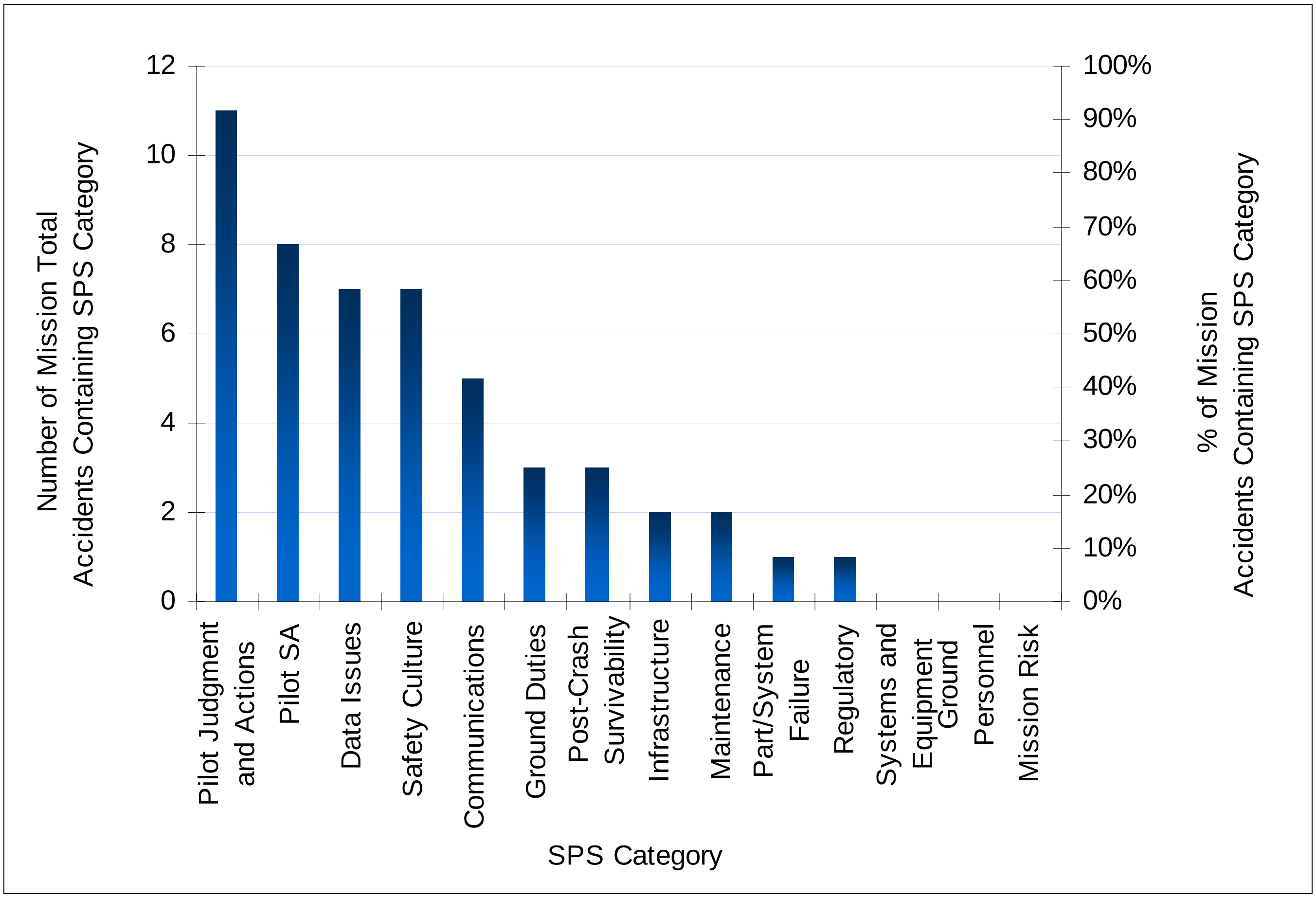


Figure 6-17. SPS Categories for EMS (12 Accidents Analyzed)

104 individual problems were identified, falling into 11 major categories: Pilot Judgment and Actions, Communications, Data Issues, Ground Duties, Infrastructure, Maintenance, Part / System Failure, Pilot Situational Awareness, Post-Crash Survivability, Regulatory and Safety Culture.

1. Pilot Judgment and Actions issues were noted in 11 of the 12 accidents. The leading Pilot Judgment and Actions issues were inadequate ADM in 48% of Pilot Judgment and Actions problems, unsafe flight profile in 22%, and inadequate landing procedures (lack of LZ recon) also in 22% of the Pilot Judgment and Actions problems.
2. Communications issues involved a lack of coordination with other crewmembers.
3. The Data Issues were primarily due to a lack of data available to the accident investigators.
4. Ground Duties issues were noted in 3 (27%) of the accidents.
5. 19 Infrastructure problems (18.3%) were related to equipment, flight profile, pilot / aircraft interface, pilot decision making, landing procedures and procedure implementation. These Infrastructure problems were cited in 30 instances (28.8%). Unsafe flight profiles, poor decision making, and disregard for significant cues accounted for 19 of these 30 instances (63.3%).
6. As previously mentioned, Maintenance problems contributed to two accidents. The issues were Maintenance Management (e.g. “Failure to supervise”) and Performance of Duties (e.g. “Failure to follow proper procedure”).
7. Both Parts / System Failure issues occurred in the same accident and were the result of inadequate oil pressure within the main transmission.

8. Pilot Situational Awareness problems contributed to 8 of the 12 accidents (66%) and were cited in 6 of the 8 night time accidents (75%).
9. Post-Crash Survivability was cited as a problem in 3 of the accidents (25%) and centered primarily on lack of installed safety equipment.
10. Regulatory failure ("Failure to disseminate pertinent flight safety information") was cited only once.
11. By contrast, Safety Culture, in 7 sub-categories was cited in 23 instances (22%). Pressure to fly and inadequate risk management was indicated in 10 of these. Lack of management oversight to provide defenses against such failures was cited an additional 6 times.

6.3.4.5 Emergency Medical Services – Safety Interventions Identified

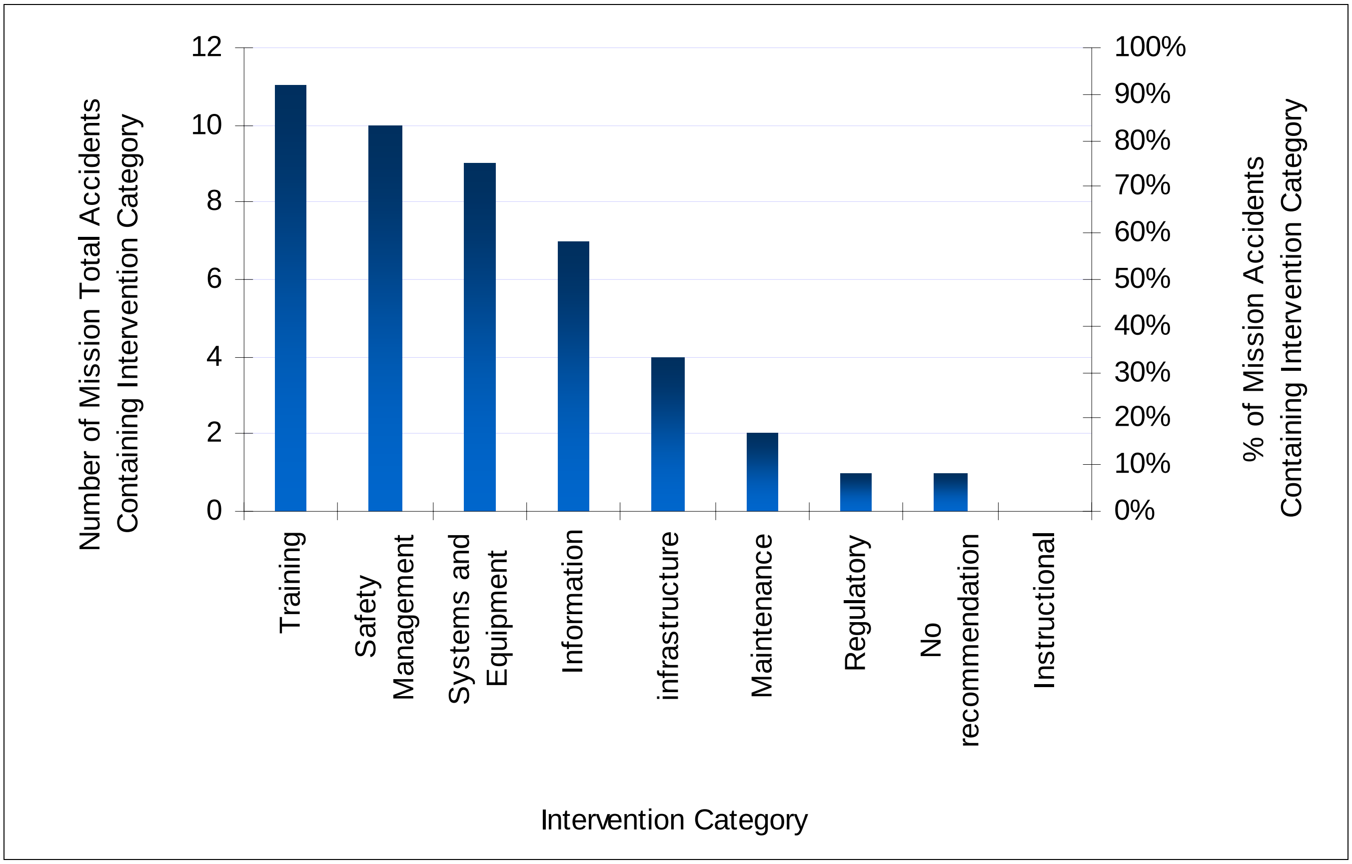


Figure 6-18. Intervention Categories for EMS (12 Accidents Analyzed)

The proposed interventions fall into seven categories. These were Systems and Equipment, Information, Infrastructure, Maintenance, Regulatory, Safety Management, and Training. Of the 104 interventions identified, 29 were in the Safety Management category (27.8%), 26 were in Training (25%), and 19 were in Systems and Equipment (18%).

1. Of the 29 Safety Management interventions, 9 were further categorized as Risk Assessment recommendations. These generally involved recommendations for formalized risk assessment programs and tools. Another 5 of the 29 Safety Management interventions dealt with risk management and included recommendations for company implementation of Safety Management Systems and use of risk management tools (to include evaluation of minimum enroute altitudes). Standardized Operating Procedures for checklist usage, landing zone operations, preflight conduct and pilot weather analysis constituted another 7 of the 29 Safety Management interventions. Thus, 21 of the 29 Safety management interventions (72.4%) directly point to the need for adoption of Safety Management Systems by EMS operators.

2. The majority of the 26 Training intervention recommendations (specifically, 11 of them) involved either adoption of the Air Medical Resources Management (AMRM) Training identified in FAA Advisory Circular (AC) 00-64 Advisory Circular, or formalized Aeronautical Decision Making (ADM) training. Another 9 intervention recommendations were for mission specific training in either conduct of EMS operations, or application of risk assessment.
3. The 19 Systems and Equipment interventions primarily focused on installation of proximity detection systems, proximity awareness systems, and enhanced vision systems.
4. Three of the remaining four intervention categories (Information, Infrastructure, and Maintenance, and Regulatory) included roughly equivalent numbers of specific intervention recommendations. The lone Regulatory intervention recommendation was for revision of an existing Advisory Circular to address improper modification of windcones (windsocks) at heliports.
5. The Information interventions reflected a need in the EMS community for recording devices to track cockpit (flight operations) data and aircraft systems operation.
6. The Infrastructure recommendations point to a need within the EMS community for standardization of radios and training for those personnel who establish the landing zones into which EMS helicopters are asked to land.
7. The overwhelming number of Maintenance recommendations fell into the sub-category of Quality Assurance. Specifically, they pointed to a need for increased oversight and adherence to established procedures.

6.3.4.6 Emergency Medical Services – Prioritized Safety Recommendations

In reviewing the Emergency Medical Services and the interventions proposed, the JHSAT makes the following recommendations:

1. Develop and use a formalized systems safety approach (i.e., SMS) to risk management and assessment to improve decision-making in flight operations and on a personal basis. Provide comprehensive risk management training to include mission-based risk assessment, weather assessment training and risk-based flight operations decision-making. The training should demonstrate that the safety culture of the organization encourages aborting or canceling the flight when the risk factors don’t justify conducting or continuing the mission.
2. Establish an operator safety culture that includes clearly communicated flight operations standards and procedures, a formalized flight operations quality oversight program, a clearly defined safety program that provides for non-punitive safety event reporting, the use of risk assessment and management practices and policy to reduce the risk of VFR flights being continued into adverse weather, and company management oversight to ensure compliance with regulations and procedures and to eliminate Procedural Intentional Non-Compliance (PINC).
3. Provide comprehensive training for all managers on their safety role in the organization and the organization’s role in providing a Safety Management System, to include safety standards and management accountability.
4. Provide training that would address: transition to a new make and model helicopter; helicopter preflight inspections; autorotation procedures and technique; recognition and response to aircraft system failures; and emergency procedures.
5. Encourage the use of new technology that would assist in raising pilots’ and crews’ situational awareness, e.g., night vision goggles (NVGs), synthetic vision systems (SVSs), terrain / proximity awareness, weather in the cockpit, GPS moving map displays, etc.
6. Develop a set of standards and a mentoring program for pilots and mechanics that places emphasis on managing / mitigating the increased risk during the following: less then one year’s service with the operator, less then one year’s experience with HEMS operations, less than one year at a particular geographical location, less then one year’s experience in a primary aircraft model.

7. Increase the frequency of and provide comprehensive ground, flight and / or simulator / flight training device (FTD) training to reduce the risk of inadvertent flight into instrument meteorological conditions (IIMC).
8. Provide comprehensive scenario-based ground and flight simulator training for Aeronautical Decision Making and risk identification and mitigation.
9. Promote the installation of cockpit data recorders (CDR) and cockpit voice recorders (CVRs), and establish a helicopter operations monitoring program (HOMP) or helicopter flight operations quality assurance program (HFOQA) to verify and improve employee flight performance. Provide feedback for scenario-based / line oriented flight training (LOFT).
10. Install cockpit recording devices to allow accident / incident investigators to understand system anomalies and pilot / crew performance that preceded an aircraft mishap.
11. Establish systems to ensure adherence to maintenance policy and procedures, and compliance with Quality Assurance requirements, with the emphasis on oversight and guidance for remote locations.
12. For OEMs: Develop a minimum equipment standard for HEMS aircraft. Emphasis should be placed on night vision-compatible cockpits, terrain / proximity awareness, weather in the cockpit, stability augmentation systems, etc.
13. For industry and operator associations: Develop an EMS community infrastructure for standardization of radios and training for those responsible for establishment and security of helicopter landing areas.

6.3.5 Mission Specific Findings – Commercial

6.3.5.1 Commercial – Mission Definition

Commercial operations involve the use of helicopters for a variety of missions typically offering a helicopter and pilot (and possibly a ground crew) for compensation or hire. The accidents analyzed encompassed a wide range of commercial scenarios: Part 135 on-demand air taxi passenger revenue service (five accidents); Part 91 positioning flights in connection with Part 135 passenger operations, Part 133 external load operations and for two undefined missions (four accidents total); commercial seismic operations (two accidents); commercial crop drying (two accidents); a Public-Use contract flight in support of the U.S. Coast Guard (USCG); a pinnacle landing training flight (commercial operation not defined). Another accident in this group involved a Canadian commercial operator flying a U.S.-Registered helicopter in Canada, but few details were provided regarding this accident.

6.3.5.2 Commercial – Synopsis of Accidents Analyzed

Of the 197 accidents analyzed in the NTSB year 2000 dataset, 16 accidents involved Commercial operations. This represented 8.1% of the accidents analyzed for the year. 104 problems and interventions were identified from analyzing Commercial accidents.

6.3.5.3 Commercial – General Characteristics of Accidents Analyzed

The accident flights involved a variety of scenarios, including disorientation while flying in flat light / whiteout conditions in Alaska (3 disorientation accidents); loss of tail rotor effectiveness (LTE) while maneuvering along a ridgeline and for a landing (2 LTE accidents); approach accidents involving loss of control and an engine failure secondary to aggressive maneuvering, and improper response to a hydraulic failure (two approach phase accidents); landing accidents in which the pilot experienced dynamic rollover after landing, a helicopter tipped over rearward after landing at the edge of a platform, a rollover when a pilot allowed his attention to be diverted, and a hard landing when attempting to land at a remote site in a snowstorm (four landing accidents); hover accidents in which a loose object blew into and disabled the rotor system, a pilot settled into trees during a downwind hover, and where a pilot collapsed a strut and rolled over in a hover taxi (3 hover accidents); a mast bumping / mast separation accident in which the initiating event was not determined; and a Canadian accident involving an engine failure.

The accidents analyzed in this mission demonstrated a variety of problems: 94% of the Commercial accidents involved Pilot Judgment and Actions issues, 63% involved Data Issues, 56% involved Safety Culture issues, 44% involved Ground Duties, and 31% involved Pilot Situational Awareness issues. Pilot experience in the accidents analyzed in this mission was high (but not unusually high for this accident data set). Average total experience was 6,783 hours; average time in helicopters was 5,870 hours; average hours in make and model was 1,504. Five of the pilots reported more than 10,000 hours total flying experience; six reported more than 5,000 hours of rotorcraft experience; and five reported more than 1,000 hours in the accident make and model helicopter. Seven of the pilots reported 3,000 or fewer total flight hours; three reported less than 1,000 hours in helicopters and three others did not report their total rotorcraft experience. Five pilots reported less than 300 hours in the accident make and model helicopter.

There were two fatal accidents, one serious injury, 3 minor injuries and 10 non-injuries. Of the 16 accidents, 15 occurred in VMC and 1 in IMC. 15 accidents occurred in daylight and the conditions were not reported in the last accident. Commercial accidents involved three reciprocating engine helicopters, 12 single engine turbine powered helicopters, and one twin-turbine powered helicopter. The certification category for 14 of the aircraft was Normal, two were Transports.

6.3.5.4 *Commercial – Problem Areas Identified*

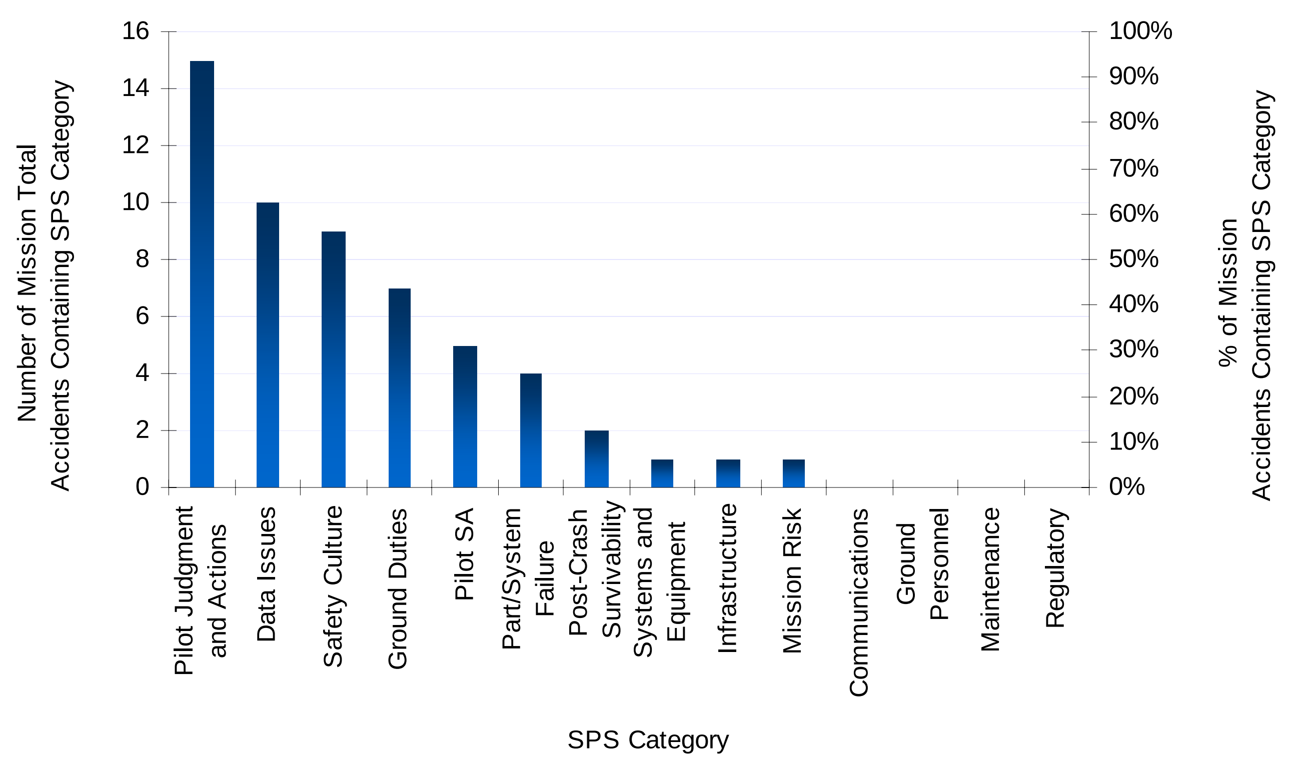


Figure 6-19. SPS Categories for Commercial Operations (16 Accidents Analyzed)

104 problems were identified in 10 categories for Commercial operations:

1. Problems with Pilot Judgment and Actions were the most frequently cited SPS category in the Commercial Ops mission, found in 94% of the mission's accidents. A breakdown of the underlying problem areas (sub-categories) contained in Pilot Judgment and Actions category are noted as follows. Inadequate implementation of procedures related to pilot handling and control deficiencies, inappropriate power / energy management and inadequate response to emergency situations were evident in 69% of this mission's accidents. Human Factors – Pilot Decisions while in flight were also identified as inadequate in 44% of the accidents; the majority of these problems were related to disregarding cues that should have led to the termination of the current course of action or maneuver. Inadequate pilot decision making related to selection

of flight profile (altitude, rotor rpm, approach, takeoff, unsuitable emergency landing terrain) was also identified in 44% of the accidents in this category. Less frequent issues, but still considered significant were inadequate landing procedures (38% of accidents) related to landing site recon and selection issues and problems identified with Human Factors - Pilot / Aircraft Interface were identified in 25% of the accidents and were related to diverted attention, visual illusions, perception errors and disregard duty flight time fatigue.

2. Data Issues (data inadequate to fully comprehend and mitigate the accident issues) were identified as a deficiency in 63% of the accidents. Data to sufficiently understand the actions taken by the crew prior to the accident was the predominant issue identified. In one of the accidents, lack of control of the accident scene was noted, which had a negative effect on the ability of investigators to understand the accident sequence.
3. Safety Culture deficiencies were cited in 56% of the mission's accidents. A breakdown of the underlying problem areas (sub-categories) contained in the Safety Culture category are noted as follows. Lack of adequate Safety Programs to provide adequate management of risk and employee performance monitoring were identified in 25% of the accidents. Similarly, lack of adequate make and model transition training was believed to be a factor in 25% of the accidents. Inadequate management policies related to risk management, remote ops supervision and disregard of known safety risks were believed to be a factor in 12% of accidents. Less frequent issues identified were inadequate pilot experience for the mission in 12% of accidents and the need for ground / LZ personnel training in 6% of the accidents.
4. Inadequate Ground Duties were identified in 44% of this mission's accidents. All but one of the problems in the sub-category involved inadequate pilot preflight consideration of aircraft operational performance limits. Specific limitations related to weather, aircraft performance and wind were noted. One problem was also noted about inadequate preflight process.
5. Pilot Situational Awareness was noted as inadequate in 32% of the mission's accidents. There were two areas identified, lack of awareness of external environment with aircraft position and hazards and lack of awareness of compromised visibility due to fog, rain, whiteout or brownout.
6. Part / System Failure was identified in 25% of the mission's accidents. The failures noted were power plant and tail rotor related. An operational FOD event resulted in severe damage to the main rotor system. A main rotor mast failure was not placed in the Part Failure category because the initiating cause of the failure was not known.
7. An Infrastructure issue was identified in one accident (6% of the mission's accidents); enroute weather information was not available which led to an encounter with IMC.
8. Mission Risk was identified in one accident (6% of the mission's accidents); the mission involved flight near hazards, obstacles or wires.

6.3.5.5 Commercial – Safety Interventions Identified

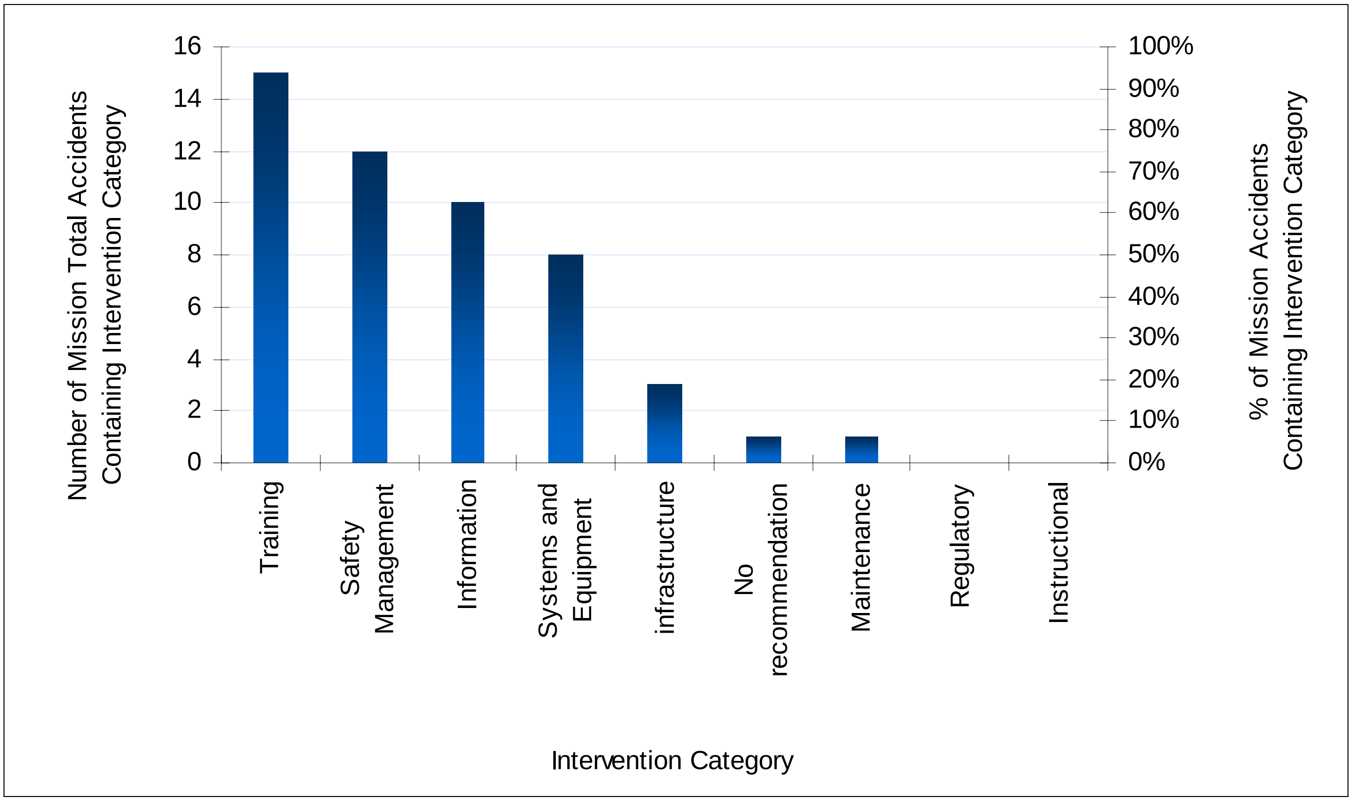


Figure 6-20. Intervention Categories for Commercial Operations (16 Accidents Analyzed)

104 safety interventions were identified in 6 areas for Commercial operations:

1. The Training category accounted for 35% of the recommended corrective actions in the commercial operator mission. Training topics were varied; however, the leading areas were as follows: New Hire Pilot, Make and model Specific, Simulator Training and Limitations Training accounted for 44% of the Commercial Operator training interventions. Emergency Procedures Training accounted for 15% of training interventions; and Mission Specific Training accounted for 13% of the training interventions. The remaining training recommendations were identified with limited frequency, but involved the following areas:

   - Risk management / assessment training
   - Ground operations
   - LTE training
   - Inadvertent IMC training
   - Proximity awareness training
   - ADM training
   - Autorotation training
   - Dynamic rollover training

2. Safety Management was also a significant intervention category in the Commercial Operator mission. Company management needs to develop and adopt policies and procedures to identify, assess and manage risk. The most frequently cited sub-category was Standard Operating Procedures (SOP). Operators should establish, improve and / or comply with SOPs regarding:

   - Procedures for assessing the risks of weather, establishing and using weather launch / abort criteria, establishing policies to minimize the risk of inadvertent VFR flight into IMC, as well as SOPs for departing into wind
   - Landing zone (LZ) recon, checklists, suitability and selection
   - Power / performance planning for the specific mission

- Implementing flight following procedures

3. Lack of information accounted for 13% of the Commercial mission interventions. Installation of cockpit recording devices predominated (10 of 13 information interventions), with improved accident reporting, investigation and documentation also cited (3 of 13).
4. Systems and Equipment issues accounted for 8% of the mission's interventions. The most common intervention was related to enhanced vision systems and proximity detection to aid pilots during those flight phases where nearby hazards could be contacted.
5. Infrastructure interventions accounted for 3% of the missions interventions. No commonality was noted in this category; the interventions were related to local weather PIREP, platform landing markings and crash scene control.
6. Maintenance interventions accounted for 1% of the mission's interventions; installation of part failure detection systems was identified.

6.3.5.6 Commercial – Prioritized Safety Recommendations

In reviewing the Commercial operations and the interventions proposed, the JHSAT makes the following recommendations:

1. Commercial operators should develop and adopt Safety Management policies and procedures to assess and minimize risk related to weather, landing zone, mission specific power / performance planning and flight following issues.
2. Each commercial operator should adopt a mission-specific training manual for air crewmen with make and model and mission specific content. The Federal Airworthiness Regulations (FARs) and Airman's Information Manual (AIM) specify minimum requirements for training manuals. Commercial operators should strengthen training curricula for emergency procedures, new hire pilots, risk management / assessment, ground operations, LTE, inadvertent IMC, proximity awareness, Aeronautical Decision Making, autorotation and dynamic rollover training.
3. Enhance the commercial operator pilot's ability to determine the aircraft's proximity to hazards by use of enhanced vision systems, proximity detection systems or rearward camera / video systems.
4. Commercial operators should develop and adopt standards for platform landing markings.
5. Install part failure detection systems such as HUMS.
6. Install cockpit recording devices that will enable crash investigators to understand accident circumstances and pilot actions prior to a crash.
7. Pilots should participate in reporting local weather via PIREP.
8. Improve crash scene control.

6.3.6 Mission Specific Findings – Law Enforcement

6.3.6.1 Law Enforcement – Mission Definition

Airborne Law Enforcement is a mission flown to provide aerial support to local, state or federal law enforcement agencies. The aerial support that these aircraft provide often involves orbiting at altitudes close to the ground. Law enforcement pilots are forced to deal with high and multi-task saturation, as they are often seeking or following a suspect(s) on the ground or monitoring other events occurring on the ground while flying the aircraft and maintaining constant situational awareness of the environment. Law enforcement aircraft are often equipped with surveillance equipment such as forward looking infra-red (FLIR) devices, video cameras and video downlink, stabilized viewing devices, computerized map systems and other complex equipment that add workload for the pilot.

Although they are exempt from many Federal Aviation Regulations (FARs), numerous law enforcement agencies elect to operate to 14 CFR Part 91. One common reason for a law enforcement agency to elect to operate to Part 91 standards is that some insurance companies will not insure an aircraft unless it is operated in accordance with Part 91 standards. The aircraft and airmen participating in Part 91 Law Enforcement operations are required to be certificated in accordance with Part 61 Regulations and the aircraft must have an FAA Certificate of Airworthiness.

Airborne law enforcement operations are sometimes referred to and can be conducted as "Public Use" operations. Public Use operations are not held to the regulations set forth by the FAA, other than compliance with general operating rules (i.e. airspace and communications compliance). Many of the aircraft utilized in Public Use operations are "Public Aircraft." Public Aircraft refers to certain government aircraft operations and means, among other things, that an aircraft will not be subject to some of the regulatory requirements applicable to civil (or civilian) aircraft. Many of these aircraft are surplus military aircraft, acquired from the U.S. government. Additionally, the pilots in public use operations are not required to hold civil airman or medical certificates to operate these aircraft. Although the FAA has an option to oversee Public Use operations and maintenance, they have no enforcement authority, so they often choose not to do so. Therefore, law enforcement agencies often supervise their own flight operations and maintenance.

It is possible for a law enforcement agency to operate only selected aircraft to Part 91 Standards. For example, a law enforcement agency may have a "public" surplus military UH-1 (non-certificated or restricted category) that they operate as public use (non-FAA standards) and a civil-certificated Bell 206 that they operate to Part 91 standards.

6.3.6.2 Law Enforcement – Synopsis of Accidents Analyzed

Of the 197 accidents analyzed in the NTSB year 2000 dataset, 13 accidents involved law enforcement operations. This represented 6.6% of the accidents analyzed for the year.

6.3.6.3 Law Enforcement – General Characteristics of Accidents Analyzed

Four of the 13 accidents (31%) involved fatal injuries. One accident involved a serious injury. The remaining eight of thirteen (62%) involved minor or no injuries. There were eight total fatal injuries, one serious injury, and eleven persons sustained minor or no injuries.

Six of the 13 accidents (46%) occurred during actual patrol missions. Three of the 13 accidents (23%) occurred during ferry flights and two (15%) occurred during training flights. There was also one accident that occurred during an aerial photography flight and one accident that occurred on a post-maintenance test flight. There were two other accidents involving law enforcement aircraft in the year 2000 dataset; however, due to the nature of the individual flights and classification by the NTSB, they were analyzed under other mission categories. One of these accidents occurred during a training flight., which can be found under the Instructional / Training mission (Section 6.3.1). The other accident was classified as an Aerial Observation / Patrol. The problems and interventions identified in these two accidents were generally consistent with those identified in the Law Enforcement accidents reviewed in this section.

Four of the thirteen accidents (31%) occurred while maneuvering. Three accidents (23%) occurred during autorotation – two during practice autorotations and one during a post-maintenance test flight. Three accidents (23%) occurred during autorotation, two of which were practice autorotations and one which was performed during a post-maintenance test flight. One accident occurred during takeoff, one occurred during landing, and one accident occurred while the aircraft was on the ground.

All but two accidents occurred in visual meteorological conditions (VMC). Both of the IMC flights occurred during inadvertent flight into IMC at night. Four of the thirteen accidents (31%) occurred at night, one (8%) occurred at dusk, and the remaining eight (62%) occurred during daylight hours.

Of the thirteen aircraft involved in accidents in this data set, eight (62 %) were surplus military helicopter models operated as public use, and five (38%) were civilian models operated to Part 91 standards. Ten of the aircraft were single engine turbine powered helicopters; the other three accidents occurred in reciprocating engine powered helicopters.

Five of the accidents involved mechanical failures, some of which suggested improper maintenance or inspection by the public use operator. One of the IIMC flights involved an aircraft that was dispatched with a non-functional attitude indicator. The standards of the operator allowed night VFR flight without an operating attitude indicator. Two accidents involved practice autorotations that were not conducted correctly.

All of the pilots were certificated to fly helicopters. Level of licenses / certificates ranged from Private to Airline Transport Pilot. Pilot total time ranged anywhere from 756 hours to 29,500 hours. Five pilots had fewer than 1,500 hours total flight time, and six pilots had fewer than 1,000 hours in rotorcraft. The average total flight time of the accident pilots was 7,379 hours. The pilots' experience in make and model of the accident aircraft ranged from 144 to 3,326 hours. Four pilots had 250 or fewer hours in make and model; and two pilots had unknown experience in make and model. The pilots' average time in make and model was 1,004 hours.

6.3.6.4 Law Enforcement – Problem Areas Identified

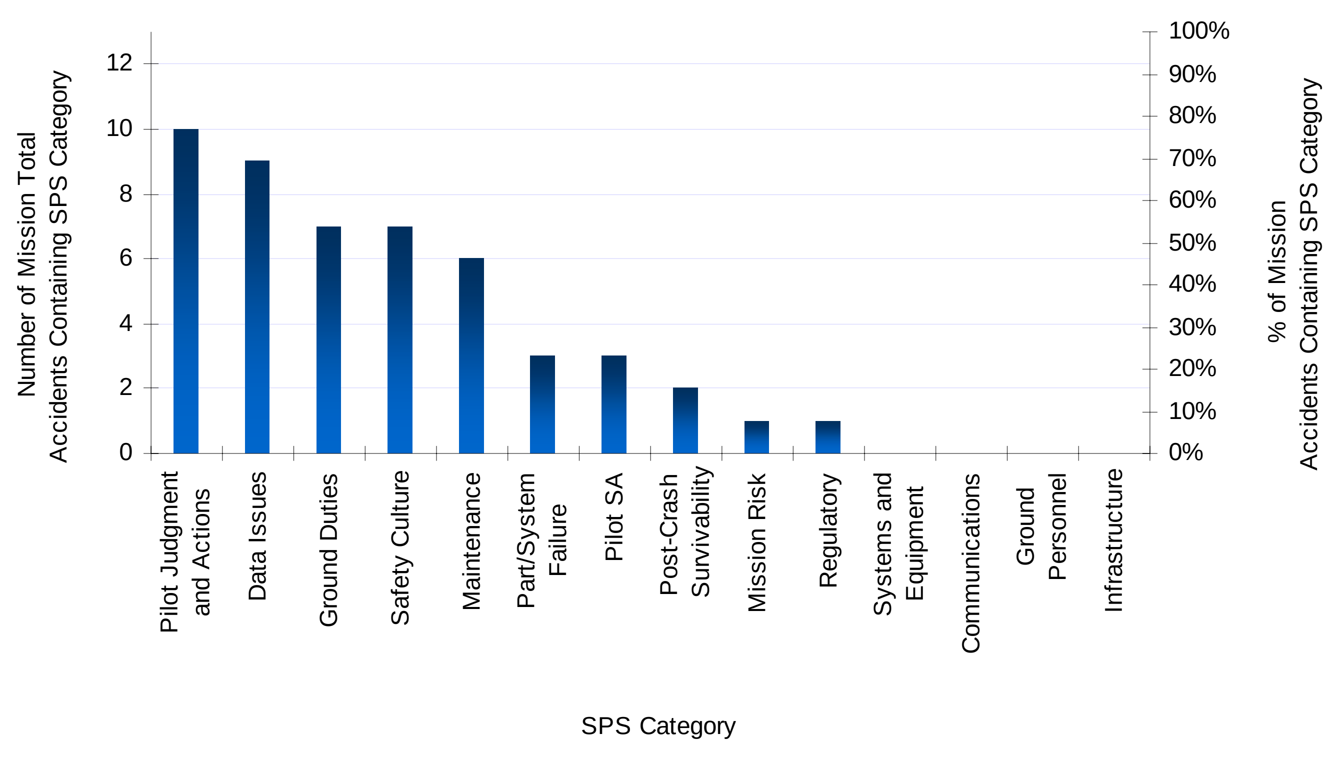


Figure 6-21. SPS Categories for Law Enforcement (13 Accidents Analyzed)

83 problems were identified in ten categories.

1. Pilot Judgment and Actions, cited in ten (77%) of the thirteen accidents, was the leading problem category in Law Enforcement accidents. In four accidents, improper landing site selection or reconnaissance was identified as a problem. In three accidents, pilots disregarded cues that should have led to the termination of a course of action or maneuver. Perceptual judgment errors or failure to follow procedures was a problem in three accidents. Inappropriate aircraft handling or inadequate energy / power management was identified in three accidents. Unsafe flight profiles were identified as a problem in two accidents, although it was determined that low altitude and airspeed was unavoidable for the one of the flights. Inappropriate response to common aerodynamic phenomena (LTE and dynamic rollover) and inadequate autorotations were also problems identified in this category. Inadequate and belated CFI action to correct student action was cited in one accident.

2. Data Issues were the next most frequently identified problem in the reviewed set of accidents, cited in nine (69%) of the thirteen accidents. In nearly all of these accidents, information that was needed to understand or to allow mitigation of the accident was either unavailable to investigators or was missing from the accident report.
3. Safety Culture was cited as a problem in seven (54%) of the 13 Law Enforcement accidents. Lack of management oversight and sufficient aircraft and pilot monitoring were identified. Inadequate pilot experience and inadequate training were also problems in this category. In one case, the helicopter was inadequately equipped for a night mission under marginal weather conditions.
4. Ground Duties were determined to be inadequate in seven (54%) of the accidents. This was found to be a high percentage when compared to other mission categories. Either preflight procedures were not performed properly or inadequate consideration was given to conditions such as wind, weather, or aircraft performance.
5. Maintenance Issues were identified in six (46%) of the 13 accidents. In three cases, mechanics did not comply with existing maintenance procedures. Additionally, there was a failure of QA or quality oversight to catch the improper maintenance or detect impending failures. In two accidents, there was no equipment installed to aid in detecting an impending failure. In one accident, a part failure occurred on an undocumented military surplus engine, which led to an in-flight failure.
6. Pilot Situational Awareness was not maintained in four (31%) of the 13 accidents. In two accidents, fog, darkness and rain were cited. In the other two accidents, the pilots were not aware of the aircraft position relative to hazards.
7. Part / System Failures occurred in three (23%) of the 13 accidents as a result of improper maintenance or inadequate part quality.
8. Post-Crash Survivability Issues were cited on two (15%) of the 13 accidents. A post-crash fire ensued on one accident, and there were communications difficulties between the survivor(s) and rescue personnel on another.
9. A regulatory requirement for data recording devices was cited in one accident (8%).
10. Mission Risk was cited once in an accident (8%) where low and slow flight was required. This is a common risk for the law enforcement mission as stated above.

6.3.6.5 Law Enforcement – Safety Interventions Identified

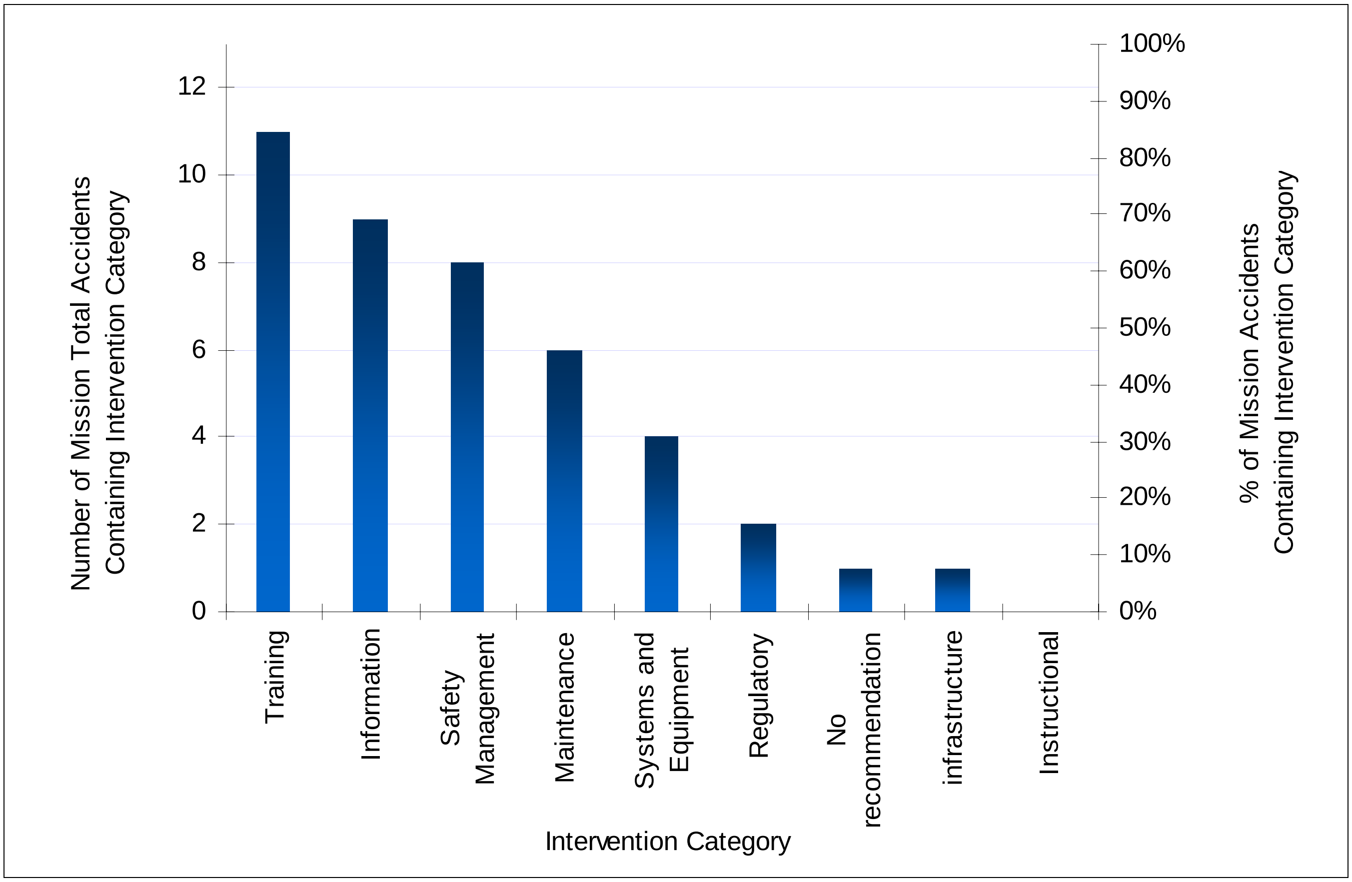


Figure 6-22. Intervention Categories for Law Enforcement (13 Accidents Analyzed)

1. Training was the most commonly cited intervention category for the law enforcement accidents. Training in the areas of mission planning, preflight procedures and planning, autorotations, enhanced CFI, aircraft performance, inadvertent IMC, risk assessment, emergency procedures, LTE, dynamic rollover, critical cues and simulators were suggested as interventions.
2. The need to install cockpit recording devices was recommended in nine of the accidents. Further investigation of a part failure was suggested in one accident.
3. Safety Management interventions ranked high on the intervention list. The need for development of safety, operational and risk assessment procedures, as well as the implementation of a safety management program, such as SMS, were the most frequent interventions cited. Department Standard Operating Procedures (SOPs) for weather, preflight planning, landing site selection and training were recommended.
4. Increased / improved QA and maintenance oversight was recommended as an intervention in several instances. Compliance with already existing procedures and adoption of civil standards for surplus aircraft were also recommended. Installation of a HUMS / HOMP system was suggested for two accidents. Also, it was suggested in one accident that SOP for post-maintenance check flights be developed.
5. The installation of safety systems and equipment such as EVS, SVS, NVGs and HTAWS were suggested as possible interventions in several of the accidents.
6. Regulatory interventions included a strong recommendation for compliance with civil standards and disciplinary action targeted at an individual who performs improper maintenance.
7. The use of Emergency Position-Indicating Radio Beacons (EPIRBs) or personal location devices to improve communications infrastructure was recommended.

6.3.6.6 Law Enforcement – Prioritized Safety Recommendations

1. Conduct additional training in the areas of:
    - Mission planning
    - Preflight procedures
    - Autorotations (full touch-down and power recovery)
    - CFI performance
    - Aircraft performance
    - Avoidance of inadvertent flight into IMC
    - Risk assessment
    - Emergency procedures
    - LTE
    - Dynamic rollover
    - Critical cues
    - Simulators
2. Install cockpit recording devices.
3. Implement risk assessment and safety management programs such as SMS.
4. Establish department standard operating procedures (SOPs) to include weather, preflight, landing zone selection, and training guidelines.
5. Maintain and operate public use aircraft to civil standards.
6. Increase maintenance and QA oversight, especially following maintenance on safety of flight components and systems.
7. Install aircraft monitoring systems such as HUMS / HOMP.
8. Install safety systems and equipment such as:
    - HTAWS
    - SVS / EVS
    - More crash-resistant fuel systems
    - radar altimeters
    - proximity detection equipment
9. Implement regulatory action to require law enforcement agencies to operate to and comply with civil operating and maintenance standards.
10. Implement the use of EPIRBs or other personal locating devices.

Note that, in conjunction with the IHST, the Airborne Law Enforcement Association (ALEA) is undertaking additional analysis of accidents that occurred in the Law Enforcement community. The mission of ALEA is to support, promote and advance the safe and effective utilization of aircraft by law enforcement agencies in support of law enforcement missions through training, networking and educational programs.

6.3.7 Mission Specific Findings – Offshore

6.3.7.1 Offshore – Mission Definition

The beginnings of the offshore helicopter industry were seen in the late 1940s when frequent rough sea conditions prevented the transportation of personnel and equipment to offshore oil rig and platform locations by boat. Transportation by boat was less costly, but the longer transportation time involved, along with the dangerous conditions, made helicopters a more appealing mode of transportation. The benefits of helicopter transportation were quickly realized and the industry continues to grow to this day. The mission profile encompasses all aspects from the small company with a few helicopters to larger operators with hundreds of helicopters operating in varied geographic locations. The typical offshore helicopter operator, whether large or small, provides the aircraft, personnel (pilots, mechanics and support staff) and aircraft maintenance facilities to sustain helicopter operations.

The offshore mission category involves the use of helicopters to transport personnel and equipment to offshore oil and gas platforms, rigs and nautical vessels. The flights require significant operations over-water at distances up to and exceeding 200 nautical miles. The majority of the flights are conducted within a radius of 100 nautical miles from shore. Additionally, offshore flight operations are performed under both VMC and IMC conditions. The offshore environment comes with inherent risks. Limited visibility conditions may exist during the winter months from sea fog and high gusting winds. The saltwater environment is highly corrosive and flocks of migratory birds pose an in-flight collision / ingestion threat. Additional risk in the offshore environment is due to flight in areas around platforms and rigs with potential obstacles, high volume of landings and departures from small surfaces, and multiple approaches and departures on a daily basis in a very congested flight environment. The majority of operations are conducted using single turbine engine powered helicopters in the Gulf of Mexico (GOM).

6.3.7.2 Offshore – Synopsis of Accidents Analyzed

Of the 197 accidents analyzed in the NTSB year 2000 dataset, eight accidents involved offshore operations. This represented approximately 4% of the accidents analyzed for the year. 68 problems and 61 interventions were identified from analyzing offshore accident data. This mission area experienced just three fatal accidents. This highly visible segment of the industry, which carried 3.4 million passengers in calendar year 2000, has comparatively few accidents and fatal injuries given the magnitude of the operation.

6.3.7.3 Offshore – General Characteristics of Accidents Analyzed

100% of the eight offshore accidents involved forced landings and / or descent into the waters of the Gulf of Mexico. 88% of the offshore accidents involved Pilot Judgment and Actions, 75% involved Data Issues, 50% involved Post-Crash Survivability issues, 38% involved Safety Culture issues, 25% involved Maintenance issues, 25% involved Regulatory issues, 25% involved Ground Duty issues, 13% involved Part / System Failures, 13% involved Communications issues and 13% involved Infrastructure issues.

Pilot experience in the accidents analyzed in this mission was high (but average for this study). Average total aircraft hours was 7789, hours in helicopters was 5794, hours in the make and model was 1641. The lowest total flight experience reflected by pilots in this mission group were the four pilots who had 3591, 2643, 2354 and 1984 hours, respectively. The pilot make and model experience level of those four pilots with less than 1,000 hours in the make and model of the accident helicopter were 857, 720, 707 and 58 hours, respectively.

Four of the accidents were precipitated by a loss of engine power or mechanical failure. The power loss initiated accidents were the result of: internal engine oil leakage and resulting turbine over-temperature, a compressor coupling adaptor failure and fuel exhaustion. Another accident was triggered by a tail rotor control linkage failure. One (fatal) accident involved a loss of control for undetermined reasons. The other three accidents involved inadvertent flight into IMC (fatal), inadequate response to loss of tailrotor effectiveness and snagging a safety fence with the tail stinger on takeoff.

As mentioned, of the 8 accidents in 2000, Offshore Operations experienced 3 fatal injuries. There were also 2 serious, 3 minor and 3 non-injuries. All 8 accident flights were initiated in Visual Meteorological Conditions (VMC). 7 of the accidents occurred in daylight conditions with one Night-Dark. All 8 accidents involved landings on or collisions with water. All 8 accidents were in single engine turbine-powered helicopters in the Normal (non Transport) Certification category. One accident (12.5%) occurred during approach, 3 (37.5%) during cruise, 2 (25%) during landing, 1 (12.5%) during maneuvering and 1 (12.5%) during take off.

6.3.7.4 Offshore – Problem Areas Identified

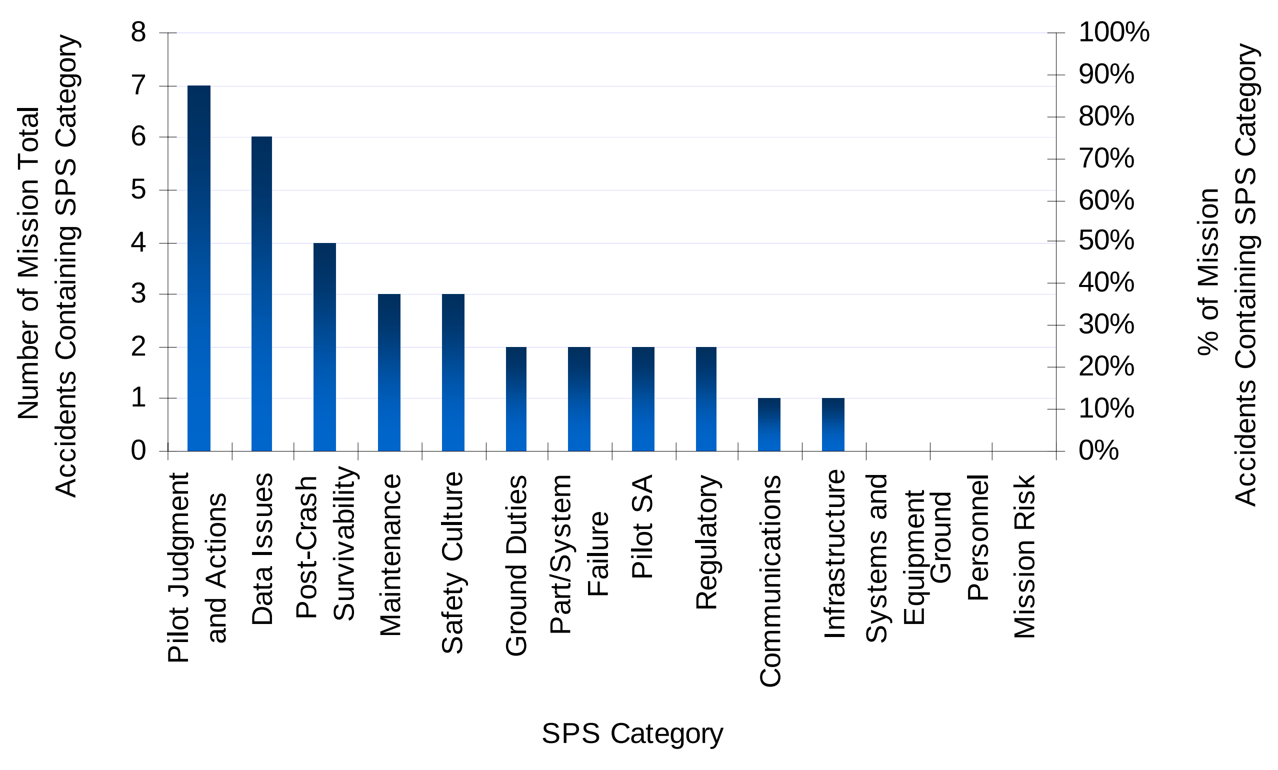


Figure 6-23. SPS Categories for Offshore Operations (8 Accidents Analyzed)

68 problems were identified in 11 categories of Offshore operations:

1. Problems with Pilot Judgment and Actions were the most frequently cited SPS category in the Offshore mission, found in 88% of the mission's accidents. A breakdown of the underlying problem areas (sub-categories) contained in Pilot Judgment and Actions category are noted as follows:
    - Procedure Implementation – lack of inflight fuel quantity monitoring, pilot control / handling deficiencies, inadequate response to loss of tail rotor effectiveness, improper recognition and response to dynamic rollover were evident in this missions' accidents.
    - Human Factors-Pilot Decisions – disregard for rules and SOPs, disregarded cues that should have led to termination of the current course of action or maneuver, pilot decision making, failed to follow procedures.
    - Flight Profile – pilot's flight profile unsafe in reference to takeoff, altitude, airspeed and unsuitable terrain. Less frequent occurrences but still considered significant were landing procedures associated with forced autorotation.
2. Data Issues (found in 75% of the accidents) were identified as a deficiency. Insufficient data available to understand the actions taken by the crew prior to the accident was the predominant issue identified. Overall deficiencies included: information unavailable to investigators, information missing / incomplete in the report and inadequate investigation conducted.
3. Post-Crash Survivability (found in 50% of the accidents): In the Offshore environment, post-crash survivability and crashworthiness are complicated by the frequency of which the helicopter capsizes or sinks. There are also occasions in which the helicopter is never recovered, or recovered a significant time later and distance from the accident site, which significantly affects the investigation.

4. Safety Culture (found in 38% of the accidents): Deficiencies were evident in management involving a disregard of human performance factors. Knowledge of crew-hiring criteria relative to pilot's prior work history was found to be problematic.
5. Maintenance issues (found in 38% of the accidents) were a factor. Helicopters used in the offshore environment are exposed to corrosion and high duty cycles and must be well maintained. None of the accidents analyzed involved helicopters configured with equipment (i.e., HUMS type recorders) to detect impending component or part failure.
6. Regulatory (found in 25% of the accidents): Lack of regulatory oversight and guidance was found to be a contributor to the accident sequence: oversight specifically in regard to inadequate government / industry standards and inadequate application of existing standards.
7. Ground Duties (found in 25% of the accidents): Inadequacies were noted in mission planning involving incorrect fuel planning / calculations, pilot experience leading to inadequate planning, and inadequate mission requirements / contingency planning.
8. Pilot Situational Awareness (found in 25% of the accidents): Problems identified were reduced visibility from fog, rain and darkness and internal aircraft awareness involving being unaware of low fuel status leading to fuel starvation.
9. Part / System Failure (found in 25% of the accidents): The failures noted were engine component failure and components used did not conform to the type design.
10. Communications (found in 13% of the accidents): One incident of inadequate procedures involved in the coordination of tactical operations control.
11. Infrastructure (found in 13% of the accidents): One occurrence that demonstrated the IFR system was incompatible with the mission.

6.3.7.5 Offshore – Safety Interventions Identified

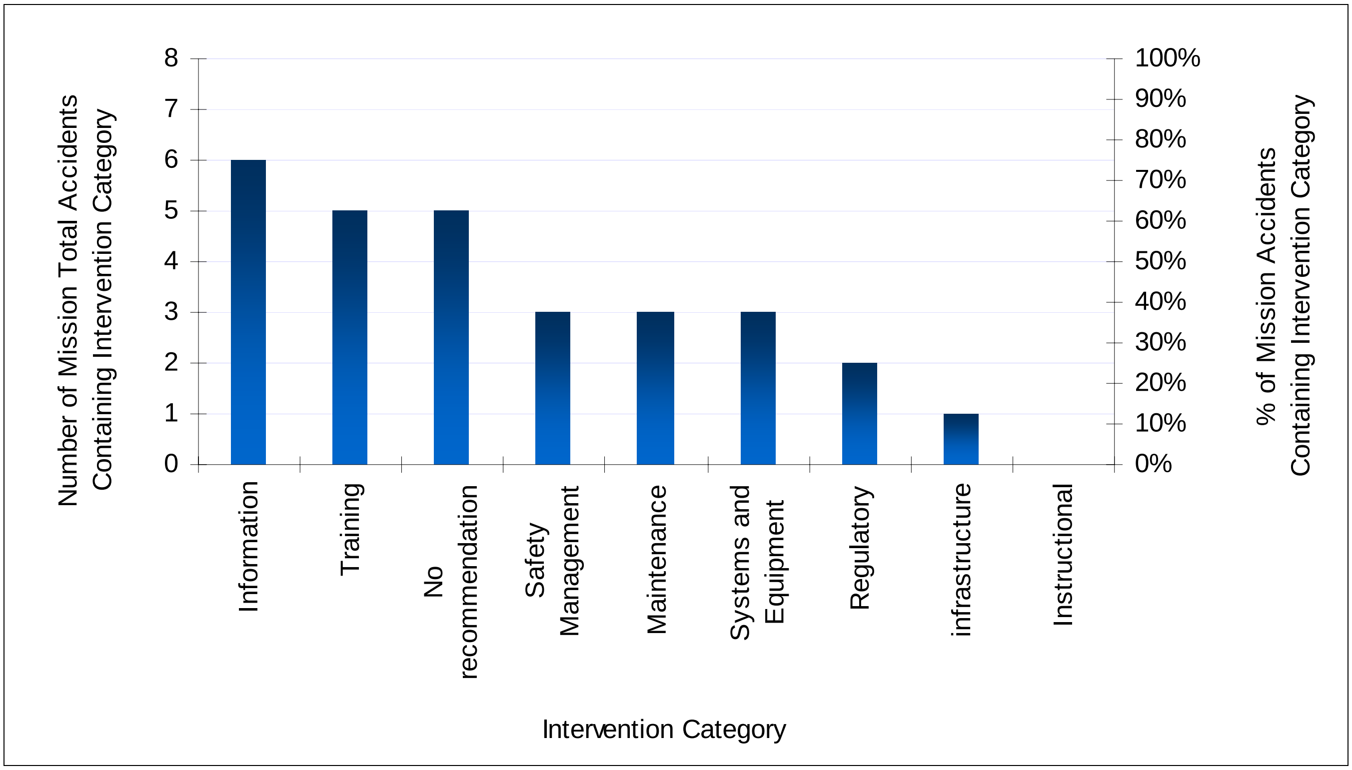


Figure 6-24. Intervention Categories for Offshore Operations (8 Accidents Analyzed)

61 safety interventions were identified in 9 areas for offshore operations:

1. Make improvements to the systems and equipment of the aircraft by adding recording devices and health monitoring equipment in and on the helicopter to ensure that the methods used to calculate component safe lives (airframe, drive train and power plant) are uniform and correctly applied by the operator community, and ensure that the type design holder adequately applies lessons learned with Repeated Heavy Lift (RHL) operators to those aircraft active in offshore operations.
2. Of the offshore accidents analyzed, there were no recommendations made against at least one problem in 63% of the accidents. These instances were determined to be due to the basic traits of the mission that left no reasonable option for safety interventions. Typically this was related to the pilot making a forced autorotative landing and the aircraft sustaining damage or being lost in the water.
3. Training: Aircraft systems training and emergency procedures training should be enhanced at all companies operating offshore. Several of the accidents were caused by inadequate autorotational techniques used by the pilot. Additionally, LTE recognition and recovery needs to be added to the training programs.
4. Maintenance: Improve critical aspects of maintaining the aircraft used in the offshore environment. Given the severe environment and usage of these aircraft, maintainers need the means to detect component problems prior to critical part failure in flight. This can be accomplished by trending equipment, such as HUMS. Cost effective solutions will be needed.
5. Regulatory: Make improvements to regulatory guidance, oversight and rulemaking. Additionally, the FAA should increase oversight of facilities responsible for maintaining offshore helicopters.
6. Information: Install cockpit recording devices that will enable crash investigators to understand cockpit indications and pilot actions that precede a crash. Cockpit imaging devices and recorders also provide information for company management to provide non-punitive corrective actions for pilot / crew performance anomalies.
7. Safety Management: Offshore operators should adopt basic Safety Management Systems concepts. Given the inherent risk in the offshore mission, the owners of these operations should develop and adopt policies and procedures that assess and minimize risk. Specific to the findings of the accidents analyzed, the policies and practices should include measures to address operational risk assessment methods, risks associated with improper maintenance, risks associated with inadequate hiring practices, and methods to target pilot and crew training focused on operating within published aircraft limitations.
8. Infrastructure: Pilot history is not being documented as well as it should be during accident investigations. This needs to be addressed with the investigating authorities.

6.3.7.6 Offshore – Prioritized Safety Recommendations

1. Adopt Safety Management methods to assess and minimize risk in maintenance, operations and hiring practices and to maximize the benefits of targeted training.
2. Install cockpit recording devices that will enable crash investigators to better understand cockpit indications and pilot actions that precede a crash.
3. Install equipment that enables maintenance personnel to detect impending component failure, such as HUMS systems.
4. Enhance the existing training programs for pilots in LTE and autorotations.

6.3.8 Mission Specific Findings – Business / Company-Owned Aircraft

6.3.8.1 Business / Company-Owned Aircraft – Mission Definition

Business / Company-Owned Aircraft operations entail helicopters primarily utilized for the conduct of its company business, as opposed to Commercial operations, which are “for hire.” Risks involve single ownership with limited flight operations knowledge and staff, recurrent training, maintenance and risk management resources. Business / Company-Owned Aircraft operate per Federal Aviation Regulations Part 91 General Operating Rules.

6.3.8.2 Business / Company-Owned Aircraft – Synopsis of Accidents Analyzed

Of the 197 accidents analyzed in the NTSB year 2000 dataset, nine accidents involved Business / Company-Owned Aircraft operations. This represented 5.0% of the accidents analyzed for the year. 51 interventions were identified from analyzing Business / Company-Owned Aircraft accident data.

6.3.8.3 Business / Company-Owned Aircraft – General Characteristics of Accidents Analyzed

Eight Business / Company-Owned Aircraft accidents occurred in single-turbine helicopters and one involved a reciprocating engine powered helicopter. One helicopter was military surplus. The “business” flights entailed a variety of missions, including ferrying the military surplus helicopter to an airshow, searching for a buffalo and post-maintenance test flights (two accidents).

There were three tailrotor system failures (a TR blade, a TR driveshaft coupling, and an inadequately lubricated TR gearbox) among the accidents in this category. Causes included manufacturing defects and improper / inadequate maintenance. Other mechanical problems included a seized engine compressor due to an improper installation and a transmission mount failure. Two accidents involved loss of main rotor rpm and subsequent hard landings. Inadequate recognition and response to LTE and Loss of Control following an abrupt maneuver were also noted. One pilot lost control when landing too close to a larger helicopter that had just landed.

There were 9 Business / Company-Owned Aircraft accidents involving 19 people, 11 of whom had no injuries, 8 serious or minor injuries, with no fatalities. All 9 accidents occurred in VMC. Eight of the 9 accidents occurred in daylight; one the light conditions was not reported. Two occurred during maneuvering, two during landing, one during approach, one during cruise, one during descent, one during an emergency landing and one during the ground phase of flight. All of the pilots had substantial aircraft and rotorcraft flying experience – 9,643 and 3,875 hours, respectively on average – with the least experienced having logged 1,599 total hours. One pilot had very high total flight time but only 455 hours in helicopters. Three pilots had low experience in the specific make and model: 14, 20, and 75 hours, respectively, in the accident helicopter type.

6.3.8.4 Business / Company-Owned Aircraft – Problem Categories

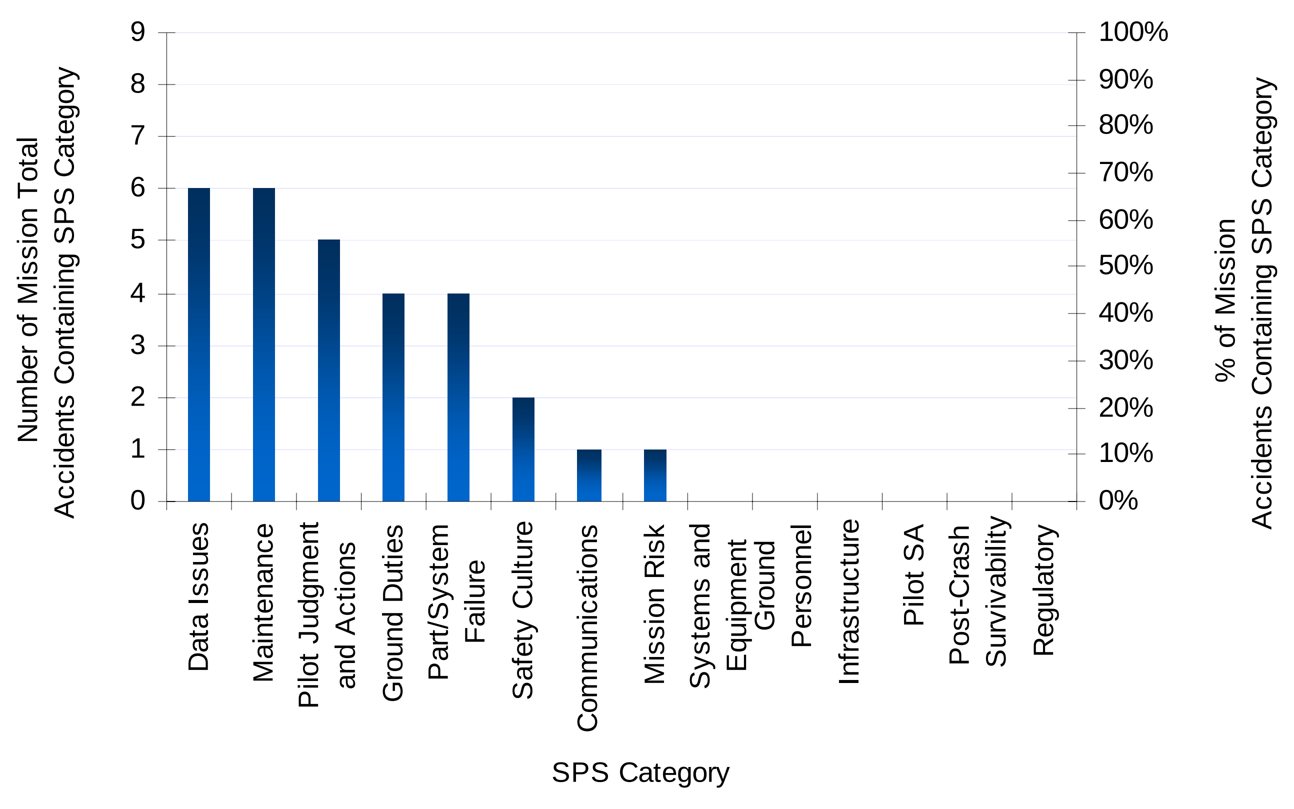


Figure 6-25. SPS Categories for Business / Company-Owned Aircraft (8 Accidents Analyzed)

51 problems were identified in the Business / Company-Owned Aircraft accidents:

1. A collection of conditions and circumstances related to Pilot Judgment were identified in Business / Company-Owned Aircraft accidents. Among them were lack of knowledge of the aircraft's aerodynamic state (envelope) and aircraft limitations; failure to follow procedures; disregarding cues that should have led to termination of current course of action or maneuver; improper action due to misdiagnosis; misjudging own limitations / capabilities; and improper decision-making. Inadequate preflight preparation (inadequate consideration of weather / wind and inadequate aircraft pre-flight) were considered significant factors in the accidents.

2. Maintenance factors were identified six times (67%). Failure to follow proper maintenance procedures, aircraft released in an un-airworthy condition and inadequate maintenance documentation were all cited as factors. Of the six Maintenance-related accidents, five were as a result of maintenance error; one was as a result of the tail rotor blade manufacturing process.

3. While not part of the causal chain, it was considered that the causes of at least one of the nine Business / Company-Owned Aircraft accidents would have been better defined and its issues resolved had the investigation gathered more data. Specifically noted here was the lack of data provided to investigators on one U.S.-Registered international mishap such that investigation details were not available to review.

4. A stronger safety culture, better training, and better company oversight of flight, maintenance and Quality Assurance operations would reduce the risk of accidents such as these.

6.3.8.5 Business / Company-Owned Aircraft – Safety Interventions Identified

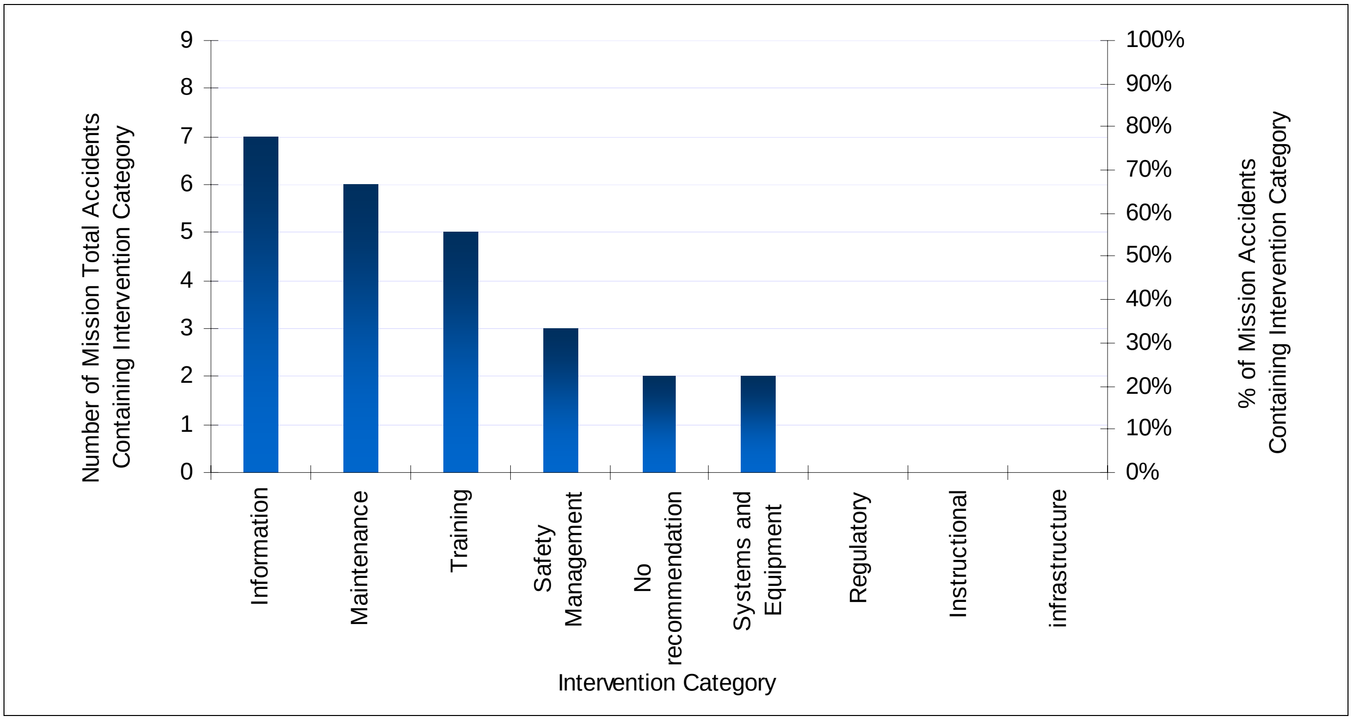


Figure 6-26. Intervention Categories for Business / Company-Owned Aircraft (8 Accidents Analyzed)

The identified interventions that would reduce the risk of the Business / Company-Owned Aircraft accidents in this dataset were heavily focused on needed safety management and training, with 20 of 51 interventions falling into these categories. Most interventions focused on training and establishing higher operational / management standards for the Business / Company-Owned Aircraft mission to solve the problems proactively. 16 interventions were in other categories: aircraft design and missing information. Each of the intervention areas are discussed below.

1. Risk assessment and risk management interventions were identified in both the Safety Management and Training categories. Included in these categories are recommendations that a formalized risk management program be developed; that personal and flight operations risk management training be provided; that pilots receive judgment training in risk assessment; and that pilots receive mission specific operational training that addresses event hazards. Other Safety Management intervention recommendations addressed the need for: establishment of departmental safety and flight operations standards; formalization of an operator flight operations oversight program; and utilization of HOMP-type data to verify employee flight performance.

2. Training intervention recommendations addressed the need for specific or high quality training that would address: transition to a new make and model helicopter; helicopter preflight inspections; autorotation procedures and technique; recognition and response to aircraft system failures; and emergency procedures training. Ground and flight, as well as simulator, training was recommended to ensure recovery from loss of tail rotor effectiveness (LTE) and other aerodynamic conditions.

3. It was recommended that cockpit recording devices be installed to provide digital data needed by crash investigators to understand system anomalies and pilot / crew performance that preceded an aircraft mishap. Such data, when used in routine operations (for example data collected in a HOMP program), has great importance as a tool for monitoring aircraft system performance and quality of the flight crew training program. Less expensive flight recorders, that are also less crashworthy, would allow routine data collection and could be useful for some accident analyses when not subjected to high impact forces or post-crash fire.

4. Maintenance-related recommendations addressed the need for: systems to ensure adherence to Instructions for Continued Airworthiness (ICA) procedures and records of compliance; quality assurance of maintenance involving “safety of flight” components; and established maintenance quality control records systems.

6.3.8.6 Business / Company-Owned Aircraft – Prioritized Safety Recommendations

1. Provide and enforce maintenance policy and procedures to ensure adherence to ICA procedures and records of compliance, quality assurance of maintenance involving "safety of flight" components, and established maintenance quality control records systems.
2. Provide training that would address: transition to a new make and model helicopter; helicopter preflight inspections; autorotation procedures and technique; recognition and response to aircraft system failures; and emergency procedures training.
3. Provide comprehensive ground and flight simulator training. Provide ground and flight simulator training to reduce the risk of accidents caused by Loss of Tail Rotor Effectiveness (LTE) and other aerodynamic conditions.
4. Develop and use formalized risk management programs to assess risk and to improve decision-making in flight operations and on a personal basis. Provide comprehensive risk management training.
5. Establish an operator safety culture that includes clearly-communicated flight operations standards and procedures, a formalized flight operations quality oversight program and a clearly defined safety program that provides for non-punitive safety event reporting, the use of risk assessment and management practices.
6. Where feasible, establish a Helicopter Operations Monitoring Program (HOMP) to verify and improve employee flight performance. Such data, when used in routine operations, has great importance as a tool for monitoring aircraft system performance and quality of the flight crew training program (answering the question, "Do we fly like we train?").
7. Install cockpit recording devices to allow crash investigators to better understand system anomalies and pilot / crew performance that preceded an aircraft mishap.

6.3.9 Mission Specific Findings – Aerial Observation / Patrol

6.3.9.1 Aerial Observation / Patrol – Mission Definition

According to the NTSB for the classification of accidents, Aerial Observation / Patrol consists of aerial mapping and photography, patrol, search and rescue, hunting, highway traffic advisory, ranching, surveillance, oil and mineral exploration, criminal pursuit and fish spotting, among others. For the purposes of this report, Aerial Observation / Patrol does not include highway traffic advisory, Electronic News Gathering, Aerial Application, Utilities Patrol and Construction, or Air Tour and Sightseeing, as these fall into other mission categories. Aerial Observation / Patrol missions often involve flight at low altitudes over unfamiliar terrain.

6.3.9.2 Aerial Observation / Patrol – Synopsis of Accidents Analyzed

Of the 197 NTSB accident reports analyzed for the year 2000, 10 involved Aerial Observation / Patrol operations, representing 5% of total accidents analyzed for the year. 49 problems and 47 interventions were identified as a result of analyzing Aerial Observation / Patrol accidents.

The accidents in this dataset included aerial game surveys, animal tracking, coyote eradication, hunting and fish spotting. They also included aerial observation of wildfires, vehicular traffic and undisclosed aerial observation activities. Generally, these activities were public use projects, but some were privately funded. One "police" helicopter was used for a public use game survey. Some of the helicopters were privately owned but contracted to perform the referenced public services. All 10 helicopters involved in Aerial Observation / Patrol accidents were operating under 14 CFR Part 91. Of those 10 helicopters, six (60%) were single engine, turbine powered helicopters and four (40%) were single engine, piston powered helicopters. All 10 helicopters had certified maximum gross weights of 7,000 lbs or less. One of the 10 helicopters (the police helicopter) was a military surplus helicopter.

There were two accidents (20%) that involved fatalities. Those accidents occurred when a helicopter hit a tree snag while following mountain lion tracks along contours of a snow-covered mountain ridge, and in another accident in which a loss of power and rotor rpm was not explained by the accident circumstances. The eight accidents that did not involve fatalities occurred as a result of unanticipated yaw (LTE) while maneuvering at low altitude, loss of rotor rpm while maneuvering, a mechanical failure that resulted in an ocean ditching and loss of the helicopter, a collision with objects when maneuvering in very low visibility (smoke from wildfires) at night, a power loss that led to a roadside landing and rollover, dynamic rollover when taking off from high vegetation (vines that entangled a landing skid) and an emergency landing that was precipitated by a crewmember throwing a weighted net from the helicopter.

At least two accidents involved mechanical failures. In one accident, an engine power loss was due to fuel exhaustion. Two accident reports lacked sufficient data to determine causal factors.

6.3.9.3 Aerial Observation / Patrol – General Characteristics of Accidents Analyzed

All 10 Aerial Observation / Patrol accidents reportedly occurred in visual meteorological conditions (VMC), although one (noted above) occurred in night, low visibility conditions. Nine (90%) occurred during daylight in bright light conditions and one (10%) occurred in Night-Dark (minimal moonlight) conditions.

Of the 10 Aerial Observation / Patrol accidents, two (20%) resulted in four fatalities, two (20%) resulted in two serious injuries, and three (30%) resulted in five minor injuries. In four (40%) of the accidents, no injuries were reported.

The majority (70%) of the accident flights had two people onboard. Two accident flights had three people onboard and one had four people onboard. A total of 24 people were onboard the 10 helicopters involved in Aerial Observation / Patrol accidents. There were a total of four (17%) fatalities, two (8%) serious injuries and five (21%) minor injuries. A total of 13 people (54%) escaped injury.

Two (20%) of the Aerial Observation / Patrol flights occurred during the takeoff phase of flight resulting in three minor injuries and one person escaping injury. Two (20%) occurred during cruise flight, resulting in four people escaping injury. One (10%) occurred during approach to landing, resulting in two minor injuries. One (10%) occurred during landing, resulting in two people escaping injury. Four (40%) occurred while the helicopters were maneuvering, resulting in four fatalities, two serious injuries, and six people escaping injury.

The average total flight hours reported for the Pilots in Command of Aerial Observation / Patrol accident helicopters was 4,850 hours. The average flight hours reported in rotorcraft was 2,956 hours and the average flight hours reported in the make and model of the accident helicopter was 1,428 hours. Of the 10 pilots involved in the Aerial Observation / Patrol accidents analyzed, four pilots had more than 1,000 flight hours in the make and model of the accident helicopter and five pilots had 500 or fewer flight hours in the make and model.

6.3.9.4 Aerial Observation / Patrol – Problem Areas Identified

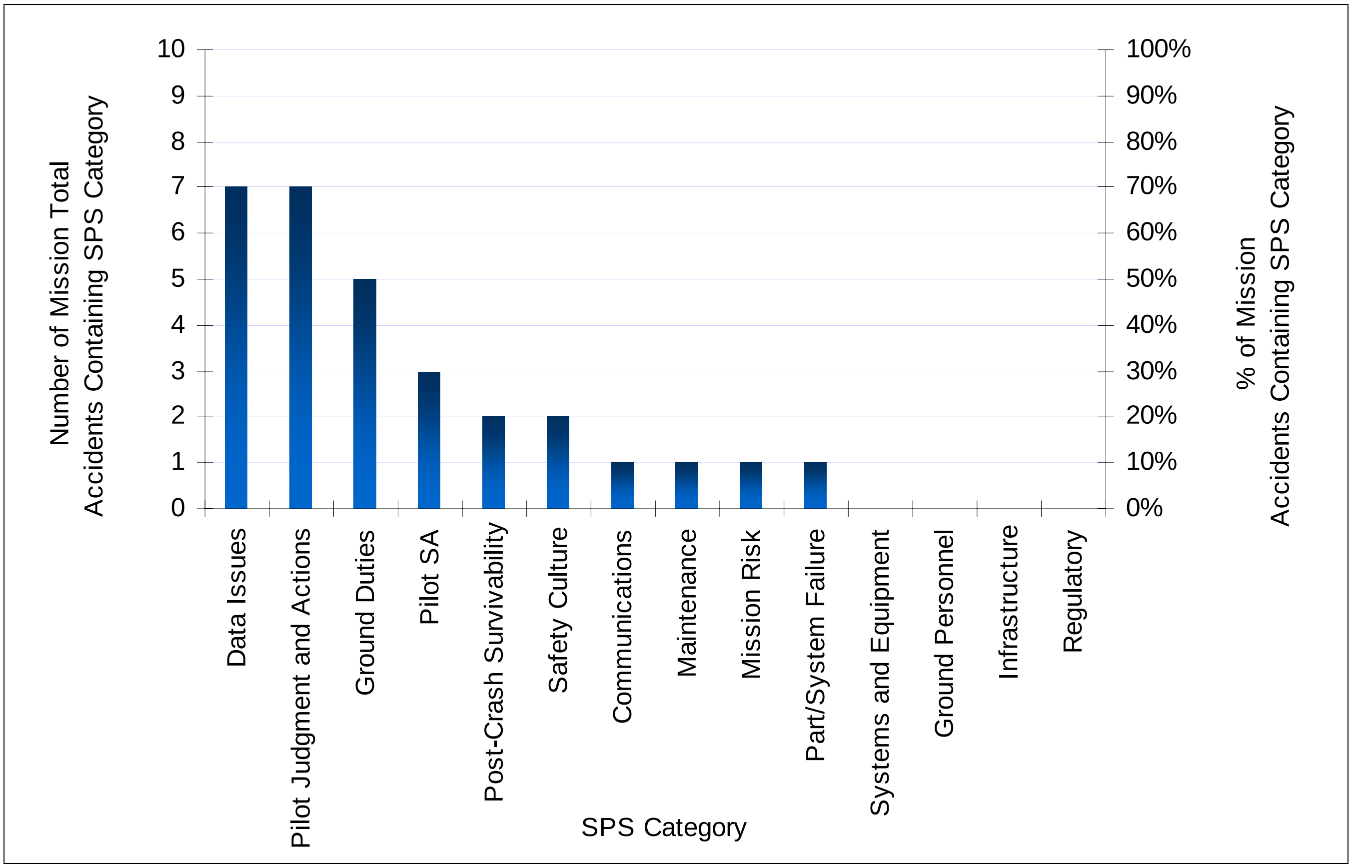


Figure 6-27. SPS Categories for Aerial Observation / Patrol (10 Accidents Analyzed)

For the 10 Aerial Observation / Patrol accidents analyzed, 49 individual problems were identified across 10 main problem categories:

1. Data-related issues were identified in seven (70%) of the Aerial Observation / Patrol accidents analyzed. In four of these accidents, information was not available to the investigators. In the other three accidents, information was either missing or incomplete in the NTSB reports. Although these accident reports had sufficient detail to make reasonable findings, they did not have sufficient depth to enable investigators to make detailed root cause findings. In the case of one of the fatal accidents, in which two fatalities occurred, the lack of information available to the investigators was detrimental in determining a cause of the accident.

2. Problems related to Pilot and Judgment Actions were identified in seven (70%) of the Aerial Observation / Patrol accidents analyzed. Pilots involved in these accidents tended to exhibit poor pilot decision making and engaged in unsafe flight profiles due to the altitudes flown as a requirement of the mission. In addition, the accident pilots tended to exhibit control and handling deficiencies of the helicopter when unanticipated flight conditions were encountered.

3. Problems related to Ground Duties were identified in five (50%) of the Aerial Observation / Patrol accidents analyzed. Helicopter preflight and mission planning were found to be lacking and fuel planning and aircraft performance considerations were found to be inadequate.

4. Pilot Situation Awareness-related issues were identified in three (30%) of the Aerial Observation / Patrol accidents analyzed. Awareness of aircraft position and surrounding hazards was a factor in one of the two fatal Aerial Observation / Patrol accidents. Other problems in this area included the failure of the pilot to recognize cues to terminate the actions being taken and the lack of awareness of the fuel state on board the helicopter.

5. Post-Crash Survivability-related problems were noted in two (20%) Aerial Observation / Patrol accidents. In one of the two fatal accidents, rescue efforts were delayed due to an inoperative or damaged ELT as a result of the impact forces.
6. Safety Culture-related problems played a role in two (20%) of the Aerial Observation / Patrol accidents. Management disregard of human performance factors, including duty time, flight time and fatigue, and inadequate risk management procedures were evident. Inadequate pilot knowledge was also apparent.
7. Communications-related problems were not found to be a significant factor in the accidents analyzed; however, where communication was identified as a problem in one accident, it was a communication issue between crewmembers, and the accident resulted in two fatalities and one seriously injured person.
8. Maintenance-related issues were not found to be a significant factor in Aerial Observation / Patrol accidents. One accident occurred as a result of a part / system failure that might have been detected if appropriate equipment had been onboard the aircraft. This accident resulted in a precautionary water landing and the subsequent loss of the helicopter.
9. Problems related to Mission Risk were not found to be a significant factor, even though flight at low altitudes is often required to perform aerial observation activities. One accident occurred when a helicopter collided with a tree during an aerial game survey over mountainous terrain, resulting in two fatalities and one seriously injured person.
10. Part / System Failure-related problems were not found to be a significant factor in Aerial Observation / Patrol accidents; however, a part / system failure resulted in a water landing and loss of the helicopter.

6.3.9.5 Aerial Observation / Patrol – Safety Interventions Identified

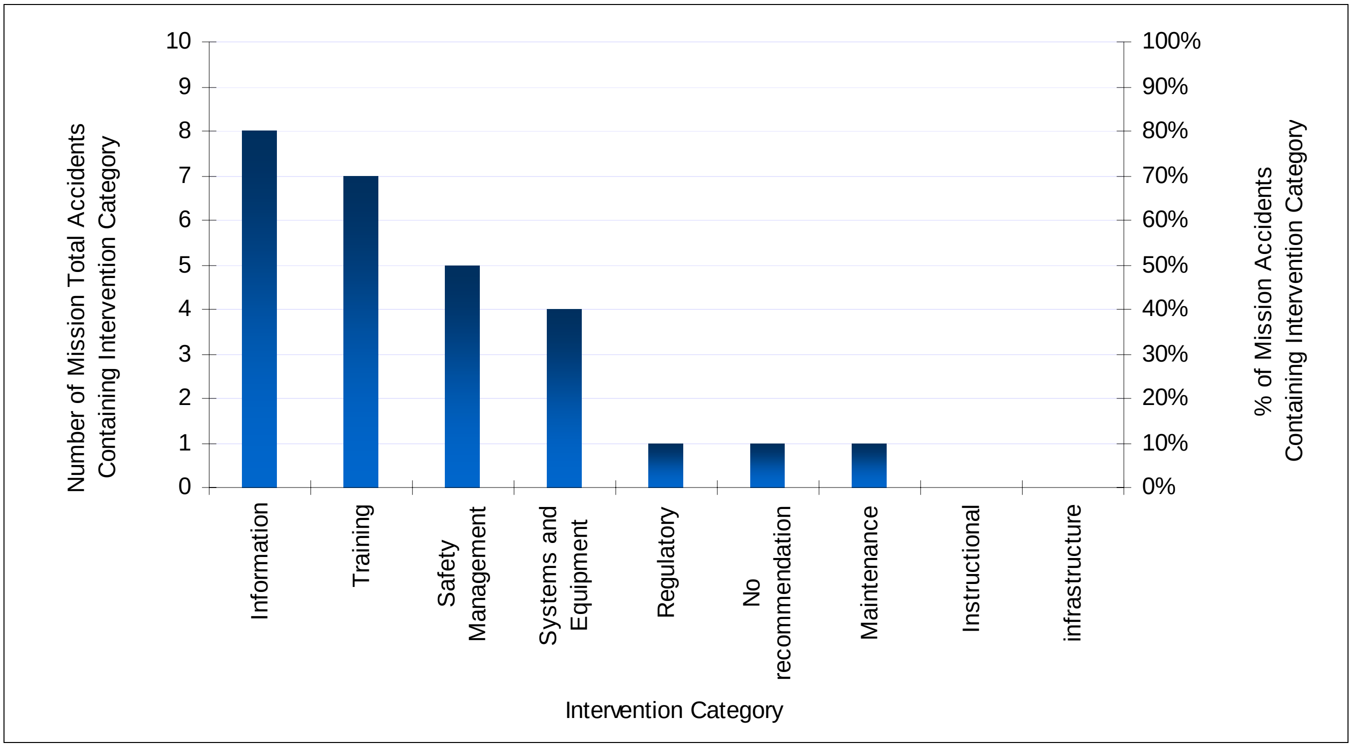


Figure 6-28. Intervention Categories for Aerial Observation / Patrol (10 Accidents Analyzed)

For the 10 Aerial Observation / Patrol accidents analyzed, 47 individual interventions were identified across seven main intervention categories:

1. To improve the quality of data available to the accident investigators, the need for data recording devices was addressed. Both cockpit voice and image recording devices were considered valuable in this regard. Cockpit recording devices would also provide information for company management to provide non-punitive

corrective actions for pilot and crew performance deficiencies. Real-time performance monitoring via satellite was another safety intervention suggested. In addition to improving the quality of data available to the investigators, it was concluded the investigations should place more emphasis on root cause identification so that interventions might be appropriately focused.

2. Training-related recommendations addressed the need for additional training in the areas of preflight procedures, LTE, quickstops, dynamic rollover, autorotations, aircraft systems failures, CRM and Inadvertent Flight into IMC. In addition, risk assessment training should be provided, and it should include mission-specific risk management training.
3. Safety Management System concepts should be adopted by Aerial Observation / Patrol operators. Operators should develop and adopt policies and procedures that assess and minimize the inherent risk in Aerial Observation / Patrol operations. Among these should be a preflight operational risk assessment program, a mission-specific operational risk assessment program, and best practices for low altitude aerial survey flights. In addition, operational oversight should be in place to ensure that better preflight planning and inflight decision making occur. Training for prevention of Procedural Intentional Non-Compliance (PINC) should be developed and implemented.
4. Systems and Equipment-related recommendations addressed the need for a low airspeed indicator or warning and a low fuel indication. In addition, the installation of a proximity detection system and radar altimeter was proposed.
5. Regulatory-related recommendations addressed the need for disciplinary or remedial action by the FAA against a pilot, should it be warranted.
6. No recommendations were identified for two problems identified in one accident. This was due to the lack of information available to the investigators, and that the helicopter sank and was not recovered.
7. Maintenance recommendations addressed the need for the installation of a HUMS system and the use of the data to intervene in the maintenance and operations of the helicopter. Also, HOMP was discussed as a way of monitoring flight operations and habits of flight crews.

6.3.9.6 Aerial Observation / Patrol – Prioritized Safety Recommendations

1. Install cockpit recording devices to enable accident investigators to better understand the accident sequence.
2. Provide mission specific risk assessment training, and training specific to LTE, quickstops, dynamic rollover, autorotation, aircraft system failures, CRM and Inadvertent Flight into IMC.
3. Adopt a “fit for purpose” Safety Management System and grow an organizational culture to support it.
4. Install proximity detection equipment (radar altimeters or HTAWS), to provide additional situational awareness to the flight crew.
5. Install low airspeed indicators or warning systems and low fuel indication systems.
6. Enforce disciplinary and remedial action against pilots where warranted.
7. Install HUMS to detect required maintenance interventions, and install HOMP to address flight operations and flight crew habits before they result in an accident.

6.3.10 Mission Specific Findings – Air Tour and Sightseeing

6.3.10.1 Air Tour and Sightseeing – Mission Definition

A commercial air tour is defined as any flight conducted for compensation or hire where the purpose of the flight is sightseeing. The operators who conduct sightseeing flights as a regular part of their business are commonly known as air tour operators and their operations are often referred to as commercial air tours.

Air tour flights are conducted in various types of scenic areas, including national parks, urban, coastal and mountainous areas. To view the scenic sites, air tours are normally conducted at relatively low altitudes, between

500 and 1,000 feet above ground level (AGL). Flights conducted at these altitudes have an inherent risk due to frequent low altitude flight over unsuitable emergency landing terrain or water.

Air tour flights are typically single-pilot operations conducted in visual meteorological conditions (VMC), most often without radar coverage or traffic advisories from an air traffic control facility. Air tours are often conducted in dense air traffic near popular scenic areas. Some of these scenic areas have localized microclimates with complex weather patterns that can change unpredictably. The air tour industry estimates that two million passengers fly annually on such flights.

Air Tour. Currently, commercial air tours that are conducted beyond 25 statute miles of the departure airport, or over a unit of the national park system, must be certificated under Title 14 CFR Part 119 to operate in accordance with either Part 121 or 135, contain operational, safety and training rules that are not limited to air tour operations. These operations tend to operate turbine engine powered helicopters that hold more than four passengers.

Sightseeing. Exceptions to the certification requirements are contained in 14 CFR 119.1(e). One of these exceptions applies to non-stop commercial “sightseeing” flights conducted within 25 statute miles of the departure airport that takeoff and land at the same airport. Operators conducting “sightseeing” flights under this exception are not required to be certificated under Part 119 and are not subject to the operational requirements of either Part 121 or 135. These excepted operations are subject only to the requirements of Part 91, and although some operate turbine powered helicopters, others frequently operate helicopters powered by reciprocating engines that hold fewer passengers than typical turbine powered helicopters performing similar missions.

These missions will be examined together and separately, as they are flown for the same purpose but have distinctly different regulatory requirements under which they operate.

6.3.10.2 Air Tour and Sightseeing – Synopsis of Accidents Analyzed

Of the 197 accidents analyzed in the NTSB year 2000 dataset, six accidents involved air tour operations, and four involved sightseeing operations, for a total of ten accidents. This represented 5.1% of the accidents analyzed in the year 2000 dataset.

6.3.10.3 Air Tour and Sightseeing – General Characteristics of Accidents Analyzed

Conditions. One of the air tour accidents occurred during a maintenance test flight when a jacket exited an open passenger door and damaged the tail rotor during flight. The other nine Air Tour and Sightseeing accidents occurred during revenue passenger flights. Eight of the accidents involved a loss of power to the rotor system and emergency landings; one accident occurred when the pilot inadvertently entered instrument meteorological conditions (IMC). Two of the power loss accidents were the result of inadequate preflight preparation (snow ingested from the engine inlet) and fuel mismanagement (fuel exhaustion). In one, the cause of the power loss was not determined. The others were the result of a variety of mechanical problems, including: a separated oil jet that precipitated clutch slippage, a clogged oil jet that caused damage to a spur adapter gearshaft, a failed bearing, internal engine damage that resulted in fuel starvation, and transmission bull and spline gear damage.

Of the six air tour accidents, three occurred during maneuvering; one occurred during approach; one occurred during descent; and one occurred during the takeoff phase of flight. Of the four sightseeing accidents, two occurred during cruise flight; two occurred while maneuvering. Five of the 6 air tour accidents occurred in visual meteorological conditions (VMC). All of the four sightseeing accidents occurred in VMC. All of the accidents, both air tour and sightseeing, occurred during daylight hours between 0815 and 1615 local time.

Aircraft. Of the six aircraft involved in air tour accidents, there were four single-engine turbine Normal category aircraft, one twin-engine turbine Normal category aircraft, and one single-engine turbine (Modified)-Transport category aircraft, which was a surplus military aircraft.

All four of the aircraft involved in sightseeing accidents were single-engine and certified in the normal category. Three of these aircraft were powered by reciprocating engines and one was powered by a turbine engine.

Pilots. The total flight time of air tour pilots ranged from 6,800 to 12,600 hours, averaging at 8,888 hours; average time in rotorcraft was 7,243 hours; average time in make and model was 2,256 hours. The pilot involved in the fatal IMC air tour accident had the highest number of rotorcraft hours (over 12,000), but the lowest number of hours in make and model (56) among the air tour accidents.

The total pilot time of sightseeing pilots ranged from 2,354 to 5,777 hours, averaging at 4,282 hours; average time in rotorcraft was 3,098 hours; average time in make and model was 804 hours (for three pilots reporting).

Air tour pilots in this group had 2.3 times as much rotorcraft flight time and 2.8 times as much time in make and model as sightseeing pilots.

Injuries. There were a total of 48 people onboard the ten total Air Tour / Sightseeing accidents. Two of the 10 accidents (20%) resulted in fatalities. One was an air tour flight with seven persons onboard, which resulted in seven fatalities. The other was a sightseeing flight with three persons onboard, which resulted in one fatality, one serious injury and one minor injury.

There were 35 people onboard the six air tour accident flights. Seven were fatally injured (all in one accident) as mentioned above. Six sustained serious injuries (all in one accident), eight received minor injuries and 14 were not injured. There were 13 people onboard the four sightseeing accident flights. One person was fatally injured, two sustained serious injuries, four received minor injuries and six were not injured.

There were generally twice as many people onboard air tour flights (6 average occupants) as there were on sightseeing flights (3 average occupants), and the air tour flights were operated in higher capacity aircraft.

6.3.10.4 Air Tour and Sightseeing – Problem Areas Identified

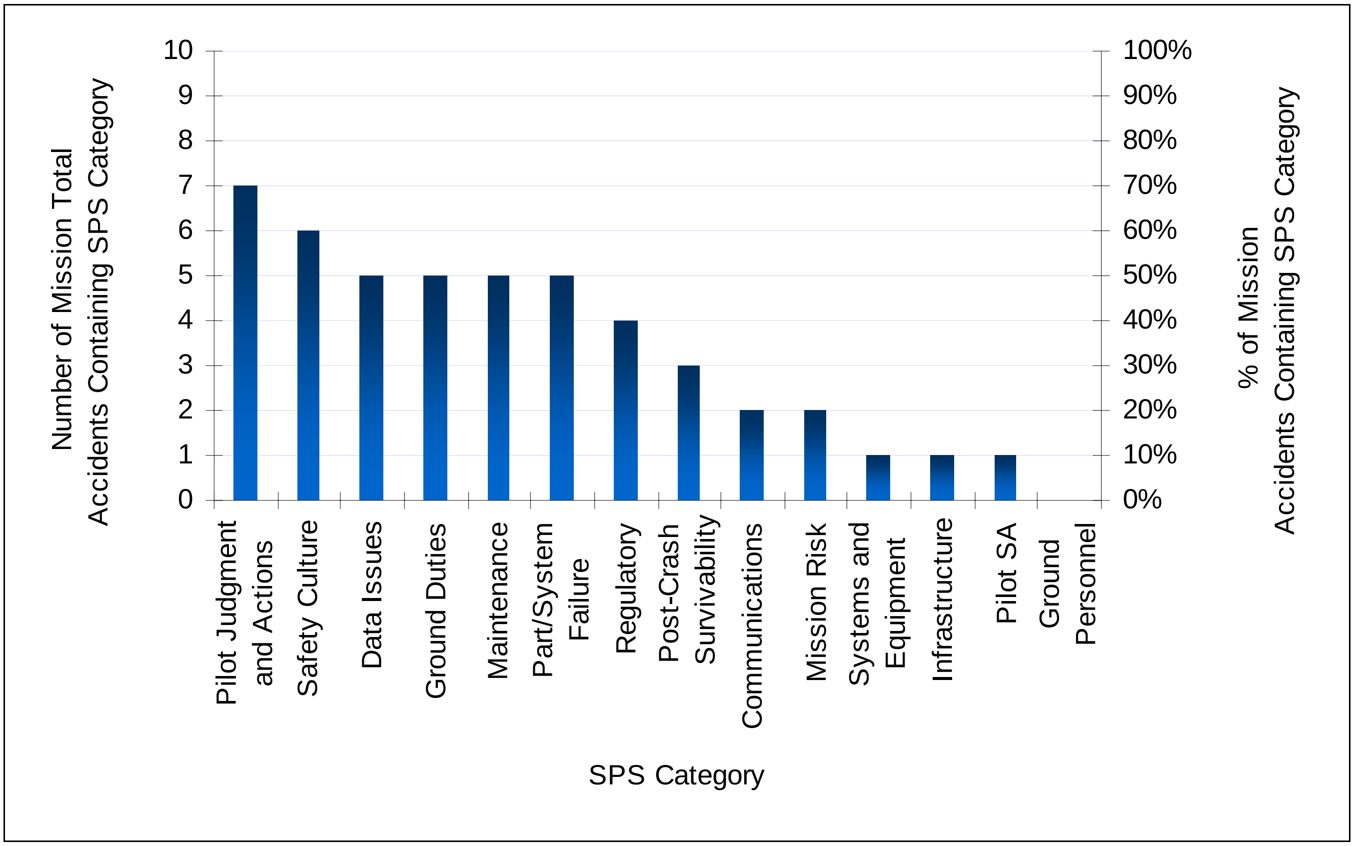


Figure 6-29. SPS Categories for Air Tour and Sightseeing (10 Accidents Analyzed)

76 total problems were identified in thirteen categories.

1. Poor Pilot Judgment and Actions comprised approximately a quarter of the problems and affected seven (70%) of the Air Tour and Sightseeing accidents. Unsafe flight profiles were cited five times. Pilots

disregarded cues that should have led to termination of the flight; disregarded rules and procedures; and failed to follow procedures. Improper fuel management, inadequate energy / power management and inadequate autorotations were also cited. Sightseeing pilots had three times as many problems in this category – percentage-wise (39%) – as the air tour pilots (12%).

2. Lack of adequate Safety Culture was also noted in six accidents (60%), comprising 17% of the problems for this mission. Management was believed to be lacking in policies and oversight, especially of remote operations and maintenance. Pilots responding to customer or company pressure was evident, and the company failed to enforce standard operating procedures. In addition, training was believed to be inadequate for Inadvertent Flight into IMC (IIMC) and transition to new aircraft models. Risk management was inadequate and in one case, a pilot disregarded a known safety risk. Air tour and Sightseeing accidents had a similar percentage of Safety Culture issues.
3. Data Issues were identified in half (50%) of the accidents analyzed. Although the accident reports had sufficient detail to make reasonable findings, three did not include sufficient data to allow investigators to make detailed root cause findings. In addition, aircraft were not equipped with data recording devices that may have provided critical information to investigators and provided data for monitoring and standardizing flight operations.
4. Ground Duties were performed inadequately in half (50%) of the Air Tour and Sightseeing accidents. Preflight, planning and briefing were areas in most need of help, with postflight duties playing a small, but important role.
5. Maintenance issues were found to be a significant factor in five accidents (50%). Published maintenance procedures were not adhered to or aircraft were released in an un-airworthy condition. In one instance, maintenance did not detect an impending failure, and in three others, equipment was not available to detect impending failures. Inadequate maintenance oversight and documentation were also identified as problems.
6. Part / System Failures comprised only 7% of the problems but affected five (50%) of the Air Tour and Sightseeing accidents. One accident involved a loss of power due to the failure of an oil cooler fan hangar bearing for an unknown reason. The other accident involved an improperly chamfered ignition solenoid housing by the manufacturer, which led to a loss of fuel flow and subsequent loss of power. The other Part / System Failures occurred as a result of improper maintenance.
7. Post-Crash Survivability was an issue in three accidents (30%). Safety equipment was either not installed or had been removed. A post-crash fire exacerbated the consequences of one accident.
8. Lack of Regulatory oversight and guidance was a contributor in four accidents (40%). Air tour operations must be conducted to Part 121 or 135 requirements, while sightseeing operations can be conducted under the less stringent Part 91 rules. Oversight of sightseeing operations and proficiency requirements were found to be inadequate. FAA control of military surplus parts was also found to be inadequate.
9. Poor Communications were cited in two accidents (20%). In one instance, there was no company flight following. In another, there was poor coordination with ground personnel.
10. Weather information was not available for a particular destination due to a lack of Infrastructure in one accident (10%).
11. Lack of Pilot Situational Awareness was also noted as an issue in one accident (10%).

6.3.10.5 Air Tour and Sightseeing – Safety Interventions Identified

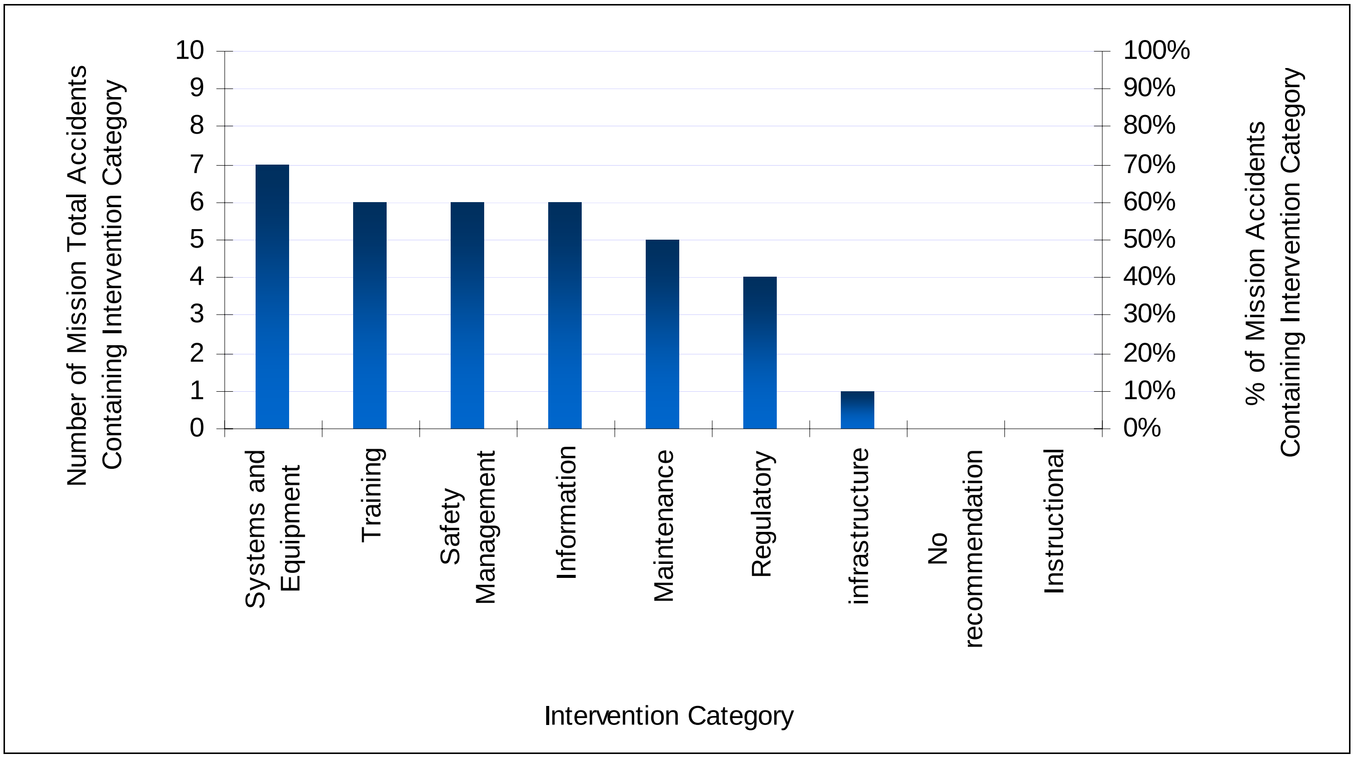


Figure 6-30. Intervention Categories for Air Tour / Sightseeing (10 Accidents Analyzed)

76 interventions were identified in seven categories.

1. Systems and Equipment: Several interventions identified in the Systems and Equipment category specified the installation of low fuel warning systems, alternate means of verifying fuel onboard and installation of door / cowl positive latch warning indications.
2. Safety Management: Implementation of a Safety Management program was the most common intervention for the problems identified in the analysis of Air Tour and Sightseeing accidents. The need for specific risk management programs for Part 91 sightseeing operations was cited on two accidents. Risk assessment tools regarding weather and flight profile planning were cited as interventions on several accidents as well. Increased operational oversight for remote operations, implementation of flight following systems, and improvement of dispatch procedures were identified as additional interventions in this category.
3. Training: In six of the 10 accidents, the need for additional training was identified. Training was needed in the areas of Aeronautical Decision-Making, model-specific power / energy management, autorotations, performance planning and fuel calculations, emergency procedures, preflight procedures, weather planning and IIMC avoidance.
4. Information: Interventions that would increase data collection and allow better understanding of the accident circumstances, such as installing cockpit recording devices that will enable crash investigators to gain critical information such as cockpit indications and pilot actions prior to a crash – were recommended. Cockpit imaging devices also provide information for company management to monitor flight operations and provide non-punitive corrective actions for pilot / crew performance anomalies.
5. Maintenance: Maintenance-related interventions were identified in four of the 10 air tour and sightseeing accidents; compliance with existing maintenance instructions, increased operational oversight for remote operations, improved quality (QA) oversight of maintenance, and installation of HUMS / HOMP systems.
6. Regulatory: Some interventions that were suggested for the problems identified in the Regulatory category were improved policy on HTAWS, EVS and SVS, improved regulatory requirements regarding IIMC

training, and increased regulatory guidance and oversight for air tour operations, particularly for Part 91 sightseeing operations.

7. Infrastructure: One intervention suggested for the lack of weather data was to encourage the greater participation in and use of the PIREP system for intra / inter company flights.

6.3.10.6 Air Tour and Sightseeing – Recommended Safety Interventions

1. Adopt Safety Management programs such as SMS to assess and minimize risk in maintenance, operations (including flight profiles) and hiring practices, and to maximize the benefits of targeted training.
2. Increase company operational oversight of remote operations.
3. Install aircraft / operations monitoring systems such as HUMS or HOMP.
4. Install low fuel warning systems and / or alternate means of verifying fuel onboard.
5. Install positive door / cowl latch indication warning systems.
6. Conduct additional pilot training in the areas of
    - Aeronautical Decision-Making
    - Model-specific power / energy management
    - Autorotations
    - Performance planning and fuel calculations
    - Emergency procedures
    - Preflight procedures
    - Weather planning
    - IMC avoidance / IIMC recovery
7. Install cockpit / information recording devices.
8. Increase QA and maintenance oversight to ensure proper compliance with operational and maintenance instructions.
9. Require that all Air Tour and Sightseeing flights, regardless of distance from takeoff and landing airport, be held to Part 121 or 135 operational standards while operating with passengers onboard.
10. Increase regulatory guidance and oversight for Air Tour and Sightseeing operations.
11. Expand communication of weather information utilizing systems such as PIREP and Intra / Inter-company Communication for preflight planning and for in-flight decision-making by flight crews. In addition, expand Automated Weather Observation System (AWOS) infrastructure and other weather reporting sources.

6.3.10.7 Air Tour and Sightseeing – Additional Discussion

The set of Air Tour and Sightseeing accidents analyzed in the CY2000 dataset limited the JHSAT to the 11 data driven safety recommendations above. The team is aware of entities in the Air Tour and Sightseeing industry that are promoting improved safety standards. The following is offered as a supplemental recommendation for Air Tours and Sightseeing operations:

Many Air Tour and Sightseeing operations have moved to adopt new standards in the last decade. This has been accomplished individually or by joining associations that self-certify compliance to stepped up safety standards. The JHSAT applauds and supports Air Tour and Sightseeing operators that are working together to adopt the following safety standards in addition to the requirements of Parts 91 and 135 including:

- Required safety program
- Annual safety audits
- Designated safety manager
- Human factors and Aeronautical Decision Making training
- Ongoing safety training

- Pilot requirements of 1,000 hours flight time and typical terrain experience
- Minimum en route altitude of 500 feet above ground level
- Minimum of 1 mile visibility
- Maximum angle of bank (30°) and pitch (10°) with smooth transitions
- Avoidance of the unsafe regions of the height-velocity curve
- 3 year experience requirement for Airframe and Powerplant (A&P) mechanics
- Maintenance factory training requirement
- Mechanic annual training requirement
- Emergency locator transmitter (ELT) requirement
- High visibility rotor blades and flashing landing lights
- Aircraft instrumentation required for night Visual Flight Rules (VFR) standard
- Specialized ground support personnel training

The FAA recently issued a final rule implementing the National Air Tour Safety Standards, 14 CFR Part 136. The final rule addressed safety issues, including the clarification of passenger briefing requirements, the requirement for life preservers and helicopter floats over water, and requirements for helicopter performance planning and operations. There is also a specific appendix that air tour operators in the state of Hawaii will be required to comply with in addition to the general rules of Part 136.

6.3.11 Mission Specific Findings – Electronic News Gathering (ENG)

6.3.11.1 Electronic News Gathering – Mission Definition

Electronic News Gathering (ENG) operations entail rapid transportation of audio, video and print media personnel and equipment to news scenes so that live or timely coverage of high public interest stories can be provided promptly to media outlets. The helicopter frequently is the platform for live media coverage. Prompt and efficient aerial coverage of a news story means favorable rankings that translate to important revenue streams for media outlets. This, in turn, creates competitive pressures that can be brought to bear on pilots providing ENG coverage. The need to respond promptly may include transporting large quantities of equipment or personnel at any time of day or night to remote, sometimes hostile sites. ENG pilots may also be called upon for promotional flying, for VIP transport, or for utility missions as rescue and recovery. Helicopters used for ENG must be well maintained, reliable, suitably equipped with navigation and audio / visual media installations, and equipped for remote site operations. Pilots must be prepared to make appropriate launch and on-site operational decisions based on assessments of mission risk. For example, ENG pilots must decide whether the mission can be safely operated, whether a remote site landing should be made, whether loitering is appropriate, or if a high hover – out of ground effect or in the vicinity of other traffic or obstacles – can be safely accomplished. ENG executives must recognize the necessity of pilots having the authority to make such decisions.

6.3.11.2 Electronic News Gathering – Synopsis of Accidents Analyzed

Of the 197 accidents analyzed in the NTSB year 2000 dataset, four accidents involved ENG operations. This represented 2.0% of the accidents analyzed for the year. Two of the accidents involved fatalities. There were a total of three fatal injuries, 2 serious injuries and 2 no-injuries. Three of the four accidents occurred in VMC; one in IMC. Two of the accidents occurred in daylight; two occurred at night. One each occurred during maneuvering and cruise flight; two of the accident scenarios began in hovering flight. Three of the pilots held ATP, and one held a commercial pilot certificate. All of the pilots had substantial flying experience – averaging 5,027 total pilot hours, 3,589 rotorcraft hours and 902 hours in the make and model of the accident aircraft. The least experienced pilot in this group had 1,661 total flight hours, all in rotorcraft, and about 450 hours in the make and model.

6.3.11.3 Electronic News Gathering – General Characteristics of Accidents Analyzed

All four ENG accidents occurred in single-turbine helicopters. Three occurred on ENG flights and one on a “positioning” flight. The positioning accident involved low altitude flying in night, IMC, low-visibility conditions and concluded with a wire-strike and an uncontrolled collision with the ground. Two of the helicopters experienced control problems that began in hovering flight during live ENG broadcasts. One of those experienced a loss of tail rotor effectiveness (LTE) while hovering out of ground effect (HOGE) at 500 feet AGL; that pilot made a hard landing and rolled over after stretching out an autorotation to clear obstructions in his path. The other experienced a hydraulic failure and lost control abruptly during a landing approach at an airport 15 miles away. That pilot's small stature and delay in initiating an emergency landing were factors in the accident. The fourth ENG accident occurred during an apparently deliberate aerobatic maneuver at low altitude. Other pilots and camera crewman had previously expressed concern about this pilot's penchant toward aggressive, aerobatic maneuvering, but his disregard for the limitations of the aircraft and operating rules went uncorrected.

6.3.11.4 Electronic News Gathering – Problem Areas Identified

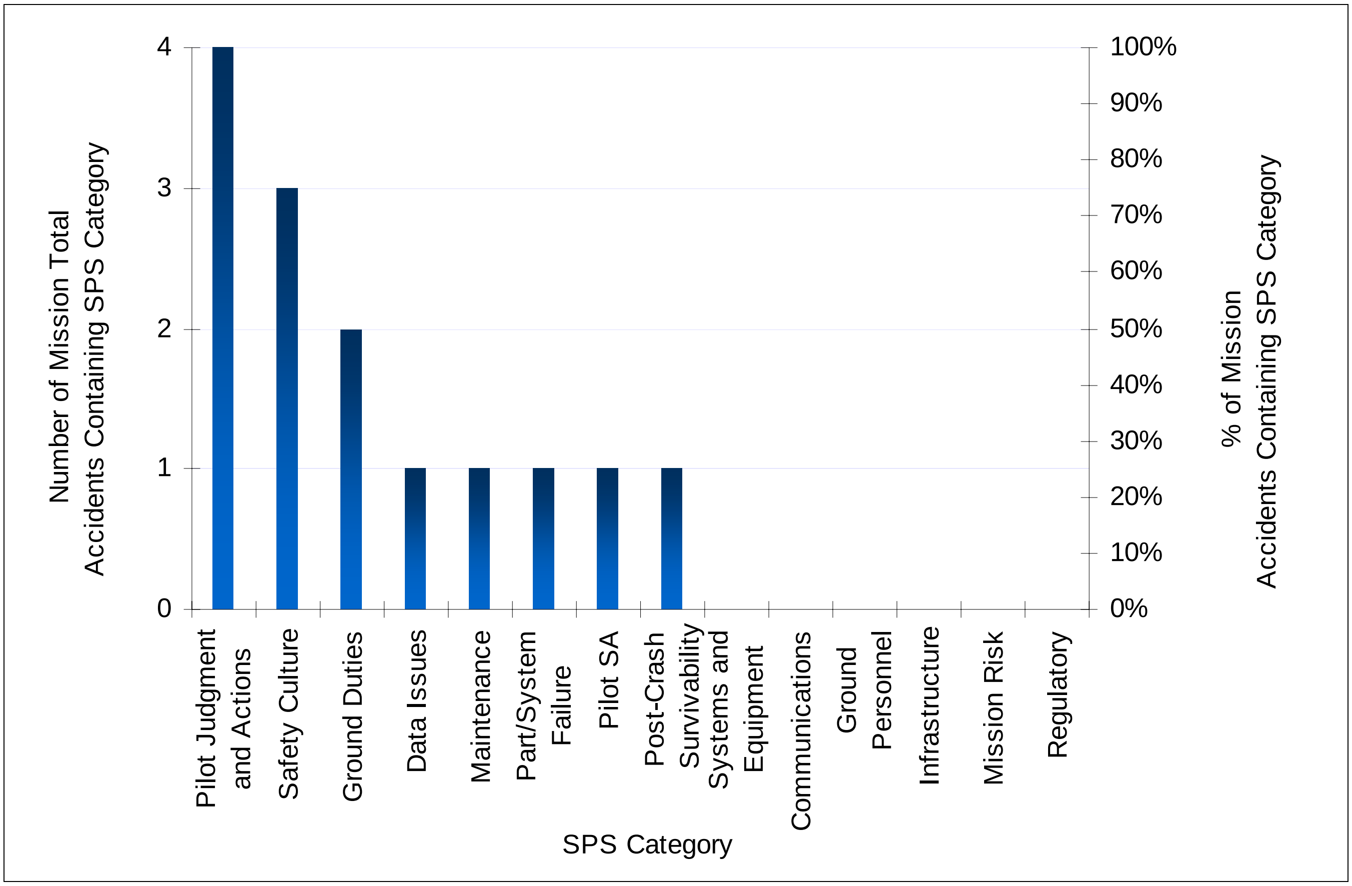


Figure 6-31. SPS Categories for Electronic News Gathering (4 Accidents Analyzed)

30 problems were identified in the ENG accidents:

1. Evidence of inadequate Safety Culture was identified nine times in three (75%) of the accidents. Inadequate company management (inadequate management policies and / or oversight inadequate, failure to enforce company SOPs, and inadequate hiring criteria), safety program deficiencies (lack of a formal system for threat-free reporting of safety-related incidents and insufficient employee performance monitoring), training program failures (transition training and flight procedures training), and pilot disregard of known safety risk were identified as problems that reflected an inadequate company approach to safety (safety culture).

2. A collection of conditions and circumstances related to Pilot Judgment and crew performance fell into another large category (11 instances) of factors in ENG accidents and were present in all (100%) of the accidents. Among them were: lack of knowledge of aircraft's aerodynamic state (envelope), evident in one accident (25%); willful disregard of rules, SOPs, and aircraft limitations; failed to follow procedures; disregarded cues that should have led to termination of current course of action or maneuver; improper action due to misdiagnosis; misjudged own limitations / capabilities; and improper decision-making. These factors were closely linked to their result: flight profile unsafe or forced autorotation landing. Inadequate preflight

preparation (inadequate consideration of weather / wind, and inadequate aircraft pre-flight) were considered links in the causal chain.

3. Maintenance factors were identified three times, all in one accident (25%). Failure to follow proper maintenance procedures, aircraft released a non-airworthy condition and inadequate maintenance documentation were all cited as causal factors in one of the ENG cases, and performance of maintenance responsibilities was cited once.
4. While not part of the causal chain, it was considered that the true causes of at least one (25%) of the ENG accidents would have been better defined and its issues resolved had the investigation gathered more data. Specifically noted here was the lack of data provided to investigators.

It is hard to look at the complexity and variety of ENG operations and to rationalize that any of these causal factors were necessitated or made more likely by the nature of the ENG mission. More likely, these accidents and their respective causal factors were a result of breakdowns in crew discipline, preparation, planning, and execution of the flights – such as were found in reports of accidents in other mission categories. While recommendations specific to ENG operations will be proffered to reduce risk in such operations, a stronger safety culture, better training, and better company oversight of flight operations in all categories of flight operations would reduce the risk of accidents such as these.

6.3.11.5 Electronic News Gathering – Safety Interventions Identified

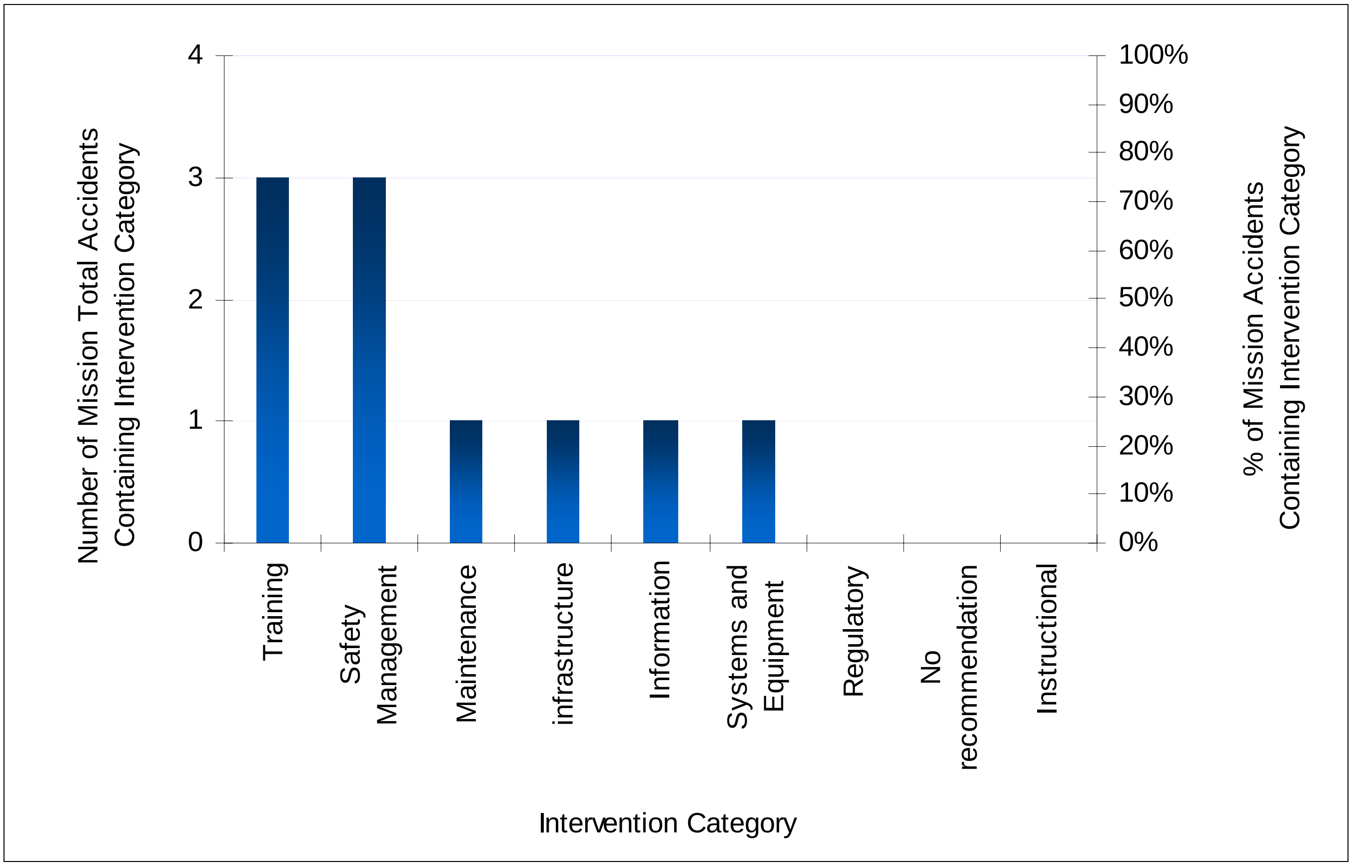


Figure 6-32. Intervention Categories for Electronic News Gathering (4 Accidents Analyzed)

30 interventions in six categories were identified from analyzing ENG accident data:

1. The identified interventions that would reduce the risk of the ENG accidents in this dataset were heavily focused on needed Safety Management and Training, with 21 of 30 interventions falling into these categories. Most addressed establishment of higher operational / management standards and training for the ENG mission in a manner that the problems identified in the accidents would be addressed proactively. Nine interventions

were in other categories: aircraft design, maintenance, system infrastructure, and missing information. Each of the intervention areas are discussed below.

2. Risk assessment and risk management interventions were identified in both the Safety Management and Training categories. Included in these categories are recommendations that a formalized risk management program be developed; that personal and flight operations risk management training be provided; that pilots receive judgment training in risk assessment; that pilots receive mission specific operational training that addresses event hazards; and that pilots receive weather training to emphasize appropriateness of aborting the mission when faced with deteriorating weather conditions.
3. Other Safety Management intervention recommendations addressed the need for: establishment of departmental safety and flight operations standards; formalization of an operator flight operations oversight program; implementation of non-punitive safety event reporting systems; a policy to reduce the risk of pilots continuing VFR flights into adverse weather; company oversight to ensure compliance with procedures in aircraft flight manuals (AFM); policy and training to reduce the risk of Procedural Intentional Non-Compliance (PINC) with company and regulatory rules or standards; and utilization of HOMP-type data to verify employee flight performance. As suggested by these recommended interventions, the circumstances of these accidents clearly indicated a need, as seen in other mission groups of accidents, for operator management to set and enforce higher standards for flight operations and to provide training to implement risk management in flight operations.
4. Training intervention recommendations addressed the need for specific or high quality training that would address: transition to a new make and model helicopter; helicopter preflight inspections; autorotation procedures and technique; recognition and response to aircraft system failures; and emergency procedures training. The development and use of comprehensive ground and flight simulator training was recommended to reduce the risk of Inadvertent Flight into Instrument Meteorological Conditions (IIMC). Ground and flight simulator training was recommended to ensure recovery from loss of tail rotor effectiveness (LTE) and other aerodynamic conditions.
5. It was recommended that cockpit recording devices be installed to provide digital data needed by crash investigators to understand system anomalies and pilot / crew performance that preceded an aircraft mishap. Such data, when used in routine operations, for example data collected in a HOMP program, has great importance as a tool for monitoring aircraft system performance and quality of the flight crew training program (answering the question, “Do we fly like we train?”). Non-crashworthy recorders intended for monitoring and standardizing flight operations are less expensive than crash resistant flight recorders and sometimes will survive an accident and be useful for accident analysis.
6. Maintenance-related recommendations addressed the need for: systems to ensure adherence to instructions for continued airworthiness (ICA) procedures and records of compliance; quality assurance of maintenance involving “safety of flight” components; and establishment of maintenance quality control records systems.
7. To prevent post-crash fire-induced injuries, it is recommended that more crash resistant fuel systems be used.
8. An Infrastructure recommendation proposed development of an industry-maintained database of pilot histories – to ensure better pilot screening and hiring decisions.
9. No Regulatory changes were proposed.

6.3.11.6 Electronic News Gathering – Prioritized Safety Recommendations

1. Develop and use formalized risk management programs to assess risk and to improve decision-making in flight operations and on a personal basis. Provide comprehensive risk management training – to include mission-based risk assessment, weather assessment training, and risk-based flight operations decision-making. The training should demonstrate that the safety culture of the organization encourages aborting or canceling the flight when the risk factors don’t justify conducting or continuing the mission.
2. Establish an operator safety culture that includes clearly communicated flight operations standards and procedures, a formalized flight operations quality oversight program, a clearly defined safety program that

provides for non-punitive safety event reporting, the use of risk assessment and management practices, policy to reduce the risk of VFR flights being continued into adverse weather, and company management oversight to ensure compliance with regulations and procedures and to eliminate PINC.

3. Provide comprehensive training that would address: transition to a new make and model helicopter; helicopter preflight inspections; autorotation procedures and technique; recognition and response to aircraft system failures; and emergency procedures training.
4. Provide comprehensive ground and flight simulator training to reduce the risk of IIMC. Provide ground and flight / simulator training to ensure recovery from LTE and other unusual aerodynamic conditions.
5. Where feasible, establish a HOMP to verify and improve employee flight performance.
6. Install cockpit recording devices to allow crash investigators to understand system anomalies and pilot / crew performance that preceded an aircraft mishap.
7. Establish systems to ensure adherence to maintenance policy and procedures, compliance with ICA and provide records of compliance; establish a system of quality assurance of maintenance involving “safety of flight” components and maintenance quality control records systems.
8. Use crash resistant fuel systems for helicopters to reduce the likelihood of post-crash fires in survivable helicopter crashes.
9. For industry and operator associations: Develop an industry-maintained database of pilot histories (in a manner consistent with that used for airline pilots under the Pilot Records Improvement Act) – to ensure better pilot screening and hiring decisions.

6.3.12 Mission Specific Findings – External Load

6.3.12.1 External Load – Mission Definition

External Load operations (also known as vertical reference operations) involve the use of helicopters to transport external loads, requiring significant operation at low altitude with heavy slung or long line loads. Examples of External Load operations range from delivering supplies to a remote location in close proximity to high obstructions, to positioning an air-conditioning unit on top of a skyscraper in a densely populated area.

The mission has inherent risk due to frequent operation inside the avoid area of height-velocity curve (low altitude and airspeed) over unsuitable emergency landing terrain. Additionally, external load flying is assumed to be an aircraft intensive operation, heavily utilizing the capabilities of the airframe, drive train and power plant. External loads may be carried a relatively short distance below the helicopter or attached to long cables. The “long line” (operations with a load more than 25 feet below the aircraft and frequently in excess of 100 feet) aspect of external load operations is particularly demanding on both pilots and aircraft, as the pilot is usually leaning out of the aircraft to see the load (vertical reference), and utilizes the aircraft to “fly” the load, which may require abrupt maneuvering and control of the helicopter.

External Load flying is extremely demanding. It is a high task load environment that requires intimate knowledge of the cargo and hook systems in addition to the systems and performance capabilities of the aircraft. Situational awareness is critical in external load operations, as the helicopters are often operating in extremely confined areas and around obstacles.

External load operations are conducted under 14 CFR Part 133, a specific regulation for external load rotorcraft operations. There are several classes of external loads. These classes range from A to D, dependent on the load and how it is attached to the aircraft. Normal class B, C and D operations are conducted at near maximum gross weight. Modern dedicated external load operations now utilize load cells that weigh the load and warn the pilot of lifting loads that exceed the maximum capability of the helicopter.

Logging, Aerial Application and Utilities Patrol and Construction accidents – all of which may involve external load operations – are addressed in other mission categories of this report. Thus, this section addresses accidents in “other” external load operations.

6.3.12.2 External Load – Synopsis of Accidents Analyzed

Of the 197 accidents analyzed in the NTSB year 2000 dataset, seven involved external load operations. This represented 3.6% of the total accidents for the year. Two of these seven accidents involved U.S.-Registered aircraft but occurred in foreign countries; therefore, limited information was available on these accidents. 53 problems and 40 associated interventions were identified from analyzing external load accidents.

One of the seven accidents (14%) resulted in fatalities. One accident (14%) resulted in a serious injury. The remaining five accidents (72%) resulted in minor or no injuries. There were two total fatal injuries, one serious injury, and nine minor or non-injuries.

6.3.12.3 External Load – General Characteristics of Accidents Analyzed

All of the accidents in this category were in single turbine engine powered helicopters. One was a transport category helicopter. Of the 7 accidents analyzed, five occurred while carrying external loads, one on a belly hook and three from a long line. In one case, the method of carrying the external load was not reported. One accident occurred on a training flight before a load was lifted, and another occurred after takeoff but without an external load. Two accidents involved engine power loss due to engine component failures. Two accidents involved loss of situational awareness (struck trees or the external load) during load positioning or while troubleshooting a cargo hook discrepancy. The reports of the two foreign accidents lacked sufficient information to identify causal factors.

Six of the 7 accidents (86%) occurred during external load flights. The single fatal accident occurred while returning to base after completing an external load mission. In this instance, the pilot was flying at a low altitude when he collided with a static wire at 39 ft AGL. A toxicology revealed the presence of marijuana metabolites in the pilot's blood that likely impaired his performance.

Of the six accidents that occurred during external load operations, four occurred during hover. One occurred while taxiing, and another occurred during climb.

Six of the accidents occurred during daytime VMC. The seventh reportedly occurred in daylight VMC but in close proximity to an area of reduced visibility in snow showers; that pilot was performing his 85th lift of the day.

The pilots involved in external load accidents were more experienced and had accrued a higher number of flight hours than pilot groups of other missions. Pilot total time ranged from 7,944 hours to 20,478 hours for the five accidents where pilot flight experience was reported. The average total flight time of the accident pilots was 14,182 hours. The pilots' experience in the make and model of the accident aircraft ranged from 2,146 to 14,500 hours. The pilots' average time in make and model was 7,532 hours.

6.3.12.4 External Load – Problem Areas Identified

42 problems in twelve categories were identified for external load accidents.

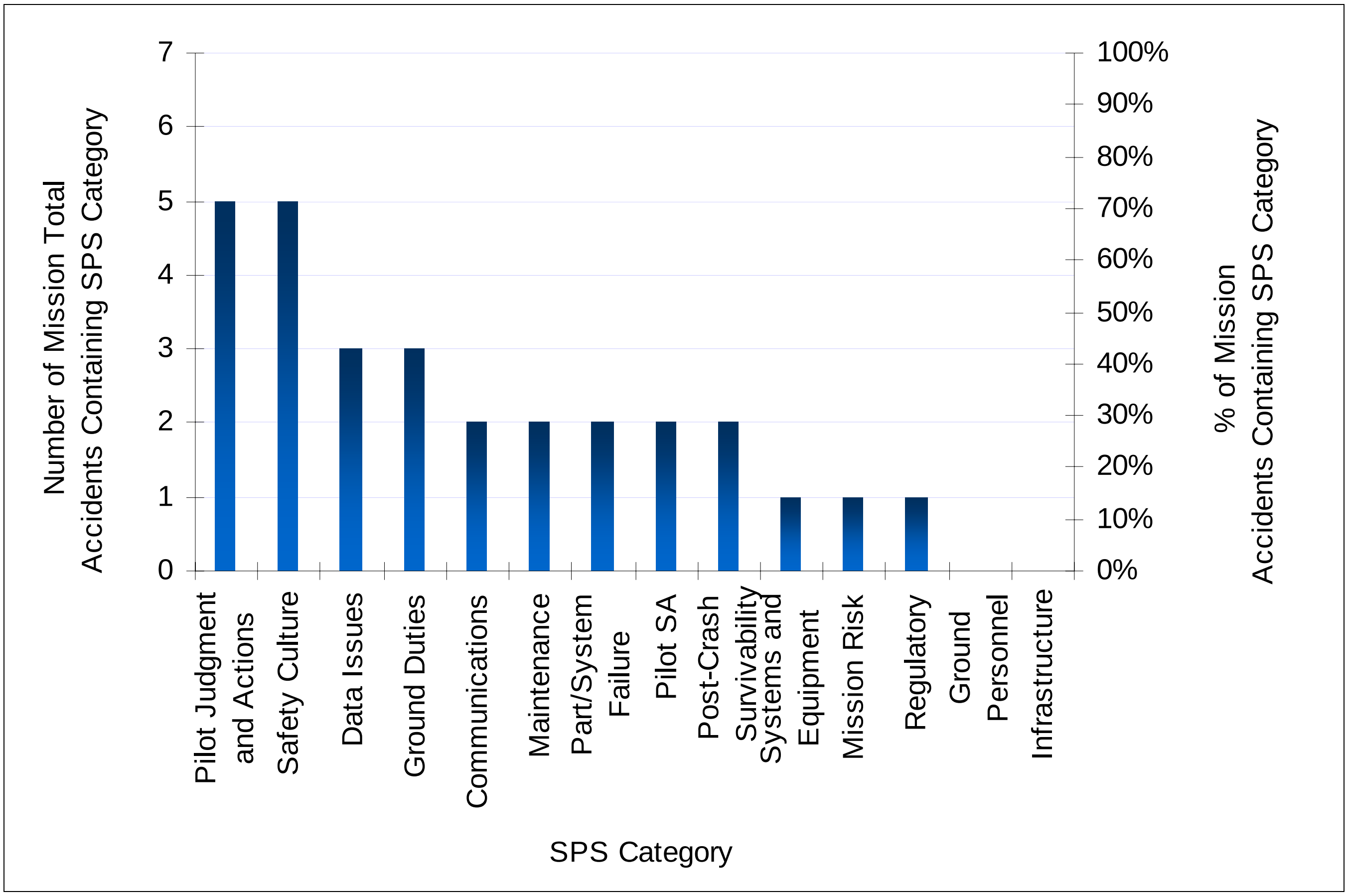


Figure 6-33. SPS Categories for External Load (7 Accidents Analyzed)

1. Pilot Judgment and Actions was the most commonly identified problem category, cited in five out of seven accidents (71%). In three accidents, there was evidence of willful disregard for SOPs or aircraft limitations. Avoidable unsafe flight profiles were flown in three accidents. Diverted attention or distraction was cited in two accidents. Other problems cited in this category were improper landing site reconnaissance, inadequate forced autorotation, improper recognition and response to dynamic rollover, and control / handling deficiencies.

2. Safety Culture was the next most frequently cited problem category, also occurring in five of the seven accidents (71%). Lack of management oversight was cited for normal and remote operations. Lack of a company safety program was cited, along with insufficient employee performance monitoring and crew hiring criteria.

3. Regarding Ground Duties, mission planning and consideration given to factors such as wind, weather and aircraft performance were found to be inadequate in three of the seven (43%) accidents.

4. Data Issues were found in two of the seven accidents (29%); there was insufficient data in the accident report because it had not been available to investigators.

5. Maintenance issues were identified in two of the seven accidents (29%). These problems included a failure to follow maintenance procedures, lack of QA or supervisory oversight, and lack of equipment to detect an impending failure.

6. Part / System Failures occurred in two of the seven accidents (29%). One failure involved an inoperative electric release hook for an external load. The other was due to fatigue of a questionable military surplus engine component.

7. Situational Awareness was cited in two of the seven accidents (29%) where the pilots were unaware of aircraft position and hazards, which led to an in-flight collision with an object(s).

8. A lack of Systems and Equipment was identified in two of the seven accidents (29%). Wire Strike Protection System (WSPS) was not installed on one accident aircraft that stuck a wire. In another case, the pilot / operator did not comply with the flight manual instructions regarding the use of an induction system deflector kit (snow baffles) while operating in snow.
9. Mission Risk: In one accident (14%), it was cited that the mission involved flight over unsuitable emergency landing terrain. This is an inherent mission risk and is often required during external load missions.
10. Lack of Communications with ground / landing zone (LZ) personnel was cited in one accident (14%).
11. Post-Crash Survivability was cited in one accident (14%) that involved a post-crash fire.
12. Regulatory: Control of military surplus aircraft and parts was determined to be a problem in one accident (14%) that ultimately resulted in an engine failure during flight.

6.3.12.5 External Load – Safety Interventions Identified

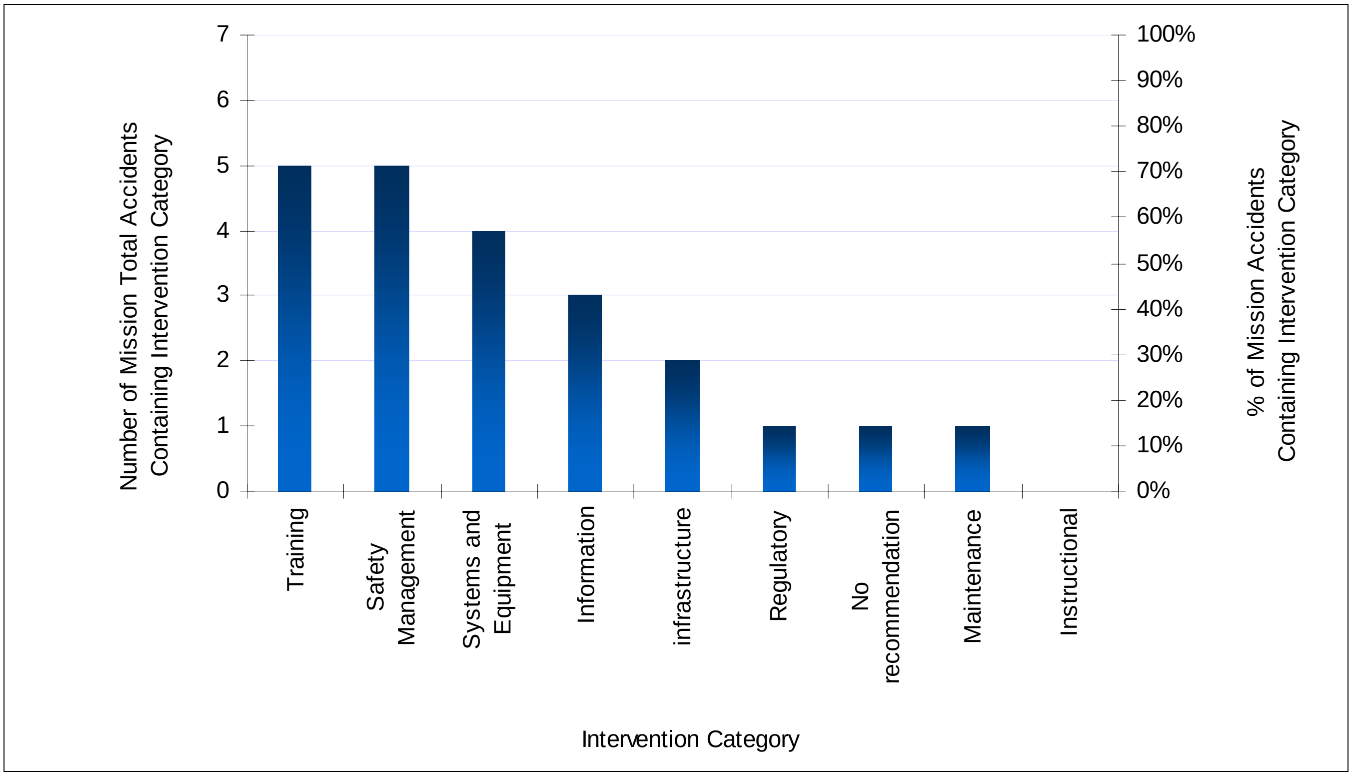


Figure 6-34. Intervention Categories for External Load (7 Accidents Analyzed)

40 interventions in seven categories were identified for external load accidents.

1. Safety Management was the most frequently identified intervention category for external load accidents. Interventions included implementation of a formal risk assessment / management program specific to the external load mission. Implementation of standard operating procedures for remote sites and preflight of mission specific equipment was recommended. Increased oversight of remote operations, both flight and maintenance was cited. Development of a short service employee program and utilization of HOMP to monitor employee performance was suggested. Last but not least, PINC training was suggested in two accidents where rules and procedures were disregarded.
2. Training: Risk assessment training for weather and mission specific tasks was recommended in three accidents. Emergency procedures training, specifically for emergencies / malfunctions related to mission specific equipment was recommended in two accidents. Training in long line SOPs was recommended. Crew Resource Management (CRM) and Aeronautical Decision Making (ADM) Training were recommended in two accidents. Training in recognition and response to dynamic rollover was recommended in one accident.

3. Systems and Equipment such as proximity detection equipment, wire strike protection system (WSPS), load meter, a more crash resistant fuel system, and a radar altimeter were recommended.
4. Information: The installation of cockpit recording devices was recommended in two accidents to assist investigators in obtaining additional information about the accident circumstances.
5. Infrastructure: The development of SOPs regarding coordination with ground / landing zone (LZ) crew was recommended. Also, it was recommended that the industry develop standards for data collection and sharing of pilot history for hiring / screening and expand the Pilot Records Improvement Act (PRIA) to include rotorcraft pilots.
6. Maintenance: Reinforcement of maintenance QA / supervisory oversight and installation of trend monitoring equipments such as HUMS was recommended.
7. Regulatory: An easily accessible database of military surplus aircraft serial numbers, history, use, etc was recommended.

6.3.12.6 External Load – Recommendation Safety Interventions

1. Implement a formal risk management program specific to the external load mission to include SOPs for remote operations, ground / landing zone crew coordination and operation of external load equipment.
2. Increase oversight of flight and maintenance operations, especially at remote sites.
3. Install monitoring systems such as HUMS and HOMP to monitor aircraft and crew performance.
4. Implement additional training in the following areas:
    - Risk assessment – weather
    - Mission planning
    - Emergency procedures – general
    - Emergency procedures – mission equipment
    - Aeronautical Decision Making (ADM) / Procedural Intentional Non-Compliance (PINC)
    - Crew Resource Management (CRM)
    - Long-line operations
    - Dynamic rollover
5. Install systems and equipment such as:
    - Proximity detection equipment
    - Wire Strike Protection Systems (WSPS)
    - Load meters
    - More crash resistant fuel systems
    - Radar altimeters
    - Engine auto-relight ignition kits
6. Install cockpit recording devices.
7. Develop standards for data collection and sharing of pilot history for hiring / screening and expand the Pilot Records Improvement Act (PRIA) to include rotorcraft pilots.
8. Regulators should develop an easily accessible database of military surplus aircraft serial numbers, history, use, etc.

6.3.13 Mission Specific Findings – Logging

6.3.13.1 Logging – Mission Definition

Logging involves the use of helicopters to remove logs, typically from heavily forested areas with steep surrounding terrain, requiring significant operation at low altitude with heavy long line loads. Additionally, logging is an aircraft intensive operation, heavily utilizing the capabilities of the airframe, drive train and power plant. The mission has inherent risk due to frequent low altitude flight over unsuitable emergency landing terrain. Logging may be conducted to harvest timber for resale or to clear zones of fallen trees to minimize fire risks.

6.3.13.2 Logging – Synopsis of Accidents Analyzed

Of the 197 accidents analyzed in the NTSB year 2000 dataset, 5 accidents involved Logging operations, this represented 2.5% of the accidents analyzed for the year. 23 problems and 18 interventions were identified from analyzing logging accidents.

The accidents did not result in any fatal injuries. There were collectively two serious injuries, three minor injuries, and two persons with no reported injuries. All 5 accidents occurred in VMC. 4 of the 5 accidents occurred in daylight, while conditions were not reported in the 5th accident. 2 of the accidents occurred during approach, 2 during hover and 1 during maneuvering. The average pilot flight hours in the 4 accidents where pilot data was reported were 10,369 hours of total pilot time, 10,143 hours of rotorcraft total time and 2,652 hours in that make and model. All of the pilots had very high experience, but one pilot had only 90 hours in the make and model of the accident aircraft.

6.3.13.3 Logging – General Characteristics of Accidents Analyzed

Four of the accidents were precipitated by a main rotor drive shaft failure, failure of an engine / transmission sprag clutch assembly, an engine main (#1) bearing failure, and dual engine fuel starvation. The main rotor mast failure was the result of fatigued damper splines. The engine bearing failed because of localized oil starvation. The fuel starvation accident occurred when the pilot elected to continue flying after seeing low fuel quantity and low fuel pressure indications. The fifth accident involved an emergency landing secondary to pitch oscillations. Each of the five subsequent forced landings involved descent into and / or contact with trees. None of the accident reports indicated that the aircraft were configured with equipment to detect impending component failures. All the Logging accidents analyzed involved Transport category rotorcraft. 22% of the problems identified did not have any interventions recommended due to inherent risk in the mission (i.e., heavy lift operations at low altitudes over densely wooded mountainous terrain). Two military surplus helicopters were among the five logging accidents. Those accidents were the ones involving an engine bearing failure and the pitch oscillations (for which the cause was not determined).

6.3.13.4 Logging – Problem Areas Identified

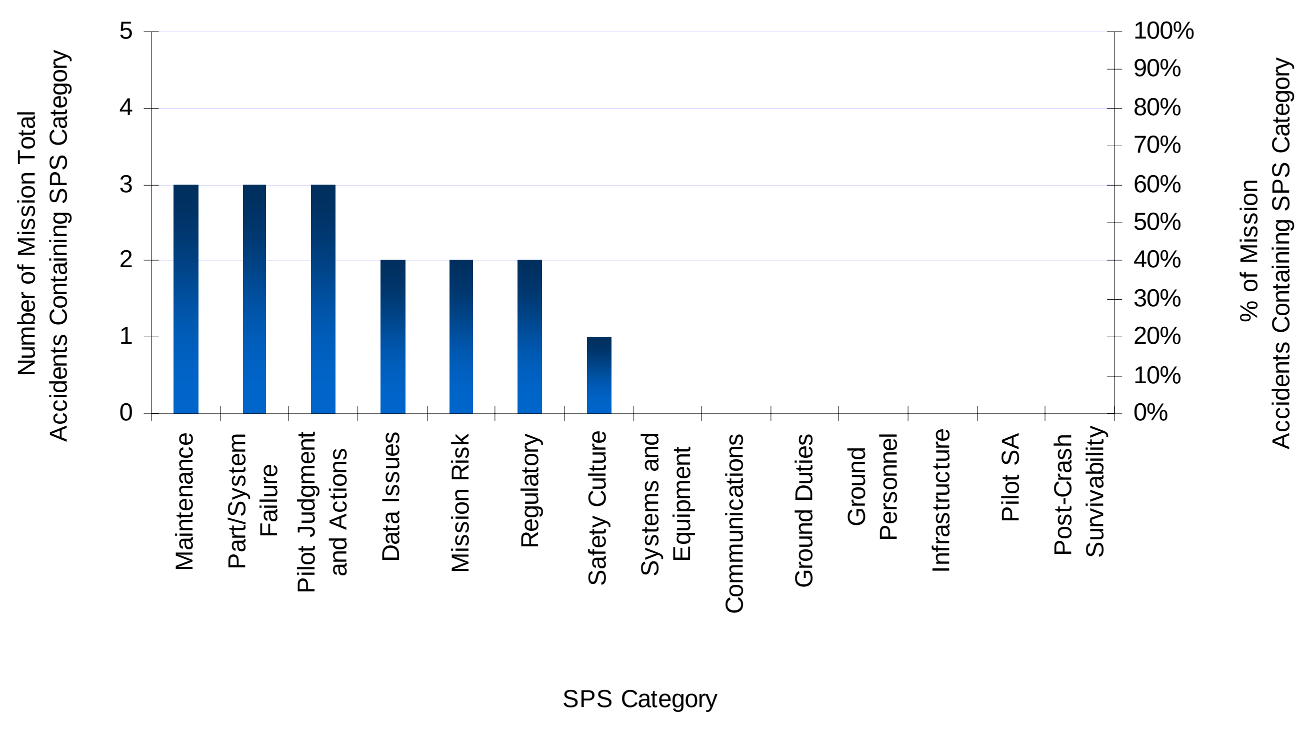


Figure 6-35. SPS Categories for Logging (5 Accidents Analyzed)

23 problems were identified in 7 areas for Logging operations:

1. Maintenance issues were identified in three of five accidents analyzed. Helicopters used in Logging are exposed to severe duty cycles and must be well maintained. It was found that maintenance procedures were poorly defined for a military surplus helicopter used for logging, prescribed maintenance procedures were not followed, and none of the reports indicated the accidents analyzed involved helicopters configured with equipment (e.g., HUMS type recorders) to detect impending component or part failure.
2. Hardware / component failures occurred in at least four (and were reported in the fifth) of the five accidents analyzed. Repeated Heavy Lift operations, such as logging, have been known to push aircraft, drivetrain and power plant components to or beyond their design limits. Main rotor, drive train and engine component failures were present in the accident data. Most of these failures are likely related to RHL aspects of logging, improper lifing calculations, lack of slung load knowledge and inadequate maintenance.
3. Pilot judgment and actions were identified in three of five accidents analyzed. Pilots were found to disregard cues that should have led to early termination of the flight and also were found to have willfully violated limitations specified in the AFM.
4. Logging operations carry inherent mission risk, compounding the consequences of poor pilot decision making and / or component failures. Two of the five accidents analyzed produced problem areas without mitigating interventions. A significant part of the mission profile involves flight with slung or long line loads at low altitude over terrain unsuitable for an emergency landing. Additionally, each of the accidents analyzed involved descent into trees and / or steep terrain that significantly complicates the consequences of forced landings or autorotation landings.
5. Data issues were identified in two of the four accidents analyzed. Although the accident reports had sufficient detail to make reasonable findings, they did not have data sufficient to allow investigators to make detailed root cause findings, nor did they contain information about pilot training or the existence of personal or company safety management systems.

6. Lack of regulatory oversight and guidance was found to be a significant problem. Two of the five accidents showed oversight and dissemination of reliable component safe life methods required to account for the rigors of logging operations to be inadequate.
7. Lack of adequate Safety Culture was indicated in one accident. Analysis revealed inadequate management oversight and policies, and knowledge of crew hiring criteria relative to pilots' prior work history was found to be an issue.

6.3.13.5 Logging – Safety Interventions Identified

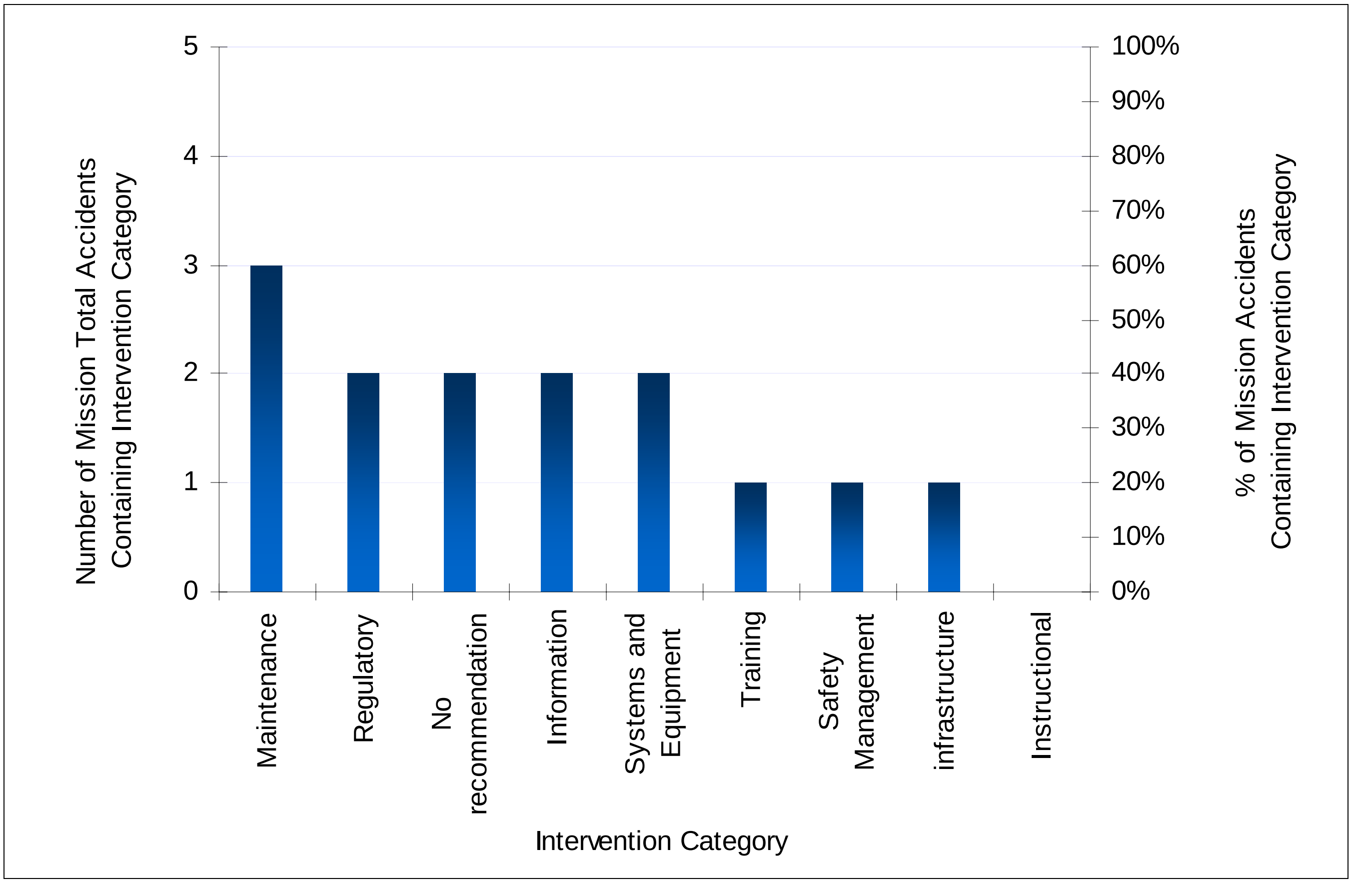


Figure 6-36. Intervention Categories for Logging (5 Accidents Analyzed)

18 safety interventions were identified in 7 areas for Logging operations:

1. Maintenance interventions were identified in three of the five accidents analyzed, indicating the need to improve critical aspects of maintaining the aircraft used in logging. Given the intensive usage environment of these aircraft, maintainers need the means to detect component problems prior to critical part failure in flight. This can be accomplished by trending equipment similar to HUMS. Cost effective solutions will be needed. Maintenance standards equivalent to those for civil aircraft should be developed and adopted when using military surplus aircraft for logging.
2. The need to improve Regulatory guidance, oversight and rulemaking was noted in two of the five accidents. The regulatory agencies should offer more comprehensive guidance to augment FAA Advisory Circular 133-1A, Rotorcraft External Load Operations [Ref. 11 in Appendix I], in accordance with Federal Aviation Regulations Part 133. Additionally, the FAA should increase oversight of facilities responsible for maintaining logging helicopters.
3. Of the 197 accidents analyzed by the JHSAT, Logging yielded no recommendation in two of five accidents. The JHSAT determined that in these instances the basic traits of the mission – low altitude over forested terrain, slung loads, aircraft intensive operation – left no reasonable option for emergency landing. Typically,

this was related to the pilot making a forced autorotation landing and the aircraft sustaining damage due to contact with unavoidable trees and / or rolling or steep terrain. The JHSAT assumed that this mission has significant inherent risk and the best means of improving safety for it was to minimize the likelihood of forced landing as discussed below.

4. Install cockpit recording devices that will enable crash investigators to understand cockpit indications and pilot actions prior to a crash. This intervention was noted in two of the five accidents analyzed. Cockpit imaging devices also provide information for company management to provide non-punitive corrective actions for pilot / crew performance anomalies.
5. Two of the five accidents also pointed to the need to make improvements to the Systems and Equipment of the aircraft by adding load weight indications to the pilot in the cockpit, ensure that the methods used to calculate component safe lives (airframe, drive train and power plant) are uniform and correctly applied by the operator community, and ensure that the type design holder adequately applies lessons learned with RHL operators to those aircraft active in logging operations.
6. Logging operators should adopt Safety Management Systems concepts. Given the inherent risk in Logging, these operators should develop and adopt policies and procedures that assess and minimize risk. Specific to the findings of the accidents analyzed, the policies and practices should include measures to address operational risk assessment methods, risks associated with improper maintenance, risks associated with inadequate hiring practices and methods to target pilot and crew training focused on operating within published aircraft limitations.

6.3.13.6 Logging – Prioritized Safety Recommendations

1. Logging operators should develop and adopt Safety Management policies and procedures to assess and minimize risk in maintenance, operations, and hiring practices and to maximize the benefits of targeted training.
2. Install equipment that enables maintenance personnel to detect impending component failure, similar to a HUMS system.
3. Install cockpit indication of external load weight.
4. Improve regulatory support for logging operations by updating available guidance material for external load operations, enhanced Flight Standards oversight of logging maintenance facilities.
5. Ensure that the methods and practices for part and component safe life calculations are easily tracked, accurate and robust.
6. Where applicable, ensure that military surplus aircraft used in logging are maintained to standards equivalent to those of civil helicopter maintenance requirements.
7. Install cockpit recording devices that will enable crash investigators to understand cockpit indications and pilot actions that precede a crash.

6.3.14 Mission Specific Findings – Firefighting

6.3.14.1 Firefighting – Mission Definition

Firefighting involves the use of helicopters for the transport of firefighting personnel, equipment and extinguishing agents to and from fire zones. A primary activity is direct fire suppression. This is accomplished by either transporting internal suppressant material to the fire or by conducting long line operations with a device (called a “Bambi bucket”) capable of retrieving and carrying water from nearby sources and then flying the water to the fire zone where it is dispersed at low altitude, as directed. Operations are conducted over a wide variety of terrains each year during the fire season, usually involving forested areas, steep surrounding terrain, frequent operation at low altitude with heavy internal or long line loads. Additionally, firefighting is an aircraft intensive operation, heavily utilizing the capabilities of the airframe, drive train and power plant. The mission has inherent risk due to frequent low altitude flight over unsuitable emergency landing terrain.

6.3.14.2 Firefighting – Synopsis of Accidents Analyzed

Of the 197 accidents analyzed in the NTSB year 2000 dataset, 6 accidents involved helicopters utilized for Firefighting operations; this represented 3.0% of the accidents analyzed for the year. 41 problem statements and 45 interventions were identified from analyzing firefighting accidents. The pilots involved in the six Firefighting Mission accidents had total flight experiencing averaging 6,872 hours, rotorcraft experience averaging 6,175 hours, and experience in the make and model of the accident aircraft averaging 2,582 hours. The two least experienced pilots in this mission group had 2,320 total hours and 1,823 hours in make and model, and 3,054 total hours and 300 hours in make and model, respectively. Four of the six accidents resulted in fatalities, one resulted in a minor injury and one in no injuries.

6.3.14.3 Firefighting – General Characteristics of Accidents Analyzed

100% of the Firefighting mission accidents involved pilot judgment errors as contributing factors. Circumstances for each of the six accidents were different. Three of the accidents involved component failures with two linked to over specification engine operation and maintenance error, and the other associated with an airframe skid structural failure. All six accidents involved turbine powered helicopters, two of which were twin turbine powered helicopters. Two helicopters were military surplus aircraft. All of the aircraft were operated as “public use” aircraft, although most were under contract to (rather than owned by) a government agency.

None of the six firefighting mission accidents was caused by factors directly associated with fire suppression operations; two occurred while carrying long line loads and four while transporting passengers. A brief summary of each accident and its principal contributing factors follows:

- A fatal passenger transport accident due to VFR flight into IMC conditions on a non-firefighting flight.
- A fatal passenger transport accident triggered by loss of control after liftoff, possibly due to a stuck skid and dynamic rollover.
- A fatal long line operational accident that involved pilot fatigue related to a grounding medical condition that the pilot concealed from his employer and a mission that involved extended flight hours.
- A fatal long line operational flight, where the right engine failed due to an overload operation, the flight being conducted with a pilot-disabled low rotor warning system, and the external load emergency release rendered inoperable due to being wired to a non-essential electrical power bus that was dropped with engine power loss (FAA field approval). Another factor was the inherent mission risk associated with operation over terrain unsuitable for emergency landing.
- A passenger transport flight with a forced landing following an engine failure due to over-temperature operation with an out-of-calibration turbine temperature indication system. No injuries.
- A passenger flight that sustained a skid structural collapse on ground and loss of control by pilot. Non-TC holder suspected unapproved parts were involved. One minor injury.

6.3.14.4 Firefighting – Problem Areas Identified

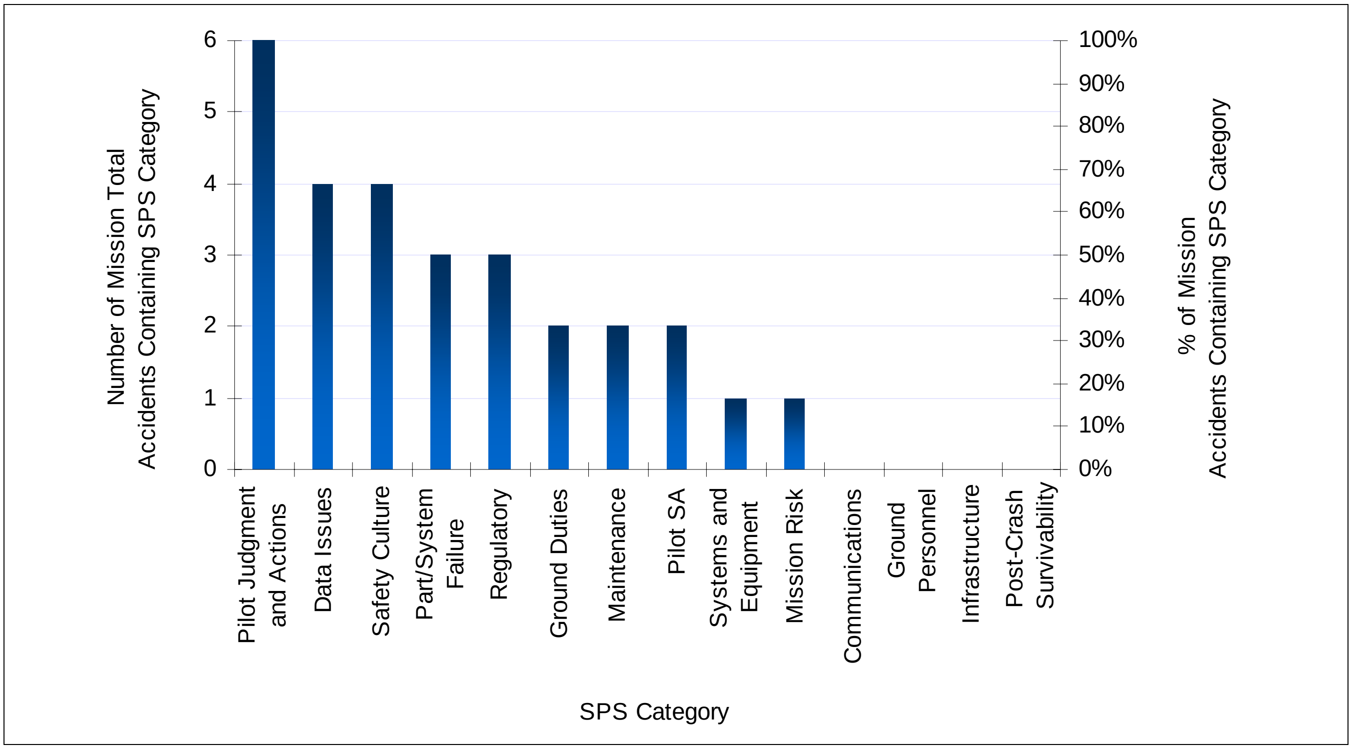


Figure 6-37. SPS Categories for Firefighting (6 Accidents Analyzed)

45 problems were identified in 9 areas for Firefighting operations:

1. In each of the six accidents, Pilot Judgment and Actions contributed to the accident sequence; pilots disregarded cues that should have led to termination of the flight, willfully violated operating procedures and limitations specified in the AFM, and exhibited control and handling deficiencies.
2. Lack of adequate Safety Culture was indicated in four of the accidents. Inadequate management oversight and policies were indicated, and knowledge of crew hiring criteria relative to pilots' prior work history was associated with one crew-related accident.
3. Hardware / component failures were also determined to be a contributing factor in three of the six accidents. Repeated Heavy Lift and remote landing site operations such as firefighting are known to push aircraft, drivetrain and power plant components to or beyond their design limits. Two accidents involved engine failures and one accident involved collapse of a skid that had been configured with non-type design conforming components of unknown origin. The two engine failures were associated with over-temperature operations undetected by the operator's maintenance program.
4. Firefighting operations carry inherent mission risk that can compound the consequences of poor pilot decision-making and / or component failures. A significant part of the mission profile involves flight with slung or long line loads at low altitude over terrain unsuitable for an emergency landing. One of the fatal accidents involved a forced descent into ground obstructions.
5. Data issues were identified in five of the accidents analyzed. Although the accident reports had sufficient detail to make supportable findings they did not have data sufficient to allow investigators to make detailed root cause findings in particular for crew actions.
6. Maintenance issues were found to be a significant factor. Helicopters used in firefighting are exposed to severe duty cycles and must be well maintained. It was found that maintenance procedures were not correctly followed. Poor maintenance record documentation was noted in each case. None of the accidents involved helicopters configured with equipment (e.g., HUMS type recorders) to detect impending component or part failure which may have been useful in identifying impending failure in the two engine related accidents.

7. Lack of Flight Standards regulatory oversight was found to be a contributor to one accident.

6.3.14.5 Firefighting – Safety Interventions Identified

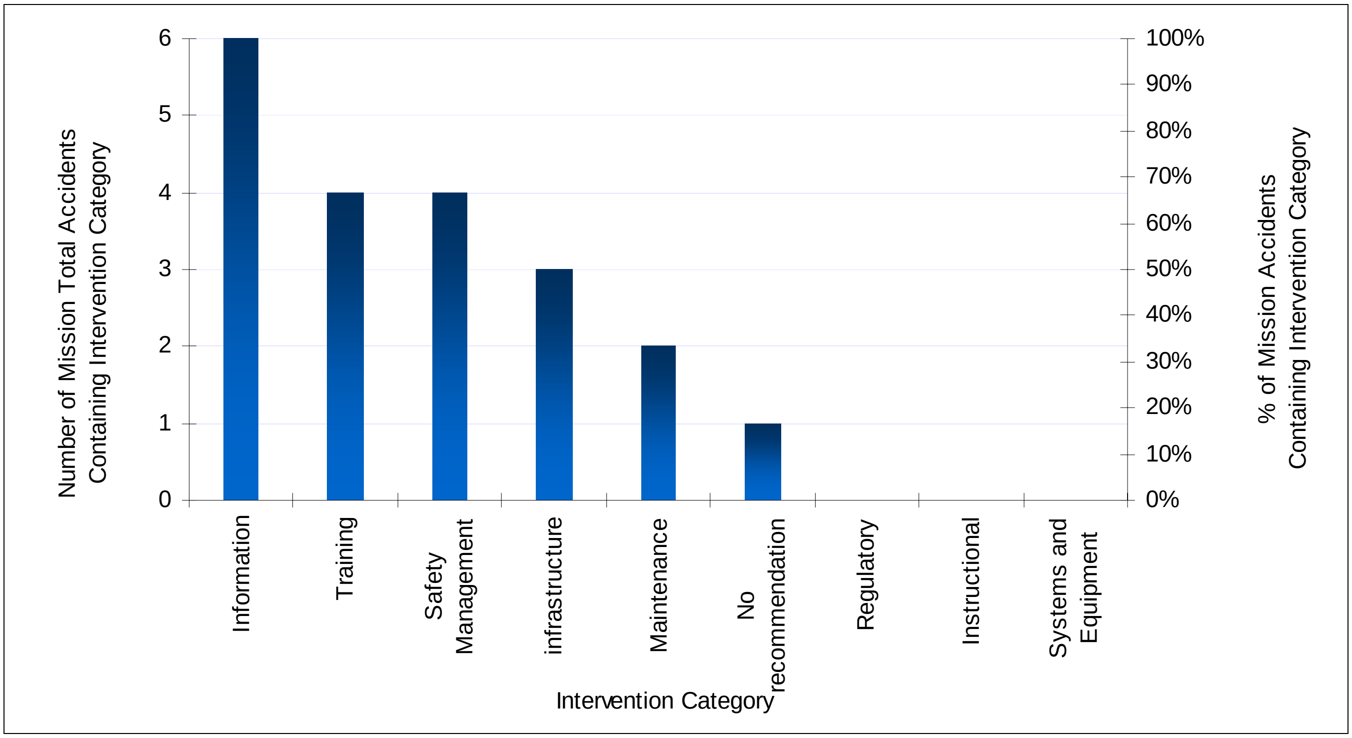


Figure 6-38. Intervention Categories for Firefighting (6 Accidents Analyzed)

44 safety interventions were identified in 7 areas for Firefighting operations:

1. Install cockpit recording devices that will enable crash investigators to understand cockpit indications and pilot actions that precede a crash. This is important both for accidents involving system failures and where crew performance was a contributing factor. Cockpit imaging devices and relatively inexpensive non-crashworthy data recorders also provide information for company management to provide non-punitive corrective actions for pilot / crew performance anomalies in routine flight operations.

2. Training was identified as an area with potential for reducing accident risk. Suggested areas for training intervention included autorotations, compliance with aircraft performance specifications, and recognition / response to dynamic rollover. The JHSAT determined that in some instances the basic traits of the mission – low altitude operations over forested terrain and slung loads – left no reasonable option for safety interventions other than good mission training before commencing the operation. When no other intervention was recommended, it was usually a scenario where the pilot had to make a forced autorotative landing and the aircraft sustained damage due to contact with trees and / or rolling on steep terrain. The JHSAT assumed that this mission has significant inherent risk and that the best means of improving safety for it was to minimize the likelihood of forced landing, as discussed below.

3. Firefighting operators should adopt Safety Management Systems concepts to identify and minimize risks. Given the inherent risk in fire suppression operations, the owners of these operations should develop and adopt policies and procedures that assess and minimize risk. Specific to the findings of the accidents analyzed, the policies and practices should include measures to address operational risk assessment methods, risks associated with improper maintenance, risks associated with inadequate hiring practices and methods to target pilot and crew training focused on operating within published aircraft limitations. It is noted that the NTSB accident reports usually did not provide specific information on safety management systems employed by the helicopter operator. The recommendation that SMS intervention is needed is based on the judgment of the JHSAT and based on its review of the documented circumstances in each applicable accident and their inference regarding safety practices for that operation were lacking.

4. Infrastructure recommendations deal primarily with pilot background checks. In one case, the background check of the pilot's medical records would have revealed conditions that likely would have prevented granting of a 2nd class medical certificate. The conditions were well known by the pilot but concealed. One accident investigation was compromised due to lack of accident site preservation leading to the recommendation for guidance for first responders to secure and preserve the accident site to the extent practical. It is recognized that NTSB rules in 49 CFR Part 830.10 already require the operator to preserve the wreckage, and that in some instances it is impossible for the operator to adequately effect this without the assistance of others.
5. Improve critical aspects of maintaining the aircraft used in firefighting. Given the severe usage environment of these aircraft, maintainers need the means to record over limit operations and potentially detect component problems prior to critical part failure in flight. Current prescribed maintenance practices require strict adherence to published ICA and could benefit from being supplemented with monitoring / trending equipment similar to HUMS.
6. Make improvements to regulatory guidance, oversight and rulemaking. The regulatory agencies should offer more comprehensive guidance to augment FAA Advisory Circular 133-1A, "Rotorcraft External Load Operations" (see Appendix I) in accordance with Federal Aviation Regulations Part 133. Additionally, the FAA should increase oversight of facilities responsible for maintaining logging helicopters. The FAA needs to assure that field approved alterations to the helicopter do not diminish the airworthiness by disabling an essential safety feature as occurred by the field approval of the ineffective external load emergency release system.

6.3.14.6 Firefighting – Prioritized Safety Recommendations

1. Adopt Safety Management methods to assess and minimize risk in maintenance, operations, and hiring practices and to maximize the benefits of targeted training. An SMS program tailored to the inherent operating environment risks is required for firefighting missions.
2. Install equipment that enables maintenance personnel to detect over limit operations and impending component failure, such as a HUMS system.
3. Improve regulatory support for Firefighting operations by updating available guidance material on external load operations. Provide enhanced Flight Standards oversight of Firefighting operator maintenance facilities and ensure better regulatory oversight of field approvals and non-conforming aircraft configurations.
4. Install cockpit recording devices that will enable crash investigators to understand cockpit indications and pilot actions that precede a crash.
5. Develop industry standards for data collection and sharing of pilot history for hiring / screening.

6.3.15 Mission Specific Findings – Utilities Patrol and Construction

6.3.15.1 Utilities Patrol and Construction – Mission Definition

Today's increasingly competitive public utility industry demands a great deal more from its internal flight department or a helicopter service contractor than it ever has in the past. The industry is split approximately 50% to 50% between internal flight departments and contracted services. Besides transport and routine patrol operations, helicopter line maintenance and construction procedures and reliability-based inspection programs have proven to be a critical success factor in a safe, reliable power distribution system.

Utility Patrol and Construction operations involve the extensive use of helicopters to successfully complete their missions. The utility and patrol realm of civilian helicopter flight operations is demanding not only on the pilots, but line crewmembers as well. Pilots and linemen spend most of their day in this hostile environment at low altitude, low speeds, in close proximity to wires and obstructions, and often operating in areas where terrain is less then suitable for emergency landings. Construction flights, although not illustrated in this accident dataset, involve the use of helicopters to transport persons and equipment in a sometimes hostile environment such as that described above regarding the External Load mission.

6.3.15.2 Utilities Patrol and Construction – Synopsis of Accidents Analyzed

Of the 197 accidents analyzed in the NTSB year 2000 dataset, 4 accidents involved Utility Patrol operations; no Construction related accidents were analyzed. This represented 2% of the accidents analyzed for the year. 14 problem statements and interventions were identified from analyzing utility and patrol accidents.

6.3.15.3 Utilities Patrol and Construction – General Characteristics of Accidents Analyzed

Three of the four accidents involved powerline patrol and inspection flights; one accident occurred on a flight to position the aircraft for a scheduled maintenance inspection. No fatalities or serious injuries resulted from the 4 accidents analyzed. Three of the four utility patrol accidents resulted in minor injuries and the remaining one accident produced no injuries. 100% of the Utility Patrol and Construction accidents occurred during daylight hours in VMC. Two of the accidents involved loss of power situations that resulted in the aircraft losing power and necessitating forced landings; 1 occurred in a hover near powerlines, with a crewman on the wire and the helicopter operating within the shaded portion of the height-velocity (HV) diagram, when the helicopter experienced an unknown power loss; 1 occurred while the aircraft was on approach to landing and experienced a clutch cable failure. The accident reports did not indicate that either of the 2 aircraft involved was configured with equipment to detect impending component failures (e.g., HUMS). The remaining 2 accidents were the result of a loss of tail rotor effectiveness (LTE) during a low altitude powerline patrol and a tail rotor drive system disconnect due to tail rotor FOD strike. The FOD came from an unsecured item that blew out of the helicopter.

Three of the 4 accidents analyzed involved single engine turbine powered helicopters. The other accident involved a reciprocating engine helicopter.

The pilots of the four Utilities Patrol and Construction accidents had total helicopter operating experience that ranged from 1,100 to 24,424 hours. Two pilots had 500 hours or less in the make and model helicopter involved in the accident. The other two pilots had 9,647 hours and 3,350 hours, respectively, in that make and model.

6.3.15.4 Utilities Patrol and Construction – Problem Areas Identified

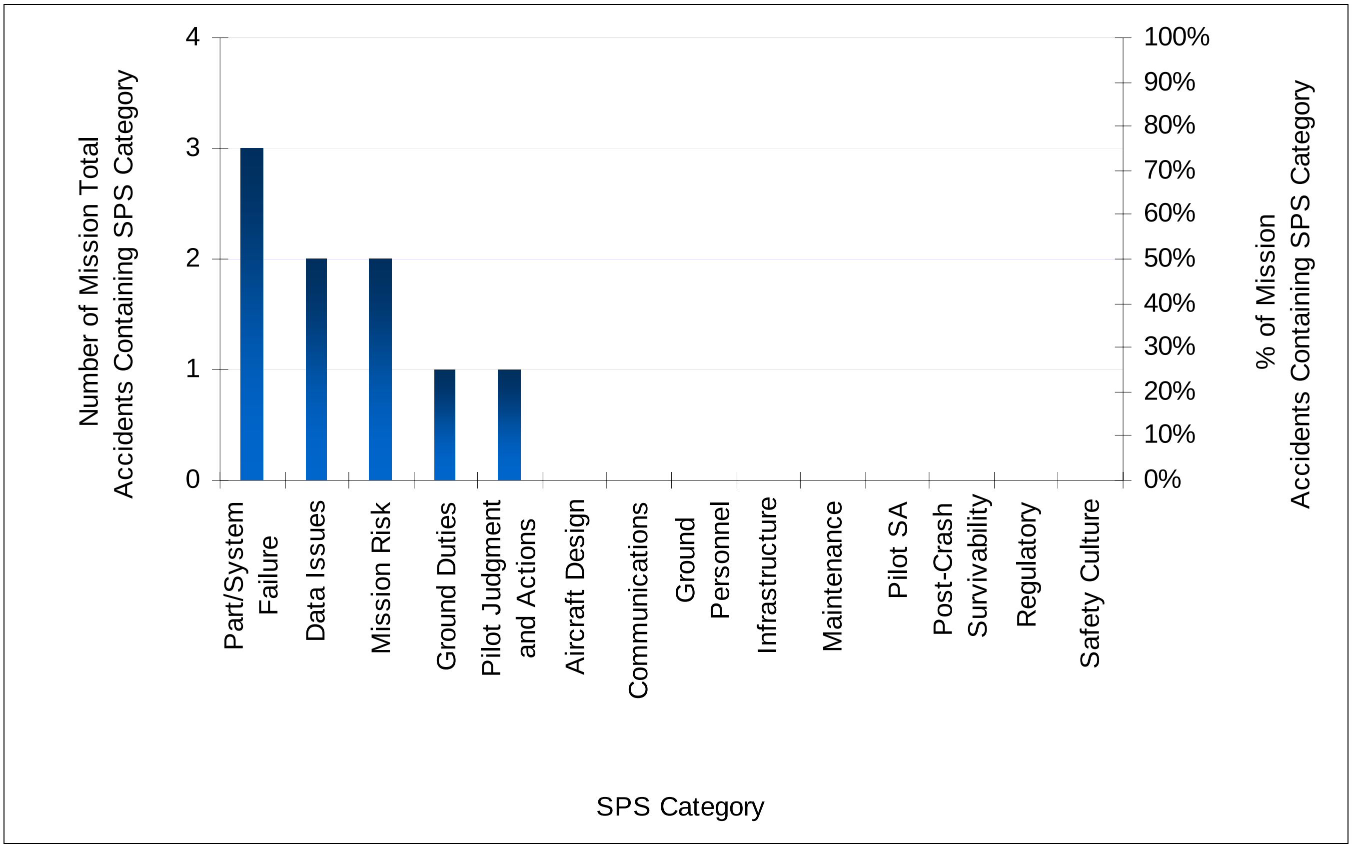


Figure 6-39. SPS Categories for Utilities Patrol and Construction (4 Accidents Analyzed)

14 problems were identified in 5 areas for Utility patrol and construction operations:

1. Utility Patrol and Construction operations carry inherent Mission Risk that compounds the consequences of poor pilot decision-making and / or component failures. A significant part of the mission profile involves missions require low, slow flight, often operating the aircraft in the shaded portion of the HV diagram and in close proximity to obstructions. Each of the accidents analyzed involved flying low and slow, which significantly complicates the consequences of forced landings or autorotation landings.
2. Pilot Judgment and Actions were determined to be a part of the accident sequence. Pilots were found to disregard cues that should have led to termination of the current course of action or maneuver and violated limitations specified in the AFM. Specific areas of concern are loss of tail rotor effectiveness and operating near the performance limits of the aircraft.
3. Part / System Failures were also determined to be a part of accident sequence. Operating in confined areas increases the exposure to inadvertent contact with obstructions, leading to increased risk of hardware / component failures such as tail rotor drive train induced failures from inadvertent contact with objects; failure to adequately inspect aircraft components was also indicated. Thorough and focused pre-flight inspections can assist in detecting impending part failures.
4. Data Issues were identified in 80% of the accidents analyzed. Although the accident reports had sufficient detail to make reasonable findings, they did not have data sufficient to allow investigators to make detailed root cause findings.
5. One accident identified issues with unsecured objects leaving the aircraft and striking the tail rotor. One very important practice is performing a thorough preflight inspection to ensure the aircraft is in a safe and airworthy condition. The preflight inspection is the first of many procedures that should be carried out using a

detailed checklist. Doors should be securely latched and the preflight must ensure objects inside the aircraft are secured so they can not inadvertently get blown out of the aircraft, possibly having serious consequences.

6.3.15.5 Utilities Patrol and Construction – Safety Interventions Identified

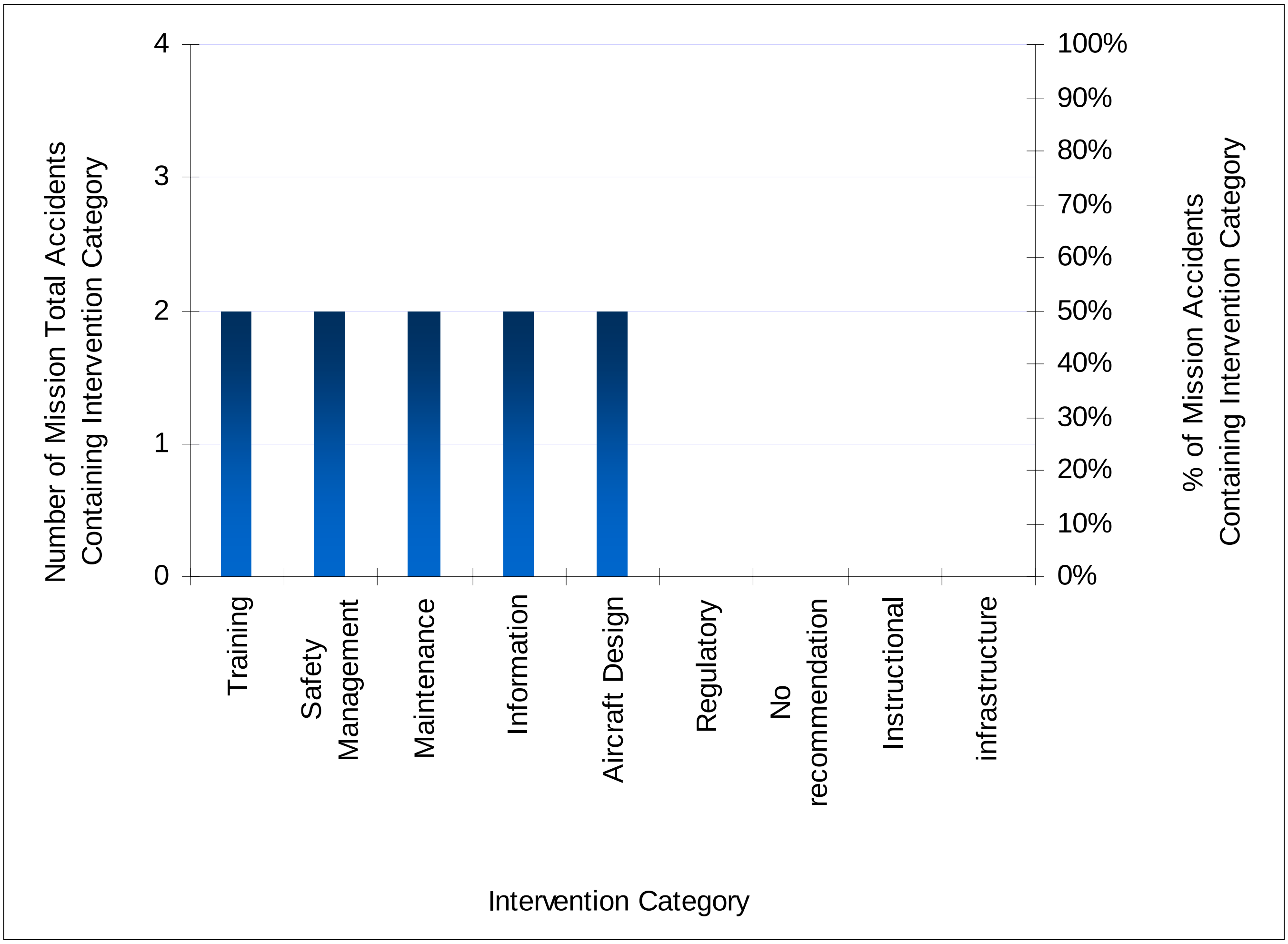


Figure 6-40. Intervention Categories for Utilities Patrol and Construction (4 Accidents Analyzed)

Of the 197 accidents analyzed by the JHSAT the 4 utility patrol accidents occurred while operating in a hostile environment (low, slow and obstruction rich environment). This mission has significant inherent risk and the best means of improving safety for it was to minimize the likelihood of forced landing as discussed below.

1. Pilot judgment and actions were a significant factor. Typically, this was related to the pilot making a forced autorotation landing and the aircraft sustaining damage due to the confined area, and the low and slow profile in which the helicopter was operating. The analysis of the data determined that 2 primary intervention strategies were needed: a low speed indicating / warning system for pilots; and ground and flight / simulator training for recognition and recovery from LTE and / or common aerodynamic conditions.
2. One key area for basic operational risk management is that Utility Patrol and Construction operators should adopt Safety Management Systems (SMS) concepts. Given the inherent risk in utility patrol and construction, the owners / operators should develop and adopt policies and procedures that assess and minimize risk. Specific to the findings of the accidents analyzed, the policies and practices should include measures to address operational risk assessment methods, risks associated with operating in the hostile / low slow environment, risks associated with inadequate hiring practices and methods to target pilot and crew training focused on operating within published aircraft limitations.

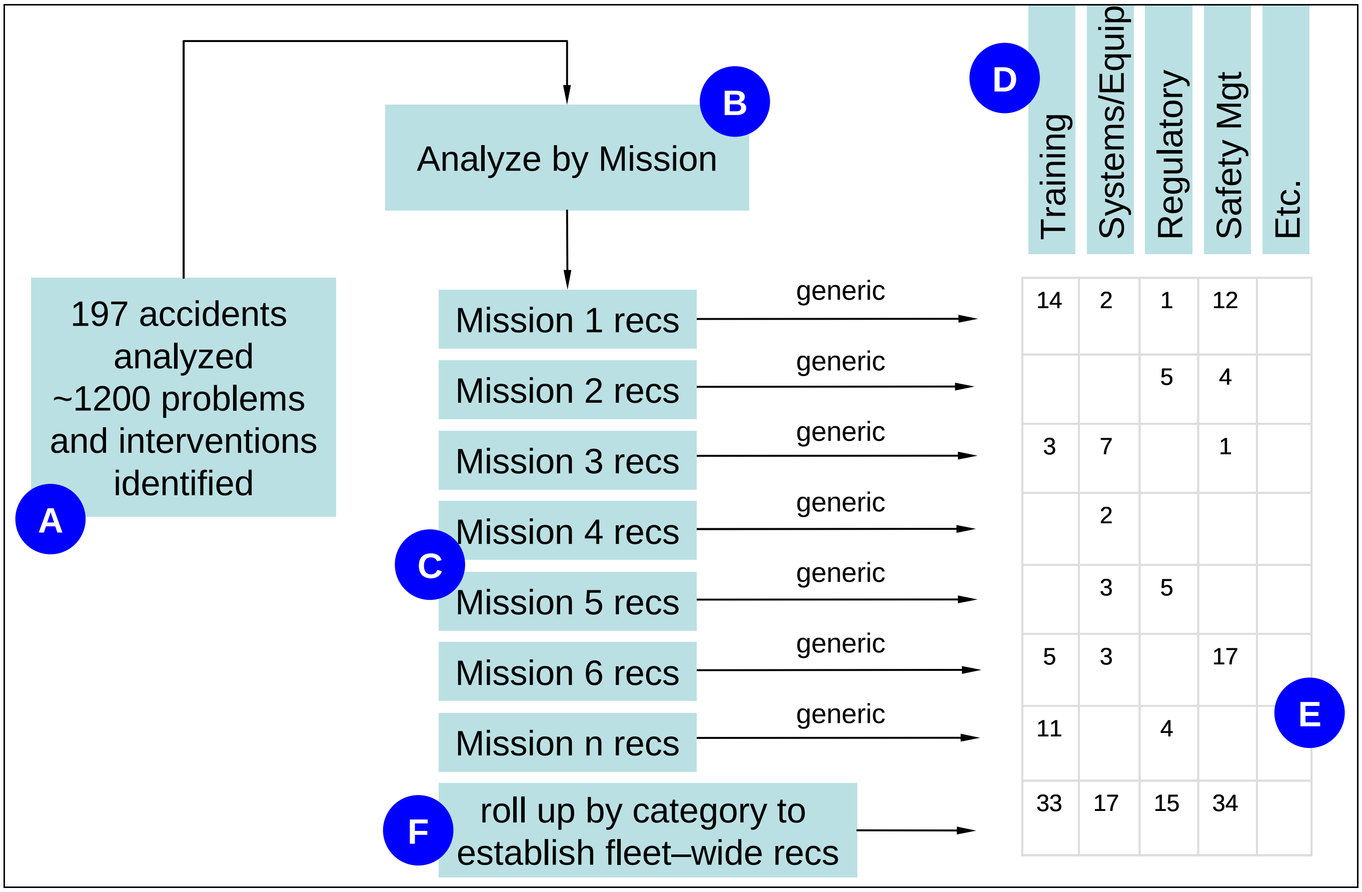
3. Consistent with other missions, each of the accidents reviewed showed a lack of information in the investigative report. Installing cockpit recording devices will enable crash investigators to understand cockpit indications and pilot actions that preceded a crash. Cockpit imaging devices also provide information for company management to provide non-punitive corrective actions for pilot / crew performance anomalies.
4. Tail rotor protection systems for helicopters could reduce the likelihood of tail rotor strikes and prevent objects from inadvertently coming in contact with the tail rotor. A second intervention factor observed was following company SOPs and / or the helicopter's ICA procedures to reduce the likelihood of an accident.
5. The analysis shows one accident that occurred as a result of a door inadvertently opening in flight and loose debris from inside the helicopter exiting and striking the tail rotor, resulting in a tail rotor driveshaft separation and loss of tail rotor thrust. The preflight inspection is the first of many procedures that should be carried out using a detailed checklist to ensure the doors are secured and that objects inside the aircraft are secured so they can not inadvertently get blown out of the aircraft should a door or window open. A second possible intervention is to install door / cowl positive latch warning indication to alert the pilot in the event a door is not properly secured or opens during flight.

6.3.15.6 Utilities Patrol and Construction – Prioritized Safety Recommendations

1. Utility Patrol and Construction operators should develop an SMS that outlines and details the risk and operational requirements to perform their missions.
2. Install cockpit imaging / recording devices.
3. Provide pilots with mission-specific operational and aeronautical decision-making training for the Utility Patrol and Construction operational environment.
4. Provide tail rotor protection systems for helicopters to reduce the likelihood of tail rotor strikes and objects inadvertently coming in contact with the tail rotor.
5. Use a detailed pre-flight checklist to ensure the doors are secured and objects inside the aircraft are secured.
6. Install door / cowl positive latch warning indications in the cockpit to alert the pilot in the event a door is not properly secured or opens during flight.

Section 7 – Fleet-Wide Safety Recommendations

Figure 7-1 depicts the process used by the U.S. JHSAT to develop fleet-wide recommendations from the accidents analyzed in the CY2000 NTSB dataset. Quantities quoted are hypothetical and for illustrative purposes only.



Training	Systems/Equip	Regulatory	Safety Mgt	Etc.
14	2	1	12	
		5	4	
3	7		1	
	2			
	3	5		
5	3		17	
11		4		
33	17	15	34	

Figure 7-1. U.S. JHSAT Fleet-Wide Recommendation Rollup Schematic (Hypothetical Data).

Specific points of note, highlighted by the blue-circled letters, are addressed below:

- **A** – The U.S. JHSAT processed 197 accidents. As discussed earlier, the process consisted of reconstructing the accident chain of events, determining what went wrong and why, assigning Standard Problem Statement (SPSs) and offering mitigating actions or “interventions” for the problems. This yielded about 1200 problem / intervention pairs.
- **B** – As discussed in the Mission section, the U.S. JHSAT identified 15 distinct missions in the accidents analyzed. Each yielded a unique set of recommendations.
- **C** – Each mission was analyzed separately and a set of recommendations were developed for each mission. The group went on to identify which of the recommendations developed in the mission analyses were either “mission specific” or applicable “fleet-wide.” About 20% of those recommendations were applicable only to the specific mission. The remaining 80% of recommendations were determined to be applicable on a fleet-wide basis.
- **D** – These fleet-wide recommendations were categorized in 8 basic areas: Training, Pilot Judgment and Actions, Maintenance, Systems and Equipment, Regulatory, Safety Management, Information, Infrastructure.
- **E / F** – Each mission’s contribution to each recommendation category was recorded in a matrix and the resulting frequency totals were used to roll up and prioritize a list of fleet-wide recommendations.

The JHSAT proposes the safety recommendations for the U.S. helicopter fleet as outlined in the following seven sub-sections of this section (followed by a reiteration of the Mission Specific Recommendations in Section 7.8). Recognizing that worldwide data will illustrate similar accidents and causes elsewhere, the U.S. JHSAT encourages worldwide helicopter operators, associations, military organizations, and aviation regulatory authorities to evaluate these recommendations for applicability elsewhere and to take action where data supports such activity. These recommendations are based strictly on the analysis of the U.S.-registered helicopters that experienced accidents in Calendar Year 2000. They are equally applicable to all missions flown by the U.S. fleet. The seven areas identified represent the top areas of need in the fleet; however, since only one year of accidents was analyzed, it is likely that all of the detailed needs specified in each area are not addressed completely.

The list of fleet-wide recommendations is presented in order of importance as determined by frequency of occurrence in the analyzed data.

7.1 Safety Management Recommendations

A need was identified for formalized programs to manage safety through the creation of a positive safety culture that increases employee safety awareness and acceptance of safety responsibility, and through routine assessment and management of flight operational risks. Safety Management Systems (SMS) provide a comprehensive solution. The creation, training and management of standards for flight operations, particularly for potentially high-risk missions, are another means of managing safety. The overall purpose of an SMS is to collect and use safety information to identify hazards and reduce risk. Risk might be reduced by designing the hazard out, establishing barriers, providing warnings through advisories or safety education, making procedural changes as needed and / or by addressing the hazards through training. It is important that pilots are not faced with mission risks without standards, training and preflight evaluations to help them manage risks. The following safety management interventions were those thought to apply across operational missions. In most cases, the recommendations were based on similar accident circumstances that suggested the lack of a structured safety management program; the culture and structure of existing operator safety programs was typically not documented in the accident investigation reports.

Develop a systematic approach:

- Promote a culture of safety and regulatory compliance, risk assessment and management.
- Develop and use a formalized systems safety approach (i.e., SMS) to risk assessment and management to improve personal and organizational decision-making.
- With consideration for size of the operator, complexity and variety of aircraft used, level of risk associated with the mission(s), remoteness of flight operations and maintenance activities from the parent organization and training requirements of the operator, create a “right-sized” SMS to manage safety in that organization. The SMS needed to manage risk at a small, non-complex operator won’t require the complexity or resources that would be required by a larger, more complex and more far-flung operation.
- Make proactive use of safety information to create awareness of known hazards and reduce the risk of accidents.
- Develop a stand alone risk assessment / management handbook for the Part 91 helicopter community.

Formalized approaches for assessing and managing risk in different operational missions, maneuvers and environments must be developed and implemented:

- Provide comprehensive training for assessing risks associated with specific missions, weather conditions, etc, to result in consideration of risk during preflight and in flight. The training should demonstrate that the safety culture of the organization allows and encourages aborting or canceling the flight when risk factors don’t justify conducting the mission or continuing.
- Identify the risks associated with the mission, specific in-flight maneuvers, flying in close proximity to the ground or obstacles and performing out-of-envelope operations. The evaluation of risk should consider the difficulty of the mission, the environment in which it will be performed, the skills and experience of the pilots and the capabilities of the aircraft and mission equipment.

Hiring and selection practices:

- Develop and use systematic hiring practices that evaluate the experience and history of applicants to reduce future operational risk. Use simulators to evaluate applicant decision-making and flying skills.
- Evaluate the continuing performance of employees and provide oversight and training as required based on those evaluations.

An important part of establishing an effective safety culture involves identifying and communicating explicit Standard Operating Procedures (SOPs) for normal and abnormal operations:

- Revise company operational checklists to be consistent with OEM checklists (except when differences are justified by unique mission or operational considerations).
- Establish well-defined safety standards to ensure compliance with regulations and procedures, eliminate Procedural Intentional Non-Compliance (PINC), and inadvertent flight into IMC.
- Develop operator SOPs for preflight preparation, maneuver briefings for training flights, weather launch / abort criteria, selection and ground survey of remote or unimproved sites, ground / landing zone crew coordination, operation of external load equipment, etc.

An important element of a safety program, regardless of the size of the operator, is the routine collection of safety event data through a non-punitive safety reporting system. Continual evaluation of safety compliance is especially critical for operations at remote sites. In addition, company operational oversight is necessary to ensure adherence to SMS policies, including the use of risk assessment and management in flight operations. The FAA recommends that SMS programs include an auditing element, as a means of providing safety assurance. The FAA notes, “The safety assurance function does not need to be extensive or complex to be effective.”

- Establish a formalized flight operations quality oversight program.
- Provide for non-punitive safety event reporting.
- Use flight Helicopter Operational Monitoring Program (HOMP)-type data to verify that employee flight performance meets training and operational standards.

Several types of recommendations pertain to ensuring the safety of training flights and providing training in all aspects of the company safety program:

- Adopt a safety management program to maximize the benefits of targeted training and consider the use of a “fit to size” approach to develop training appropriate for the type of mission performed by the organization and its size.
- Provide comprehensive risk management training that includes mission-based risk assessment, weather assessment and risk-based flight operations decision-making. The training should demonstrate that the safety culture of the organization encourages aborting or canceling a flight when the risk factors don’t justify conducting or continuing the mission.
- Provide mission-specific risk assessments for all training flights to reduce risk of accidents while performing autorotation training, and recognition and recovery from Loss of Tail Rotor Effectiveness (LTE). Consider more extensive use of ground and flight simulator training and LTE recognition training before permitting solo flight in an unfamiliar aircraft.
- Ensure that training policies and SOPs enhance training for crew awareness of critical flight systems, operational risk management and appropriate Aeronautical Decision Making (ADM) training.
- Provide comprehensive training for all managers on their safety role in the organization and the organization’s role in providing an SMS, to include safety standards and management accountability.

Performance of maintenance can be improved by adopting a formal safety management program, such as SMS, to assess, minimize, and oversee maintenance risk:

- Establish systems to ensure adherence to maintenance policy and procedures and compliance with Instructions for Continued Airworthiness (ICA) and provide records of compliance.
- Establish a system of quality assurance of maintenance involving “safety of flight” components and maintenance quality control records systems.
- Install equipment that enables maintenance personnel to detect impending component failure, similar to a HUMS system

- Increase oversight of flight and maintenance operations, especially at remote sites.

7.2 Training Recommendations

Promote increased use of training aids, training devices, and simulators in training programs. Through the use of training aids, training devices and simulators, more effective training can be achieved. Training areas that would benefit significantly include, but are not limited to:

- Autorotation
- Loss of Tail Rotor Effectiveness (LTE)
- Aircraft performance capabilities and limitations
- Helicopter emergencies and emergency procedures outlined in the rotorcraft flight manual
- Inadvertent Flight into Instrument Meteorological Conditions (IIMC)
- Make and model transition training
- Aeronautical Decision Making (ADM) and risk management
- Model-specific power and energy management
- Quick-stop maneuvers
- Landing practice in unimproved areas, on landing platforms, and from pinnacle approaches.

Provide extensive initial and recurrent training in helicopter emergencies as described in the Rotorcraft Flying Handbook [Ref. 9 in Appendix I] and the emergency procedures outlined in the OEM rotorcraft flight manual. Among helicopter emergencies that require extensive training are:

- Autorotation
- Vortex ring state (settling with power)
- Dynamic rollover
- Systems and equipment malfunctions
- LTE

Extensive training is also required for the recommended procedures and airspeeds for emergency situations, as outlined in the Rotorcraft Flight Manual. The use of simulators and ground instruction is highly recommended to improve the effectiveness of emergency training. Expand training in aeronautical decision making (ADM) and risk management.

- As the majority of aircraft accidents can be attributed to human error, or human factors related issues, ADM and risk management training require special emphasis (See FAA, Rotorcraft Flying Handbook, 2000).
- The use of simulators and ground instruction is highly recommended to improve the effectiveness of ADM training.

Provide comprehensive training on aircraft performance capabilities and limitations, and the use of that information in preflight planning and in-flight decision making.

- Understanding the performance capabilities and limitations of the aircraft is important to the safety of each flight and is important information required in risk assessment and preflight planning.
- The use of model specific simulators and ground instruction is highly recommended to improve the effectiveness of helicopter performance training.

Provide comprehensive training on inadvertent flight into instrument meteorological conditions (IIMC).

- Comprehensive training in the determination of en route weather, establishment of in-flight weather abort criteria, avoidance of inadvertent flight into instrument meteorological conditions (IIMC) and recovery from IIMC is highly recommended.
- The use of simulators and ground instruction is highly recommended to improve the effectiveness of IIMC training.

Provide comprehensive transition training to new make and model aircraft.

- Transition training should include, but should not be limited to, power and energy management, aircraft performance capabilities and limitations, emergency procedures and systems and equipment differences training.
- The use of model specific simulators and ground instruction is highly recommended to improve the effectiveness of transition training.

Provide comprehensive preflight preparation and preflight procedures training.

- Preflight preparation training should include, but should not be limited to, flight risk assessment and personal risk assessment, flight planning and weather planning, and helicopter performance capabilities and limitations.
- Preflight procedures training should include, but should not be limited to, the importance of conducting a thorough preflight inspection, as well as what to look for while performing a preflight inspection.

Provide specialized mission training.

- Mission specific training should include familiarization with the use of specialized equipment and standards and procedures unique to the mission.
- The use of model specific simulators and ground instruction is highly recommended to improve the effectiveness of mission specific training.

7.3 Systems and Equipment Recommendations

Equipment and systems can be used to improve safety by both preventing accidents and mitigating the severity of accidents. Mitigation is achieved via crash protection and survivability equipment. The mitigation equipment recommended in this category consists primarily of crash-resistant fuel systems and personal locating devices.

Install HUMS to detect needed maintenance interventions, and utilize HOMP to evaluate flight operations and address flight crew habits that may contribute to an accident.

Install proximity detection and protection equipment to provide additional situational awareness to the pilot and flight crew. This equipment may be one of the following appropriate to the situation:

- Radar altimeter
- Helicopter Terrain Avoidance Warning System (HTAWS)
- Synthetic Vision Systems (SVS)
- Enhanced Vision Systems (EVS)
- Video systems, including rearward-facing cameras

Encourage development and use of optional aircraft warning systems to include:

- Low rotor speed
- Low fuel quantity
- In-cockpit dynamic rollover alert systems
- Door latches and cowlings

Post-crash fire was noted in 10% of the accidents in the year 2000 data. Use of helicopters with a CRFS installed should be encouraged and a requirement on contracted efforts. Recommend additional study to determine the benefits of incremental fuel system modifications and / or feature improvements to minimize post-crash fire for aircraft without CRFS..

Encourage development and use of indicators for the following systems:

- Power-available versus power-required indicators
- Loss of translational lift (low airspeed)
- Load meter (for external load)
- Install protection equipment:

- Wire strike protection system
- Proximity detection/alerting

Encourage the use of Emergency Position-Indicating Radio Beacons (EPIRB) or other personal locating devices.

Note: cockpit recording devices are addressed in Section 7.4 Information Recommendations, below.

7.4 Information Recommendations

Information recorders can be both Reactive (after the accident) and Proactive (monitor precursor events and data needed for an SMS. Information recording devices will allow accident investigators to obtain essential information about the circumstances of an accident to allow greater understanding of accident causes and potential for safety improvements. Proactive use of recorders allows the operator to provide individual aircraft flight operations oversight and to identify and correct poor habits and SOP non-compliances before it escalates into an accident

Types of information recording devices include, but are not limited to:

- Cockpit Image / Information Recorders (CIR)
- GPS positional flight recorders
- Aircraft monitoring systems (e.g., HUMS or Engine Monitoring Systems (EMS))
- Fully-certified Cockpit Voice Recorders (CVR) / Flight Data Recorders (FDR)
- Flight Operational Quality Assurance (FOQA) quick-access recorder (QAR) or limited data-collection recorders, typically used to monitor flight operations and to validate and improve flight crew training.

Other intrinsic benefits of information recording devices are that they can be utilized as:

- Training aids (allow pilots / instructors to view flight performance)
- Information resources for company flight monitoring program (i.e. HOMP, FOQA)
- Potential for real-time flight tracking / following
- Electronic airframe / engine logbooks

Encourage accident investigation authorities to increase frequency and quality of on-site accident investigation, conduct more comprehensive investigation, documentation and reporting to enhance root cause analyses (and prevention) of helicopter accidents.

During analysis of the accident dataset, it was determined that additional information was needed in accident reports. Some examples of missing information include:

- Safety culture and background of the organization
- Training and experience information for pilots and maintenance personnel
- Availability and equipage of safety systems and devices
- Information on adherence to published procedures (AFM, ICA, SOP, etc.)

The JHSAT has initiated contact with the NTSB to recommend improvements to data collected while investigating helicopter accidents. These discussions are on-going.

7.5 Maintenance Recommendations

Aircraft and powerplant component or system failures were involved in 45 accidents. In 23 of these accidents, that involved 16 aircraft and 7 engines, the failure modes were such that there was a reasonable opportunity to detect impending failure prior to the event with utilization of modern monitoring, diagnostic and / or recording technology. The most frequently applied intervention recommendation for maintenance related accidents was implementation of Health and Usage Monitoring Systems (HUMS) or Engine Monitoring Systems (EMS) as a maintenance tool to reduce system failure risk. Modern digital technology has enabled introduction of monitoring systems in new larger helicopters and some of this capability may become economically feasible for smaller helicopter applications.

- The practicality and effectiveness of HUMS and EMS for different classes of helicopters will require additional data review and analysis to determine accident mitigation potential and support recommendations.
- Maintenance error frequently contributing to accidents has been found to be directly related to non-compliance to published ICA. Interventions identified recommend strict adherence to published ICA and confirmation by improved maintenance Quality Assurance functions and in some cases improved FAA oversight.
- Alternate oversight and QA processes should be developed for remote maintenance.
- To address several maintenance related accidents involving public use and / or military surplus aircraft, it is recommended that civil ICA (or equivalent) and regulatory requirements be applied to these operations.

7.6 Regulatory Recommendations

Inadequate regulatory oversight and standards and lack of regulations governing Public Use aircraft have been linked to several accidents analyzed by the JHSAT.

Public Use operators, and those that contract for public use services, should specify maintenance following the requirements of CFR Parts 91 and 43. These operators should also be required to comply fully with Part 91 operating rules in addition to the present general requirements. Additionally, the FAA should review existing Public Use rules and advisory material for consistency and appropriateness.

The JHSAT used the following definition for Public Use: federal, state or local government flight operations such as but not limited to official travel, law-enforcement, aerial observation, aerial application, firefighting, search and rescue, biological or geological resource management, or aeronautical research. Public Use operations may include government owned and operated aircraft or civilian operations in support of government activities when operating under an exclusive use contract to a government entity. Although military flights would meet the definition of “Public Use” flight operations, they are not included in this report because NTSB does not normally (except by special request from a military service and when the aircraft have commonality with the domestic fleet) investigate such accidents and none were in the CY2000 NTSB helicopter accident dataset.

To minimize unapproved parts use, the government (i.e., the General Services Administration and the Defense Reutilization and Marketing Services) should develop and make available an easily accessed database to identify released surplus:

- Aircraft
- Engines
- Critical parts

The Pilot Records Improvement Act of 1996 (PRIA) requires that a hiring air carrier under 14 CFR Part 121 and 135, or a hiring air operator under 14 CFR Part 125, request, receive and evaluate certain information concerning a pilot / applicant’s training, experience, qualifications and safety background, before allowing that individual to begin service with their company as a pilot. This process allows the entity to make a more informed hiring decision. This process should be expanded to include helicopter pilots.

- PRIA data should be made readily available to employers to provide a database of information on pilots and other aviation personnel for background checks by helicopter operators.
- FAA disciplinary actions should be recorded and available to PRIA for use by companies doing background checks of personnel.

Solicit FAA’s support for regulatory flexibility for installation of data recording systems (HUMS / EMS type) for use on aircraft.

7.7 Infrastructure Recommendations

Of the seven safety intervention areas, infrastructure had the least impact to the accidents analyzed. However, two specific recommendations can enhance safety across all missions.

- The Pilot Records Improvement Act of 1996 (PRIA) should be expanded to include rotorcraft pilots.

- Several accidents noted inadequate availability or use of weather information especially in remote locations. To ensure that crews are aware of adverse or deteriorating weather conditions, expand availability of weather information needed for preflight planning and for in-flight decision-making by flight crews.
  - Obtain more information through improvement of the AWOS infrastructure and other weather reporting sources.
  - Share weather information, both reporting and receiving, through PIREP, HEMS weather tool, and other systems.
  - Companies operating in the same local areas should formalize agreements to share weather data, especially when weather considerations result in refusing to accept or canceling flight operations.
  - Encourage early expansion of ADS-B to cover all of the U.S.

7.8 Mission Specific Recommendations

The following is a summary of all the mission specific recommendations presented in Section 6.3.

7.8.1 Instructional / Training Recommendations

1. Improve autorotation training by making greater use of training aids, training devices, and flight simulators to ensure students gain procedural skills coupled with knowledge of aircraft performance characteristics.
2. Provide enhanced training through greater use of coupled ground, flight, and simulator training for pilot recognition and recovery from LTE and other common aerodynamic conditions.
3. Improve training by using flight simulators for introduction to quick-stop maneuvers, recognition of and recovery from dynamic rollover, and for landing practice in unimproved areas, on landing platforms, and from pinnacle approaches.
4. Ensure that training programs provide a thorough understanding of recognition and recovery from dynamic rollover.
5. Ensure that training programs provide a thorough understanding of power / energy management; cues to avoid low rotor rpm, power, and airspeed conditions; training in recovery from power settling; the hazards of landing and / or maneuvering in tailwinds and in mountainous terrain; and emergency procedures training.
6. Use simulators to improve instrument and visual approach procedures training and model-specific power / energy management training.
7. Use simulators for introductory transition training in new make and models before beginning instruction in the aircraft.
8. Use simulators to provide enhanced CFI training on emergency procedures and conditions.
9. Provide advanced CFI training on judgment, risk management, and aeronautical decision-making to include preflight preparation and student / trainee mission briefings; cues for recognition and prevention of low rotor rpm and airspeed conditions; techniques for maintaining alertness to cues critical for safe flight; specific guidance regarding student monitoring and when intervention is warranted; and communications regarding transfer of control protocols and crew resource management.
10. Provide introductory and recurrent CFI training on advanced handling techniques and procedures to avoid LTE, dynamic rollover, and autorotation accidents.
11. Develop SOPs to minimize risk in the training environment for: (1) preflight preparation and maneuver briefings; (2) weather launch / abort criteria; and (3) autorotation training.
12. Provide operator training on landing site selection and the importance and correct methodology for conducting landing site or LZ recon before landing. Select any ground survey remote or unimproved sites before using them for training.

13. Revise company operational checklists to be consistent with OEM checklists (except when differences are justified by unique mission or operational considerations).
14. Develop in-flight training techniques to familiarize student pilots with aircraft performance characteristics.
15. Establish for CFIs an “instruction” mission-specific Safety Management System (SMS) to include risk assessment and management training and protocols; transfer of control protocols; training to ensure compliance with SOP, regulations, and aircraft performance limitations; procedures to prevent Inadvertent Flight into IMC (IIMC) and provide for recovery from IIMC; personal risk management; and to provide the CFI with an enhanced awareness of hazards on the ground and on training flights.
16. Ensure that the company Safety Management System, through all of its elements, cultivates a culture of safety and regulatory compliance, risk assessment and management, and making proactive use of safety information to create safety awareness and reduce the risk of accidents. In a training environment, this program should provide operational risk management training and SMS policy that includes training mission-specific risk assessment.
17. Provide company operational oversight to ensure adherence to its SMS policies, including the use of risk assessment and management in flight operations.
18. Conduct preliminary pilot hiring screening in a flight simulator, when available.
19. Ensure that SOPs address the proper planning for instructional flights, including establishment of risk-based solo flight release approval procedures; provide for the use of preflight / maneuver briefings for training flights; provide policy to ensure that standardized preflight mission briefings will be conducted for all intended training maneuvers; provide CRM / assertiveness training for CFIs; provide policy to clarify CFI retention of PIC responsibility on dual flights, regardless of the sometimes greater experience of the pilot receiving instruction; provide procedures for proper transfer of control by CFIs and pilots receiving instruction; familiarize student pilots and CFIs with aircraft performance characteristics and limitations; establish policy for evaluating weather risk factors and use weather risk management tools; provide for enhanced CFI training for simulated emergencies; and provide training for pilots on common operational pilot errors.
20. Ensure that training policy and standardized operational procedures (SOP) enhance training for crew awareness of critical flight systems; provide for appropriate aeronautical decision-making training; provide an adequate transition training program; provide methodology that reduces risk of accidents in autorotation training; and provide ground and flight / simulator training for recognition and recovery from LTE and provide LTE recognition training before solo.
21. Require proper training and proficiency before allowing pilots to operate from trailers / dollies. Require CFI endorsements for student operation from platforms and trailers / dollies.
22. Use (HOMP-type) flight data to verify that employee flight performance meets training and operational standards.
23. Encourage development and use of optional aircraft equipment to include: low airspeed and low rotor speed warning systems; in-cockpit dynamic rollover alert systems; short-term auto-hover recovery systems; power-available versus power-required indicators; and cockpit recording devices.
24. To prevent post-crash fire-induced injuries, it is recommended that more crash resistant fuel systems be used.
25. To ensure that adequate data exists to provide for company operational oversight and standardization of flight operations and improved accident prevention through more in-depth analysis of accidents:
    - Install cockpit recording devices (video, audio or digital format as appropriate for the helicopter and mission).
    - Encourage accident investigation authorities to provide adequate staffing and conduct comprehensive investigation, documentation, and reporting to allow root cause analysis (and prevention) of helicopter accidents.

- Where student pilots are involved in accidents, require investigators to assess the adequacy of the student training.
- Require investigation of ELT malfunctions.
- Require a standard format for recording pilot logbook / experience data.

7.8.2 Personal / Private Recommendations

1. Establish a Personal / Private risk management training program and distribute through general aviation media or FAA safety programs.
    - Develop a stand alone risk assessment / management handbook for the Part 91 community (a fit to size SMS program).
2. Emphasize the importance of model-specific training on aircraft performance and systems to owners and rotorcraft CFIs; encourage more time be spent on this during biannual check-rides.
    - Include emphasis on carburetor ice and other performance limiters published in the Aircraft Flight Manual.
    - Increase use of simulator training on aircraft performance and emergency procedures. Desktop and software-based aides may be useful to increase rotorcraft knowledge.
3. Develop and integrate into training programs autorotation training aids, simulators, etc.
4. Encourage compliance with published preflight check procedures.
5. Increase training emphasis on maintaining awareness of cues critical to safe flight, including situational and proximity awareness.
6. Inform owners and mechanics of the importance of following the published maintenance or Instructions for Continued Airworthiness (ICA) procedures with confirmation of compliance. Increase awareness of proper records management and military surplus parts risks.
7. Consider requiring system data recording for new production aircraft (HUMS / Engine Monitoring System).
8. Increase awareness of common accident causes through publication of accident scenarios and root causes. Publish in general aviation media or the FAA Federal Aviation Administration Safety Team (FAAST) program.
9. Encourage the installation of cockpit recording devices.
10. Conduct more comprehensive accident reporting, investigation and documentation.

7.8.3 Aerial Application Recommendations

1. Develop and distribute “fit for size” Safety Management System development and implementation tools. The tools and systems should recognize the variability of size, types of operators, and fleets used in Aerial Application. A one-size-fits-all or a traditional safety management system template may not work. Developing a comprehensive safety management system will help address the following interventions:
    - Safety culture
    - Risk assessment and management
    - Training and communications (through CRM)
    - Maintenance
    - Some aspects of pilot judgment and actions
2. Develop and encourage implementation of best practices for development of standard operating procedures covering both operations and maintenance in the Aerial Application community.
3. Encourage installation of protective hardware like wire strike protection systems (WSPSs) or other proximity-obstacle detection systems that will enhance the pilot’s awareness of hazards.

4. Encourage installation of annunciations and / or warning indications to help increase pilot awareness of aircraft state and assist in decision making.
5. Work with National Agricultural Aircraft Association (NAAA) to develop a Best Practices Guide that identifies:
    - The need for clear and concise communications between the pilot and ground personnel.
    - A means for operators to receive and respond to current safety information / issues.

7.8.4 Emergency Medical Services Recommendations

1. Develop and use a formalized systems safety approach (i.e., SMS) to risk management and assessment to improve decision-making in flight operations and on a personal basis. Provide comprehensive risk management training to include mission-based risk assessment, weather assessment training and risk-based flight operations decision-making. The training should demonstrate that the safety culture of the organization encourages aborting or canceling the flight when the risk factors don't justify conducting or continuing the mission.
2. Establish an operator safety culture that includes clearly communicated flight operations standards and procedures, a formalized flight operations quality oversight program, a clearly defined safety program that provides for non-punitive safety event reporting, the use of risk assessment and management practices and policy to reduce the risk of VFR flights being continued into adverse weather, and company management oversight to ensure compliance with regulations and procedures and to eliminate Procedural Intentional Non-Compliance (PINC).
3. Provide comprehensive training for all managers on their safety role in the organization and the organization's role in providing a Safety Management System, to include safety standards and management accountability.
4. Provide training that would address: transition to a new make and model helicopter; helicopter preflight inspections; autorotation procedures and technique; recognition and response to aircraft system failures; and emergency procedures.
5. Encourage the use of new technology that would assist in raising pilots' and crews' situational awareness, e.g., night vision goggles (NVGs), synthetic vision systems (SVSs), terrain / proximity awareness, weather in the cockpit, GPS moving map displays, etc.
6. Develop a set of standards and a mentoring program for pilots and mechanics that places emphasis on managing / mitigating the increased risk during the following: less then one year's service with the operator, less then one year's experience with HEMS operations, less than one year at a particular geographical location, less then one year's experience in a primary aircraft model.
7. Increase the frequency of and provide comprehensive ground, flight and / or simulator / flight training device (FTD) training to reduce the risk of inadvertent flight into instrument meteorological conditions (IIMC).
8. Provide comprehensive scenario-based ground and flight simulator training for Aeronautical Decision Making and risk identification and mitigation.
9. Promote the installation of cockpit data recorders (CDR) and cockpit voice recorders (CVRs), and establish a helicopter operations monitoring program (HOMP) or helicopter flight operations quality assurance program (HFOQA) to verify and improve employee flight performance. Provide feedback for scenario-based / line oriented flight training (LOFT).
10. Install cockpit recording devices to allow accident / incident investigators to understand system anomalies and pilot / crew performance that preceded an aircraft mishap.
11. Establish systems to ensure adherence to maintenance policy and procedures, and compliance with Quality Assurance requirements, with the emphasis on oversight and guidance for remote locations.

12. For OEMs: Develop a minimum equipment standard for HEMS aircraft. Emphasis should be placed on night vision-compatible cockpits, terrain / proximity awareness, weather in the cockpit, stability augmentation systems, etc.
13. For industry and operator associations: Develop an EMS community infrastructure for standardization of radios and training for those responsible for establishment and security of helicopter landing areas.

7.8.5 Commercial Recommendations

1. Commercial operators should develop and adopt Safety Management policies and procedures to assess and minimize risk related to weather, landing zone, mission specific power / performance planning and flight following issues.
2. Each commercial operator should adopt a mission-specific training manual for air crewmen with make and model and mission specific content. The Federal Airworthiness Regulations (FARs) and Airman's Information Manual (AIM) specify minimum requirements for training manuals. Commercial operators should strengthen training curricula for emergency procedures, new hire pilots, risk management / assessment, ground operations, LTE, inadvertent IMC, proximity awareness, Aeronautical Decision Making, autorotation and dynamic rollover training.
3. Enhance the commercial operator pilot's ability to determine the aircraft's proximity to hazards by use of enhanced vision systems, proximity detection systems or rearward camera / video systems.
4. Commercial operators should develop and adopt standards for platform landing markings.
5. Installation of part failure detection systems such as HUMS.
6. Install cockpit recording devices that will enable crash investigators to understand accident circumstances and pilot actions prior to a crash.
7. Pilots should participate in reporting local weather via PIREP.
8. Improve crash scene control.

7.8.6 Law Enforcement Recommendations

1. Conduct additional training in the areas of:
    - Mission planning
    - Preflight procedures
    - Autorotations (full touch-down and power recovery)
    - CFI performance
    - Aircraft performance
    - Avoidance of inadvertent flight into IMC
    - Risk assessment
    - Emergency procedures
    - LTE
    - Dynamic rollover
    - Critical cues
    - Simulators
2. Install cockpit recording devices.
3. Implement risk assessment and safety management programs such as SMS.
4. Establish department standard operating procedures (SOPs) to include weather, preflight, landing zone selection, and training guidelines.
5. Maintain and operate public use aircraft to civil standards.

6. Increase maintenance and QA oversight, especially following maintenance on safety of flight components and systems.
7. Install aircraft monitoring systems such as HUMS / HOMP.
8. Install safety systems and equipment such as:
   - HTAWS
   - SVS / EVS
   - More crash-resistant fuel systems
   - radar altimeters
   - proximity detection equipment
9. Implement regulatory action to require law enforcement agencies to operate to and comply with civil operating and maintenance standards.
10. Implement the use of EPIRBs or other personal locating devices.

7.8.7 Offshore Recommendations

1. Logging operators should develop and adopt Safety Management policies and procedures to assess and minimize risk in maintenance, operations, hiring practices and to maximize the benefits of targeted training.
2. Install equipment that enables maintenance personnel to detect impending component failure, similar to a HUMS system.
3. Install cockpit indication of external load weight.
4. Improve regulatory support for logging operations by updating available guidance material for external load operations, enhanced Flight Standards oversight of logging maintenance facilities.
5. Ensure that the methods and practices for part and component safe life calculations are easily tracked, accurate and robust.
6. Where applicable, ensure that military surplus aircraft used in logging are maintained to standards equivalent to those of civil helicopter maintenance requirements.
7. Install cockpit recording devices that will enable crash investigators to understand cockpit indications and pilot actions that precede a crash.

7.8.8 Business / Company-Owned Aircraft Recommendations

1. Provide and enforce maintenance policy and procedures to ensure adherence to ICA procedures and records of compliance, quality assurance of maintenance involving “safety of flight” components, and established maintenance quality control records systems.
2. Provide training that would address: transition to a new make and model helicopter; helicopter preflight inspections; autorotation procedures and technique; recognition and response to aircraft system failures; and emergency procedures training.
3. Provide comprehensive ground and flight simulator training. Provide ground and flight simulator training to reduce the risk of accidents caused by Loss of Tail Rotor Effectiveness (LTE) and other aerodynamic conditions.
4. Develop and use formalized risk management programs to assess risk and to improve decision-making in flight operations and on a personal basis. Provide comprehensive risk management training.
5. Establish an operator safety culture that includes clearly-communicated flight operations standards and procedures, a formalized flight operations quality oversight program and a clearly defined safety program that provides for non-punitive safety event reporting, the use of risk assessment and management practices.

6. Where feasible, establish a Helicopter Operations Monitoring Program (HOMP) to verify and improve employee flight performance. Such data, when used in routine operations, has great importance as a tool for monitoring aircraft system performance and quality of the flight crew training program (answering the question, “Do we fly like we train?”).
7. Install cockpit recording devices to allow crash investigators to better understand system anomalies and pilot / crew performance that preceded an aircraft mishap.

7.8.9 Aerial Observation / Patrol Recommendations

1. Install cockpit recording devices to enable accident investigators to better understand the accident sequence.
2. Provide mission specific risk assessment training, and training specific to LTE, quickstops, dynamic rollover, autorotation, aircraft system failures, CRM and Inadvertent Flight into IMC.
3. Adopt a “fit for purpose” Safety Management System and grow an organizational culture to support it.
4. Install proximity detection equipment (radar altimeters or HTAWS), to provide additional situational awareness to the flight crew.
5. Install low airspeed indicators or warning systems and low fuel indication systems.
6. Enforce disciplinary and remedial action against pilots where warranted.
7. Install HUMS to detect required maintenance interventions, and install HOMP to address flight operations and flight crew habits before they result in an accident.

7.8.10 Air Tour and Sightseeing Recommendations

1. Adopt Safety Management programs such as SMS to assess and minimize risk in maintenance, operations (including flight profiles) and hiring practices, and to maximize the benefits of targeted training.
2. Increase company operational oversight of remote operations.
3. Install aircraft / operations monitoring systems such as HUMS or HOMP.
4. Install low fuel warning systems and / or alternate means of verifying fuel onboard.
5. Install positive door / cowl latch indication warning systems.
6. Conduct additional pilot training in the areas of
    - Aeronautical Decision-Making
    - Model-specific power / energy management
    - Autorotations
    - Performance planning and fuel calculations
    - Emergency procedures
    - Preflight procedures
    - Weather planning
    - IMC avoidance / IIMC recovery
7. Install cockpit / information recording devices.
8. Increase QA and maintenance oversight to ensure proper compliance with operational and maintenance instructions.
9. Require that all Air Tour and Sightseeing flights, regardless of distance from takeoff and landing airport, be held to Part 121 or 135 operational standards while operating with passengers onboard.
10. Increase regulatory guidance and oversight for Air Tour and Sightseeing operations.

11. Expand communication of weather information utilizing systems such as PIREP and Intra / Inter-company Communication for preflight planning and for in-flight decision-making by flight crews. In addition, expand Automated Weather Observation System (AWOS) infrastructure and other weather reporting sources.

7.8.11 Electronic News Gathering Recommendations

1. Develop and use formalized risk management programs to assess risk and to improve decision-making in flight operations and on a personal basis. Provide comprehensive risk management training – to include mission-based risk assessment, weather assessment training, and risk-based flight operations decision-making. The training should demonstrate that the safety culture of the organization encourages aborting or canceling the flight when the risk factors don't justify conducting or continuing the mission.
2. Establish an operator safety culture that includes clearly communicated flight operations standards and procedures, a formalized flight operations quality oversight program, a clearly defined safety program that provides for non-punitive safety event reporting, the use of risk assessment and management practices, policy to reduce the risk of VFR flights being continued into adverse weather, and company management oversight to ensure compliance with regulations and procedures and to eliminate PINC.
3. Provide comprehensive training that would address: transition to a new make and model helicopter; helicopter preflight inspections; autorotation procedures and technique; recognition and response to aircraft system failures; and emergency procedures training.
4. Provide comprehensive ground and flight simulator training to reduce the risk of IIMC. Provide ground and flight / simulator training to ensure recovery from LTE and other unusual aerodynamic conditions.
5. Where feasible, establish a HOMP to verify and improve employee flight performance.
6. Install cockpit recording devices to allow crash investigators to understand system anomalies and pilot / crew performance that preceded an aircraft mishap.
7. Establish systems to ensure adherence to maintenance policy and procedures, compliance with ICA and provide records of compliance; establish a system of quality assurance of maintenance involving "safety of flight" components and maintenance quality control records systems.
8. To prevent post-crash fire-induced injuries, it is recommended that more crash resistant fuel systems be used.
9. For industry and operator associations: Develop an industry-maintained database of pilot histories (in a manner consistent with that used for airline pilots under the Pilot Records Improvement Act) – to ensure better pilot screening and hiring decisions.

7.8.12 External Load Recommendations

1. Implement a formal risk management program specific to the external load mission to include SOPs for remote operations, ground / landing zone crew coordination and operation of external load equipment.
2. Increase oversight of flight and maintenance operations, especially at remote sites.
3. Install monitoring systems such as HUMS and HOMP to monitor aircraft and crew performance.
4. Implement additional training in the following areas:
    - Risk assessment – weather
    - Mission planning
    - Emergency procedures – general
    - Emergency procedures – mission equipment
    - Aeronautical Decision Making (ADM) / Procedural Intentional Non-Compliance (PINC)
    - Crew Resource Management (CRM)
    - Long-line operations
    - Dynamic rollover

5. Install systems and equipment such as:
    - Proximity detection equipment
    - Wire Strike Protection Systems (WSPS)
    - Load meters
    - More crash resistant fuel systems
    - Radar altimeters
    - Engine auto-relight ignition kits
6. Install cockpit recording devices.
7. Develop standards for data collection and sharing of pilot history for hiring / screening and expand the Pilot Records Improvement Act (PRIA) to include rotorcraft pilots.
8. Regulators should develop an easily accessible database of military surplus aircraft serial numbers, history, use, etc.

7.8.13 Logging Recommendations

1. Logging Operators should develop and adopt Safety Management policies and procedures to assess and minimize risk in maintenance, operations, hiring practices and to maximize the benefits of targeted training.

2. Install equipment that enables maintenance personnel to detect impending component failure, similar to a HUMS system.

3. Install cockpit indication of long line load weight.

4. Improve Regulatory support for Logging operations by updating available guidance material on external load operations, enhanced Flight Standards oversight of Logging maintenance facilities.

5. Ensure that the methods and practices for part and component safe life calculation are easily tracked, accurate and robust.

6. Where applicable, ensure that military surplus aircraft used in Logging are maintained to standards equivalent to those of civil helicopter maintenance requirements.

7. Install cockpit recording devices that will enable crash investigators to understand cockpit indications and pilot actions prior to a crash.

7.8.14 Firefighting Recommendations

1. Adopt Safety Management methods to assess and minimize risk in maintenance, operations, hiring practices and to maximize the benefits of targeted training. An SMS program tailored to the inherent operating environment risks is required for firefighting missions.
2. Install equipment that enables maintenance personnel to detect over limit operations and impending component failure, such as a HUMS system.
3. Improve regulatory support for Firefighting operations by updating available guidance material on external load operations. Provide enhanced Flight Standards oversight of Firefighting operator maintenance facilities and ensure better regulatory oversight of field approvals and non-conforming aircraft configurations.
4. Install cockpit recording devices that will enable crash investigators to understand cockpit indications and pilot actions that precede a crash.
5. Develop industry standards for data collection and sharing of pilot history for hiring / screening.

7.8.15 Utilities Patrol and Construction Recommendations

1. Utility Patrol and Construction operators should develop an SMS that outlines and details the risk and operational requirements to perform their missions.
2. Install cockpit imaging / recording devices.
3. Provide pilots with mission-specific operational and aeronautical decision-making training for the Utility Patrol and Construction operational environment.
4. Provide tail rotor protection systems for helicopters to reduce the likelihood of tail rotor strikes and objects inadvertently coming in contact with the tail rotor.
5. Use a detailed pre-flight checklist to ensure the doors are secured and objects inside the aircraft are secured.
6. Install door / cowl positive latch warning indications in the cockpit to alert the pilot in the event a door is not properly secured or opens during flight.

Section 8 – Future Efforts

The U.S. JHSAT plans to continue its effort beyond the analysis of the CY2000 accidents until after the target year of 2016. The exact nature of these continuing efforts has not yet been fully defined and will likely have some variation from year to year. This section provides the basic structure of the continuing effort in the intervening years and the wrap-up effort in early 2017.

8.1 Final JHSAT Effort

A reasonable approach is to look at the CY2016 endpoint. Working backwards, the types of tasks can be determined that will be needed in the intervening years to achieve the CY2016 goal. The final U.S. JHSAT effort should occur in January and February of 2017. The objective of this final JHSAT effort will be two fold:

- Answer the Question: During CY2016, was the IHST 80% accident rate reduction goal to an annual accident rate of 1.8 accidents / 100,000 flight hours achieved by U.S.-Registered helicopters?
- Summarize the U.S. JHSAT efforts from 2006 through 2016. This includes the annual accident rates from 2006 through 2016 and lessons learned for the entire JHSAT experience.

There will be no need for detailed analysis of the accidents of 2016. The results for 2016 will be the culmination of the IHST worldwide helicopter community effort to make the 80% reduction is the helicopter accident rates. The root causes of these 2016 accidents do not need to be determined at this point. JHSAT only needs the number of accidents and the particular mission in progress, which will be known in early January 2017. The U.S.-Registered helicopter flight hours will be determined as discussed in Section 5 – Metrics for 2016 and will be available for use by mid-January 2017. This final JHSAT report will be ready for public release at a large public venue for helicopters, such as HAI's HELI-EXPO 2017.

It is expected that each regional JHSAT will be performing similar tasks for their respective fleets on the same schedule. The accidents and flight hours of each region and the world will be known. Each regional JHSAT final report should be completed and submitted to the IHST and the Lead JHSAT by the end of January 2017. The intent is that all regional JHSATs (including the U.S. JHSAT) will be ready for IHST public release at the HELI-EXPO 2017 or other similar public venue.

The IHST Lead JHSAT has the additional duty to pull together the information from all regional JHSATs. It is expected that the IHST Lead JHSAT Group will do these same two tasks for the worldwide fleet as those accidents will be known at the same points. The worldwide report will also include a region-by-region status toward their respective 80% accident rate reduction goal. The worldwide IHST JHSAT final report will also be ready for public release at the HELI-EXPO 2017 or similar venue.

8.2 U.S. JHSAT Efforts Until 2016

Efforts Through the End of 2007: The activities of the U.S. JHSAT to date are included in this report. The activities for the remainder of 2007 are expected to be of a wrap-up and planning nature. There will be coordination meetings at the Second International Helicopter Safety Symposium in September 2007. Support and training of regional IHST efforts will continue. Planning for the U.S. JHSAT effort of CY2008 will also occur.

Efforts From 2008 Through 2015: The exact nature of the U.S. JHSAT continuing efforts have not been determined and will likely be modified from time to time. This section provides the basic approach that needs to be maintained until 2017. The JHSAT effort should not be abandoned after 2007 and then reconstituted in 2017 just to answer the question of whether the goal was met or not. A continuing annual effort is needed to:

- Identify new problems
- Determine new interventions
- Measure the effectiveness of interventions
- Recommend course corrections
- Share lessons-learned among the different regional JHSATs
- Refine the JHSAT analysis process

The 2008 U.S. JHSAT effort is anticipated to be a continuation of the JHSAT process being applied to CY2001 U.S.-Registered helicopter accidents similar to the CY2000 analysis of this report herein. There will likely be some refinements explored to speed up the process and more detailed analysis in some specific problem areas. For example, it is anticipated that key words would be assigned to an individual accident. This will allow the team to quickly access accidents being analyzed with similar conditions. This should improve consistency and reduce analysis time.

It was found in analysis of CY2000 data that once all team members had been well indoctrinated in the analysis process, that separation into two subgroups was possible and the team was then able to process twice as many accidents in a given meeting. This two subgroup approach will be used in 2008 and subsequent JHSAT activities. Other lessons learned in Appendix F: Lessons Learned will be considered as the JHSAT goes forward.

There will be some detailed analyses of specific problem areas that are not mission-specific. For example, maintenance issues were found in all missions in the CY2000 study, so more detailed analysis is expected for maintenance issues regardless of mission. Regardless of any special detailed analyses in a given area, all of the accidents will still be analyzed for subtle shifts in causal factor changes from year to year. Specific problem area analyses are an addition to, not replacement for a consistent analysis of all accidents within a year.

The consistent analysis of all helicopter accidents of CY2001 (as well as subsequent years) is important. In addition, the CY2001 SPSs will be compared to those of CY2000. It will be interesting if the same Standard Problem Statements and their relative frequencies are still present in CY2001. This changing of Standard Problem Statements and their frequencies from year-to-year will be an integral part of subsequent JHSAT analyses. This can indicate the reduction of a particular problem or the introduction of new problems from year-to-year.

Flight hours should be available in the latter part of 2008, allowing use of frequency / flight hour in the analyses. Flight hours by mission are not expected to be available in 2008. Once analysis of the CY2001 accidents is completed, a similar final report will be prepared and submitted to the IHST and JHSIT. Each year's final report should include a comparison between the accidents analyzed that year and those analyzed in previous years. More coordination meetings between the JHSAT and the JHSIT are expected each year as the JHSAT starts measuring the effects of interventions that have entered the fielded fleet.

In 2009, it is anticipated that flight hours by mission will be available, so mission frequency / flight hours can be calculated. It is expected that the mission hours will be available back to CY2000 such that problem rates by mission can be calculated and compared to the same problem rates in the prior years. This same process of comparison will continue with each year up to and including CY2005. The CY2005 final report should also include the 5-year (2001-2005) average accident rate by mission as well as for the entire U.S.-Registered helicopters fleet for CY2005. This 5-year average accident rate becomes the starting point for comparisons of the SPSs against the annual SPS rates of each year. This comparison will continue on an annual basis for CY2006 through CY2015 data. Frequency of SPS occurrences can be measured at different levels. It is not possible to forecast the proper SPS rollup level at the time of this first JHSAT report. The JHSAT team will determine the most appropriate SPS level that makes sense depending on the data.

Each year until 2015, accidents will be analyzed, problems identified and interventions proposed. In addition, comparisons will be made with similar data developed for previous years to identify trends. Particular attention will be paid to the SPS frequency / flight hour changes from year to year. Comparison of individual mitigations and their effects will start in 2006 and grow in importance as different mitigations are introduced. The JHSAT will coordinate with the JHSIT, who will track when each individual mitigation was introduced, how many aircraft / pilots are affected in a given year, and when that mitigation is 100% implemented. The JHSAT function is to evaluate the mitigation's effectiveness in reducing accidents.

The analysis of CY2015 data in CY2016 will be a challenge. The detail analysis level for most 2015 accidents will likely be limited due to the NTSB investigations still being in progress. The JHSAT should do what is needed for determining continuity of rates and wrapping up the JSHAT activities. Analysis will likely be at a higher SPS level due to lack of details. The JHSAT should use all available information (outside of NTSB as well) to see if 2015 rates are consistent with 2014. The CY2015 final report will be the last status report on progress toward meeting the 80% accident rate reduction goal.

Appendix A: U.S. JHSAT Team Members

The following personnel comprised the U.S. JHSAT for this report:

- Mark Liptak – FAA Engine & Propeller Directorate (Co-chairperson)
- Jack Drake – Helicopter Association International (Co-chairperson)
- Tony Alfalla – Sikorsky Aircraft Corporation
- Lindsay Cunningham – American Eurocopter
- Clark Davenport – FAA Rotorcraft Directorate
- Tom Fleming – Bristow Group International
- Roy Fox – Bell Helicopter Textron Inc
- Steve Gleason – Schweizer Aircraft Corporation
- Joan Gregoire – Turbomeca USA
- Sandra Hart – NASA Ames Research Center (Retired)
- Laura Iseler – IHST
- Joe Lemma – Air Methods Corporation
- Ron Luhmann – Silver State Helicopters, LLC
- Matthew Rigsby – FAA Rotorcraft Directorate
- Barry Rohm – Rolls Royce Corporation
- Ed Stockhausen – Air Methods Corporation
- Joe Syslo – American Eurocopter
- Denise Uhlin – Bristow Group International
- Ray Wall – Bristow Group International

A short biographical overview is provided for the members of the team except where it was not available at the time of publishing this report.

Mr. Mark Liptak is currently the FAA Engine and Propeller Directorate's Safety Management Program Manager. Mr. Liptak was selected as co-chairperson of the JHSAT due to his past experience working on successful aviation safety programs with the Commercial Aviation Safety Team and, earlier, on the FAA's Safer Skies initiative. He has been employed by the FAA for the last 11 years and has significant experience in Safety Management Systems development, use of state of the art data and text mining software, regulatory requirements development and maintenance and large turbine engine certification program management. Prior to working at the FAA, Mr. Liptak worked at the General Electric Company for 15 years as an FAA Designated Engineering Representative and as a Gas Turbine Performance Engineer. He graduated magna cum laude from the University of New Hampshire with a B.S. degree in Mechanical Engineering.

Mr. Jack Drake is currently an independent aviation safety consultant and Acting Director of Safety for Helicopter Association International (HAI). Mr. Drake was selected as co-chairperson of the JHSAT because of his extensive knowledge and experience in aircraft accident investigation and aviation safety program management, his helicopter expertise, and his ability to objectively represent domestic and international helicopter operators as the HAI representative on the team. Mr. Drake graduated from the U.S. Naval Academy and served in the U.S. Navy as a rescue helicopter pilot, standardization flight instructor and Aviation Safety Officer. After leaving the Navy, Mr. Drake was employed by the National Transportation Safety Board for 26 years, serving as an accident analyst, regional aviation safety investigator, aviation go-team investigator-in-charge and Manager of the NTSB Aviation Engineering Division. After retiring, Mr. Drake was employed by America West Airlines as Director of Operations Safety, where he developed and directed safety management and emergency response programs. Afterward, Mr. Drake performed aviation safety audits and other contract work for HAI before assuming his current position.

Mr. Wilfred A. "Tony" Alfalla is the Sikorsky Aircraft Corporation's Aviation & Product Safety / Aviation Safety Operations Manager assigned to the Development Flight Test and Production Center located in West Palm Beach, Florida. He has been employed by Sikorsky Aircraft for the last 30 years and has significant experience in aviation maintenance, safety programs, flight test, field service operations and aircraft safety investigations. He has extensive aviation maintenance experience in military (both Department of Defense and foreign) and commercial operations. He was a Sikorsky Field Service Representative for 10 years, working on Sikorsky Contract Maintenance Support, and for 20 years with Aviation and Product Safety, responsible for aviation safety and flight test safety operations. Mr. Alfalla attended the Academy of Aeronautics located in New York City and is a licensed FAA Airframe & Powerplant mechanic. Prior to working with Sikorsky Aircraft, Mr. Alfalla was with the United States Marine Corps, assigned as a Sikorsky CH-53A/D flight crewmember / crew chief.

Ms. Lindsay Cunningham is an Accident Investigator for American Eurocopter in Grand Prairie, Texas. Her prior investigative experience included an extended Air Safety Internship at the NTSB and a year as an Associate Accident Investigator at American Eurocopter. She has participated in nearly 30 onsite field investigations of both helicopter and fixed-wing aircraft accidents. Ms. Cunningham is a Commercial/Instrument Pilot. She graduated Summa Cum Laude from Embry Riddle Aeronautical University with a B.S. Degree in Professional Aeronautics and is completing a Masters Degree in Aeronautical Science, specializing in Aviation Safety Systems and Operations. Additionally, Ms. Cunningham has graduated from and participated as an Instructor at the Transportation Safety Institute's Rotorcraft Accident Investigation Course.

Mr. Clark Davenport is the human factors engineer and the acting flight test analyst at the FAA Rotorcraft Directorate. He has worked for the FAA for five years. Prior to joining the FAA, he retired from the US Air Force where his duties included KC-135Q Instructor Navigator, aerospace physiologist, USAF Safety Center aircraft accident investigator and human factors investigator/analyst. While in the Air Force, he was selected to be a member of the Loss of Control Joint Safety Analysis and Joint Safety Implementation Teams. He has master degrees in engineering psychology from University of Illinois and human resources and organizational development from Chapman University. He received his bachelor degree in Biology from Whitman College.

Mr. Roy G. Fox is the Chief of Flight Safety for Bell Helicopter Textron Inc, where he has worked since receiving a Bachelor of Science in Mechanical Engineering with Aeronautical Option from New Mexico State University in 1966. He founded the System Safety Engineering Group at Bell and still directs that effort. He also directs worldwide accident investigations for Bell Helicopter. In addition to Safety Engineering, he is deeply involved in crash survival research and improvement efforts involving military and civil helicopters, as well as tiltrotor aircraft. He has headed the helicopter industry Aerospace Industries Association (AIA) Crashworthiness Project Group, was a member of the General Aviation Safety Panel for seats and post-crash fire protection, and a member of Society of Automotive Engineers (SAE) committees on aircraft seats and occupant restraints; he was Chairman of the SAE subcommittee that developed the general aviation and rotorcraft safety assessment document (ARP5151). Mr. Fox also lectures on crash survival and human performance at the FAA Helicopter Safety & Accident Investigation and Human Performance in Accident Investigation Courses, and at Aviation Safety Seminars. He performs various analyses of helicopter accident data to support helicopter industry needs, such as reversal of ICAO helicopter operation prohibitions, the NASA Helicopter Accident Analysis Team, and the International Certification Procedures Task Force. Presently, he is chairman of the HAI Restricted Category Aircraft Committee and the AHS Crash Safety Committee. In 1989, Mr. Fox received the AHS Harry T. Jensen award for significant improvements in reliability, maintainability, or safety due to crash survival efforts that have become mandatory FAA rules. In 1990, he received the Flight Safety Foundation Business Aviation Meritorious Award for crash survival and teaching efforts that are resulting in improved safety in business aviation. In June 1992, Mr. Fox received U.S. Patent #5,125,598 for a crash energy absorbing seat design.

Mr. Steven Gleason completed two semesters at Texas A&M in engineering and then went to work as an aircraft mechanic; he was licensed in 1975 and received his Inspection Authorization in 1978, after which he became Director of Maintenance for the Hughes Service Center, and later attended various Hughes, Bell and Allison maintenance schools. He maintained a variety of helicopters around Houston, Texas until joining Schweizer as a Customer Service Technical Representative in 1985. In 1988, he transferred to the engineering department as a maintenance liaison; the following year, he went to the USC helicopter accident course and has been the Chief Accident Investigator since then. Mr. Gleason acted as the Schweizer Engineering/FAA liaison on service difficulties until 2004, when he was assigned as the Aviation Safety Manager and Sikorsky purchased Schweizer as a wholly-owned subsidiary. He has also been a manager of the FAA Repair Station since 1988. Mr. Gleason has served in various technical support roles, including technical support for the Northrop Grumman RQ-8 Fire Scout. He holds a private pilot license with a helicopter rating and has reciprocating and turbine engine experience.

Ms. Joan Gregoire is currently the Product Integrity and Safety Manager at Turbomeca USA. Ms. Gregoire was asked by Turbomeca France to participate on the JHSAT and represent Turbomeca in the helicopter safety community. She has been employed by Turbomeca USA for the last 16 months and is new to the helicopter industry. Ms. Gregoire holds a commercial pilot certificate, with airplane ratings for single and multi-engine land. She also holds an instrument airplane rating. Ms. Gregoire holds a flight instructor certificate, with airplane ratings for single engine land. Prior to working at Turbomeca USA, Ms. Gregoire worked at Hewlett-Packard Company for 17 years and Oracle Corporation for 3 years in information technology. She holds a B.S. degree in Business Administration with a concentration in Accounting from California State University, Chico, and a M.S. Degree in Aviation Safety Science from Embry-Riddle Aeronautical University, Prescott, Arizona.

Ms. Sandra Hart was involved in NASA's aviation safety research efforts from 1997 until her retirement in 2007; she was the rotorcraft representative on the Aviation Safety Investment Strategy Team (ASIST), organized the Helicopter Accident Analysis Team, and managed the Safe All-Weather Flight for Rotorcraft (SAFOR) and System-Wide Accident Prevention Projects. Between 1988 and 1994, she served as Chief of the Rotorcraft Human Factors Research Branch. Before that, she led NASA's Workload and Performance Research Program. She received a BA and MA in Psychology from San Jose State University and was a member of many scientific and technical organizations, serving on the Executive Board of the Department of Defense Human Factors Engineering Technical Advisory Group for more than 10 years; the Operating Board of Institute of Electrical and Electronics Engineers (IEEE) Systems; Man and Cybernetics; the AHS Crew Station/Human Factors Committee; and study groups sponsored by the National Research Council and National Academy of Science. In conjunction with her duties as NASA delegate to the NATO / AGARD Aerospace Medical Panel, she co-chaired a study group on Human Performance Modeling. Her career achievement awards included the Jack Kraft Award from the Human Factors Society, a US Army Aviation Systems Command Director's Award for Interagency Cooperation, and NASA Medals for Scientific Achievement, Exceptional Service, and Outstanding Leadership.

Ms. Laura Iseler has been the Program Manager for the International Helicopter Safety Team since its inception. She serves as technical chairman of the safety symposiums, coordinator for the executive committee and member of the JHSAT. Prior to that, she worked in the Helicopter Division at NASA Ames Research Center for 18 years on a variety of projects from analyzing control system failures and pilot-in-the-loop control system design for cockpit displays during terminal area procedures, to developing civil tiltrotor and tiltwing terminal area procedures, and Rotorcraft Unmanned Aerial Vehicle (RUAV) ground stations. After performing extensive helicopter accident analysis for the purpose of tailoring NASA's helicopter safety research efforts, Ms. Iseler created NASA's safecopter website and was named to lead NASA's SAFOR Program. She then spent three years as communication and outreach specialist interacting with NASA headquarters and representing NASA's rotorcraft division in public forums. She holds bachelor of science and bachelor of engineering degrees from Dartmouth College and an master of science degree in mechanical engineering degree from Stanford University.

Mr. Matthew Rigsby holds a BS in Aviation Science and a Master of Science degree in Aviation Safety Management. He is an FAA-licensed fixed wing, instrument rated and rotary wing pilot, as well as holding an Airframe and Powerplant Mechanics certificate. He currently works for the Southwest Region FAA's Aircraft Certification Rotorcraft Standards Staff, Safety Management Group ASW-112 as an Air Safety Investigator and has responsibility for Continued Operational Safety issues for rotorcraft operating in the United States. Matt is also the Aircraft Certification Groups representative on the FAA's Air Medical Task Force. He has participated in over 80 on-scene rotorcraft accident investigations both in the US and abroad. Previous to coming to the FAA, Rigsby worked as an Air Safety Investigator for the Bell Helicopter Textron Product line, and as a system/flight test safety engineer and flight test engineer on the MV-22 and CV-22 tilt-rotor aircraft. Previous to Bell Helicopter, he worked as a helicopter engineer for the US Army Aviation and Troop Command Center in St. Louis, Missouri.

Mr. Barry Rohm is currently an engineering consultant on retainer to Rolls-Royce Corporation. Mr. Rohm retired after 46 years of industry experience from Rolls-Royce as Engineering Director of Product Assurance. He graduated with a B.S. in Mechanical Engineering from General Motors Institute and spent his early career at GM's Allison Gas Turbine Division as an experimental test project engineer followed by management assignments as Turbofan and Advanced Technology Test Projects Supervisor, General Supervisor Laboratory Operations and Department Head Experimental Test. Product development experience followed as the Chief

Project Engineer for the T56/501 Installation, then Chief Project Engineer for T800 Controls, Performance and Helicopter Integration. He was appointed the Director of Product Safety in 1988, responsible for FAA certification as Management Designated Engineering Representative (DER), air safety investigations, product safety management and later had responsibilities for engineering quality, reliability analysis and design review programs. He was a Member of the Rolls-Royce Company Product Safety Review Board and has industry and regulatory experience, included company representative and chairman of the AIA Propulsion Committee. He was the Rolls-Royce representative on the General Aviation Manufacturers Association (GAMA) Technical Policy Committee, the AIA Propulsion Committee representative on FAA/Industry Joint Management Team, an Aviation Rulemaking Advisory Committee working group member for FAA engine regulations including Vibration (Chair), Rain/Hail Ingestion, Bird Ingestion, Rotorcraft 30 sec. OEI Ratings (Chair) and Power-Plant Installation Harmonization Working Group, and member of the FAA / GAMA Certification Process Improvement team. Other aviation experience includes private pilot single engine land instrument rating and 20 years with the Indiana Air National Guard Flight Operations 113th Tactical Fighter Squadron.

Mr. Ed Stockhausen is the Director of Safety for Air Methods Corporation. He is a Certified Medical Transport Executive (CMTE) and has been in the air medical industry since 1982. Beginning his aviation career in 1976, he served three years with the Army Parachute Team, The Golden Knights, as crew chief and loadmaster. He started flying EMS in 1982 for Norfolk General Hospital. He has also flown for Geisinger Medical Center and Cleveland Metro as a line pilot. As a relief pilot, he has flown at over 20 different programs, including a three month stint in West Berlin, Germany and has accumulated over 8,000 accident/incident free flight hours. During his 25 years serving the EMS Community, he has held positions as an IFR Captain, Instructor Pilot, Check Airman, Regional Manager, Chief Pilot and Director of Operations. He has a diverse educational background ranging from studying maintenance management at Pikes Peak Community College to Professional Aeronautics and Flight Safety at Embry Riddle. Mr. Stockhausen's involvement in flight safety started when he attended the first FAA EMS safety summit in the early 1980s. Since that time, he has been active in National Emergency Medical Services Pilots Association, Air Medical Services Safety Advisory Council, HAI, The IHST, and the Association of Air Medical Systems. He speaks regularly across the country to professional groups focused on Systems Safety and Air Medical Resource Management.

Mr. Joe Syslo is currently the Senior Manager, Aviation Safety, for American Eurocopter, LLC, where he also served in the capacity of Manager, Accident Investigation from 2002 until 2007. Prior to employment at American Eurocopter, Mr. Syslo spent 20 years at Bell Helicopter as a Senior Accident Investigator and was concurrently involved with the Texas Army National Guard as a UH-60 Pilot and Aviation Safety Officer. Prior to his career with Bell Helicopter, Mr. Syslo was a U.S. Marine Corps Aviator, Commercial Line Pilot, Deputy Chief Pilot, and Chief Pilot, and has flown a variety of helicopters from the Bell Model 47 through the Eurocopter Puma and Bell 412, including an operational tour in Viet Nam flying the Sikorsky UH-34D. Civilian missions have included electronic news gathering, emergency medical services, photography, long line, corporate and law enforcement. Throughout his flying career, he has accrued approximately 10,000 flight hours. Mr. Syslo also holds a B.S. in Aeronautical Science with a Minor in Aviation Management from Embry Riddle Aeronautical University. Mr. Syslo has taught helicopter landing site safety and accident investigation for approximately 20 years at the Transportation Safety Institute's Rotorcraft Accident Investigation Course.

Ms. Denise Uhlin is currently the Western Hemisphere Assistant Director of Quality and Safety for Air Logistics, a Bristow Company. She started in the company in 2003 as Operations Coordinator for AirLog International before transferring to Quality and Safety in 2005. Previous experience includes eight years at another major helicopter company in the following roles: consultant, aeromedical customer service representative, director/general manager of aeromedical division and wholly-owned subsidiary, and senior marketing representative. Ms. Uhlin was a registered nurse by profession, entering the air medical industry in 1980 where she served in a staff position and then in management, focusing on safety, public speaking, and lobbying efforts on Capitol Hill. In 1992, Ms. Uhlin received the North Carolina Governor's Award of Excellence and the North Carolina Great 100 Nursing Excellence Award, and remains active and involved in the helicopter industry today.

Mr. Ray Wall is the Director of Quality and Safety for Air Logistics, where he is responsible for the western hemisphere safety and investigative activities. He also is a member of the Global Quality and Safety Standardization Team for Bristow Corporation. He retired from the NTSB as a Senior Air Safety Investigator where he had conducted over 500 investigations as the Investigator-In-Charge of civil aircraft accidents ranging from 14 CFR Parts 91 to 121 operations and wrote the final Factual Reports along with the proposed probable causes. He instructed FAA, military and civilian personnel in accident investigation at the Department of Transportation's Transportation Safety Investigation, and taught Human Factors In Accident Investigations, Aviation Risk Management and Aviation Safety Program Management. Mr. Wall worked for and was trained by a subsidiary company of a major aviation insurance underwriter as an accident investigator; he also headed their Aviation Services Division with responsibility for aviation risk management programs of both national and international clients. Mr. Wall served in the United States Army as an officer and pilot for 12 years of active duty, including serving one year in the combat zone of Southeast Asia, flying attack aircraft; he was awarded numerous military decorations for valor, including the Distinguished Flying Cross, two Air Medals with "V" devices, 28 total Air Medals, and the Republic of Vietnam Cross of Gallantry with Palm, the Bronze Star, and others. Additionally, he was awarded both the Senior and Master Aviation Wings. Mr. Wall was trained by the military as an Aviation Safety Officer/Accident Investigator, Combat Intelligence Officer, NATO Air/Ground Operations Officer, and TNOE Instructor Pilot. Additionally, he served as a test pilot for the Department of the Army's Aircraft Test Branch during the development of the Airborne Laser Systems for attack aircraft. Mr. Wall holds an FAA pilot's license, rated in both fixed wing (single and multi-engine) and rotorcraft – helicopters (single and multi-engine); he also holds instrument ratings in both classes and has accumulated over 6,000 flight hours. He has held the positions of Chief Pilot and Director of Operations for a commercial operator. Additionally, Mr. Wall has served as the Director of Safety for a Part 121 regional airline where he was responsible for all safety program related matters. He has a B.S. degree in Aeronautical Sciences.

Appendix B: Joint Helicopter Safety Analysis Team (JHSAT) Charter

1. Sponsorship

The JHSAT is sponsored by the IHST per their charter, which was approved January 10, 2006. JHSAT activities shall be conducted in accordance with the IHST charter requirements.

2. JHSAT Goal

Provide a prioritized assessment of the most safety-critical hazards to commercial, private and military rotorcraft in worldwide operations as derived from selected rotorcraft data sources. Provide intervention strategies to the IHST and Joint Helicopter Safety Implementation Team (JHSIT) that maximize the likelihood of reducing worldwide helicopter accident rates by 80 percent by 2016. Provide a JHSAT interim report documenting the team's findings to the IHST by January 31, 2007.

3. Deliverables

Deliver a summary report to the IHST for use by the JHSIT, providing accident report analyses, intervention strategies, an evaluation of the effectiveness of each strategy, and recommended strategies and metrics for long-term measurement of safety critical attributes affecting rotorcraft safety. The JHSAT will also issue annual metric reports that provide a means of determining the effectiveness of the actions taken by the IHST. Metric reports will be issued annually until 2016.

4. Effective Date and Duration

The JHSAT was formally established on February 27, 2006. The JHSAT shall remain in effect until 2017 and the metric report of 2016 is submitted to the IHST.

5. Process

The JHSAT will adopt a process similar to that used successfully by the Commercial Aviation Safety Team (CAST) and Joint Safety Analysis Teams (JSAT) consistent with characteristics and potential limitations present in helicopter data. This is a disciplined and structured method of identifying appropriate datasets and prior studies which utilizes a data-driven approach to characterize and develop safety interventions that mitigate risk. The JHSAT will utilize government, industry and operator experts to analyze accidents in key safety areas, utilize the JHSAT process and recommend intervention strategies. Additionally, the JHSAT will conduct literature reviews of existing rotorcraft safety reports and may recommend near term non technical rotorcraft risk mitigation strategies.

Representatives of Original Equipment Manufacturers (OEMs) will not be required to participate in analyses of accidents involving the OEM that are in litigation or anticipated to result in litigation. Findings of the committee do not represent concurrence or an admission on the part of the OEM.

6. Specific Tasks

The JHSAT will:

- Conduct detailed accident report analyses and identify causal and / or probable cause factor trends.
- Identify roadblocks and impediments to achieving IHST goals.
- Investigate and recommend improvements and develop mitigation strategies to allow goal achievement and periodic status measurements.
- Draft action plans to determine intervention strategies and milestones for JHSIT implementation planning and IHST approval.
- Provide periodic status reports to IHST as directed by IHST members.

- Develop an analysis process consistent with helicopter accident data quality and limitations.
- JHSAT will combine any and all JHSAT subcommittee inputs into the JHSAT summary report to the IHST.
- Make provisions for feedback from operations groups, HSAC [Helicopter Safety Advisory Committee], etc.
- JHSAT will provide collection, analysis and dissemination of rotorcraft safety data and periodic measurement of the effects of the interventions implemented until 2016.
- Monitor and report annually on the worldwide helicopter fleet safety changes / progress annually until 2016.

7. Resources

The participating organizations agree to provide the financial, logistic and personnel resources to carry out this charter.

8. Membership

The team will include representatives with the appropriate technical or operational background provided by industry and government.

Co-chairs

IHST will select or elect two co-chairs, one representing the industry / operator community and one representing government.

The co-chairs will:

- Establish an agenda for all meetings and publish minutes of each meeting.
- Ensure the agenda meets criteria to improve safety.
- Provide leadership for ongoing products and accomplishments.
- Identify and manage the required administrative support.
- Promote consensus among the group members.
- Be responsible for the JHSAT performing the tasks and delivering the products described in the JHSAT Charter.

JHSAT Analytical Working Group

The JHSAT Analytical Working Group shall be composed of a variety of member organizations, including representatives of major helicopter airframe manufacturers, operators and operator representatives, engine manufacturers, systems and systems integrators, simulation manufacturers and agencies and organizations representing the military, government regulatory and government accident investigation communities. The Analytical Working Group may be divided into sub groups in a way that best supports the JHSAT's needs.

With direction from the co-chairs, the JHSAT Analytical Working Group will be responsible for performing the analytical work necessary to develop data-based intervention strategies for submittal to the IHST and JHSIT.

Additionally, all JHSAT members shall:

- Come to meetings prepared, having reviewed pre-meeting materials and ready to engage and make decisions.
- Complete assigned tasks.
- Maintain communications and linkage with parent organization.
- Deliberate and raise issues.
- Actively support JHSAT decisions and enlist parent organization support.
- Be prepared to commit personal time and energy to JHSAT priorities.
- Share respective parent organization inputs with other members.

- Ensure duplication of effort is minimized or eliminated.
- Use approved JHSAT presentations to represent JHSAT objectives or products to external organizations.
- Stay focused on JHSAT goals and objectives.

9. Number and Frequency of Meetings

JHSAT meetings will follow the general schedule below:

<u>2006</u>

- March through April – strategy meetings, team formation, dataset selection, JHSAT process review / modification.
- May through December – team data analysis meetings (8 meetings).

<u>2007</u>

- January through March – meet as needed to finalize the JHSAT interim report.
- April through December – team data analysis meetings on second data set.

Additional meetings may be necessary to accommodate major events such as the HAI Heli-Expo, the AHS Annual Forum, the EHA [European Helicopter Association] annual meeting, outreach meetings, and periodic IHSS meetings.

10. Background Discussion

The White House Commission on Safety and Security in 1997 set a goal of an 80 percent reduction in the fatal accident rate within 10 years and identified the need for strong government-industry partnerships to support the aviation system of the future. Additionally, the White House Commission encouraged expanded cooperative efforts to enhance aviation safety. The National Civil Aviation Review Commission (NCARC) followed up with a strong recommendation that the FAA and industry work together to develop a comprehensive integrated strategic safety plan to implement the many existing safety recommendations. The Commission recommended that performance measures and milestones be developed to assess progress in meeting the safety goal. Further, the Commission advocated periodically reviewing priorities and monitoring progress made in achieving the overall safety goal.

The FAA, NASA and industry Commercial Aviation Safety Strategy Team (CASST) groups determined that each of their organizations had complementary ongoing work to enhance the safety of commercial aviation. Each group used accident data to determine top safety focus areas. They intended to use the data to develop an understanding of the best actions or interventions to take to prevent future accidents before they occur. The FAA and the industry CASST formed the Joint Safety Analysis Steering Committee (JSASC) as the organizational body that would work together in these aviation safety areas. The scope of the work was to collaborate on identifying the top safety areas through the analysis of past accident and incident data, charter joint teams of experts to develop methods to fully understand the chain of events leading to accidents, identify high-leverage interventions to address these safety areas and remain focused on implementing these critical few high leverage interventions in the identified areas. The JSASC expanded its membership to include NASA, the DoD, and the Joint Aviation Authorities, as well as the International Civil Aviation Organization (ICAO), the International Air Transport Association (IATA) and the National Air Traffic Controllers Association (NATCA) under the umbrella of a new organization that became the Commercial Aviation Safety Team (CAST) for Part 121 Commercial Air Carriers.

NASA created an Aviation Safety Investment Strategy Team (ASIST) whose focus was on the needed research required to improve aircraft safety as part of the effort to achieve the National Aviation Safety Goal. NASA then formed the Helicopter Accident Analysis Team (HAAT) to address helicopter safety. Team members included NASA, the FAA, NTSB, other government agencies, as well as helicopter operators and manufacturers. HAAT's study, unfortunately, had to be limited to 34 fatal civil helicopter accident reports to be analyzed. Due to the report selection process and the small percentage of helicopter accidents analyzed, the HAAT study of 1998 could not be used to determine the frequency and relative value of the Safety Investment Areas (SIAs).

To determine if the National Safety Goal of five-fold reduction, i.e. 80 percent reduction, in accident rates for civil helicopters was possible, Bell Helicopter in 1998 conducted an analysis of civil helicopter accidents during the 1990-1994 period. The study demanded that the SIAs must be cost effective and applicable to all types of existing helicopters. Also, they expanded the safety metrics to include accident rate, fatal accident rate, and individual occupant risk of fatal injury. The study concluded that an 80 percent reduction in these metrics is an achievable goal for all types of civil helicopters.

Recognizing the need for a similar initiative focused on improving helicopter safety and reducing the helicopter accident rate, AHS International and its AHS Montreal / Ottawa Chapter hosted an International Helicopter Safety Symposia 2005 in Montreal on September 26-29, 2005. Sponsors included Bell Helicopter Textron, Sikorsky Aircraft Corp., The Boeing Company, AgustaWestland and Eurocopter. A number of organizations partnered with AHS International in hosting the meeting, including the FAA, ICAO, Transport Canada, European Helicopter Association (EHA), Helicopter Association International (HAI), Association of Air Medical Services (AAMS), Transportation Safety Board of Canada, Flight Safety Foundation, Inc., U.S. Naval Safety Center Naval Air Systems Command, and the U.S. Army Combat Readiness Center.

Attendees at IHSS 2005 agreed upon the need to reduce the helicopter accident rate by 80 percent within 10 years. To achieve that goal, they also agreed to create a separate process through the creation of an independent committee and process modeled after CAST to be known as the International Helicopter Safety Team (IHST).

Appendix C: SPS Category and Sub-Category List

Top Tier Identification	Second Tier Identification	SPS Code	Standard Problem Statement Description
Ground Duties			
100	Mission Planning		
100	10	101010	Inadequate consideration of aircraft / op limits
100	10	101020	Inadequate consideration of aircraft performance
100	10	101030	Inadequate consideration of weather / wind
100	10	101040	Pilot experience leads to inadequate planning regarding wind / weather
100	10	101050	Mission requirements / contingencies planning inadequate
100	10	101060	Pilot did not adequately consider and plan for alternate
100	10	101070	Incorrect fuel planning / calculations
100	10	101080	Weather – accurate weather information not available to Flight Crews and dispatchers
100	Weight and Balance		
100	20	102010	Incorrect weight and balance calculations
100	20	102020	Incorrect aircraft loading so it is out of CG / weight limits
100	20	102030	Company SOP procedures not followed
100	Aircraft Preflight		
100	30	103010	Aircraft Preflight process inadequate
100	30	103020	Performance of Aircraft Preflight inadequate
100	30	103030	Doors / cowlings not properly secured
100	30	103040	Diverted attention, distraction
100	30	103050	Tie downs not removed
100	Preflight Briefings		
100	40	104010	Pax safety brief inadequate
100	40	104020	Inadequate flight crew brief
100	Postflight Duties		
100	50	105010	Inlet covers not installed
Safety Culture			
200	Management		
200	10	201010	Non-aviation dispatcher / communication center
200	10	201020	Management policies / oversight inadequate
200	10	201030	Failure of company to realize the unintended consequences of new flight operations policies
200	10	201040	Failure to enforce company SOPs
200	10	201050	Management disregard of crew aeromedical factors
200	10	201060	Management disregard of human performance factors, i.e., duty / flight time, fatigue
200	10	201070	Management disregard of known safety risk
200	10	201080	Customer / company pressure
200	10	201090	Crew hiring criteria
200	10	201100	Lack of local supervision of remote ops
200	10	201110	Lack of supervision of remote maintenance

Top Tier Identification	Second Tier Identification	SPS Code	Standard Problem Statement Description
200	10	201120	Public use operating below civil (FAA) standards
200	Safety Program		
200	20	202010	Safety program inadequate
200	20	202020	Lack of a formal system for threat-free reporting of safety-related incidents within company / industry
200	20	202030	Risk management inadequate
200	20	202040	Insufficient employee performance monitoring
200	20	202050	Inadequate lessee risk awareness
200	Equipment		
200	30	203010	Helicopter inadequately equipped for mission
200	Pilot		
200	40	204010	Disregard of known safety risk
200	40	204020	PIC self-induced pressure
200	Scheduling / Dispatch		
200	50	205010	Crew assignment
200	50	205020	Crew – crew matching
200	50	205030	Crew – mission assignment
200	50	205040	Lack of monitoring of flight ops data
200	Training Program Management		
200	60	206010	Training vehicle too unforgiving for use
200	60	206020	Training inadequate for inadvertent IMC
200	60	206030	CFI preparation and planning
200	60	206040	Inadequate flight crew training due to cultural / economic
200	60	206050	Inadequate CRM training
200	Flight Procedure Training		
200	70	207010	Emergency training inadequate
200	70	207020	Inadequate post vortex ring state (“settling with power”) or loss of tail rotor effectiveness avoidance, recognition and recovery training
200	70	207030	Inadequate systems failure training
200	70	207040	Autorotation Training Inadequate
200	70	207050	Special operations training inadequate
200	Transition Training		
200	80	208010	Pilot transition training
200	80	208020	Transition to aircraft make and model
200	80	208030	Transition from one engine type to another
200	80	208040	Transition from one geographic area to another
200	Inadequate Pilot Experience		
200	90	209010	Pilot inexperienced
200	90	209020	Pilot inexperienced with area, mission

Top Tier Identification	**Second Tier Identification**	**SPS Code**	**Standard Problem Statement Description**
200	90	209030	Pilot lacking experience in make and model
200	90	209040	Student pilot
200	90	209050	Inadequate pilot knowledge
200	Ground / Pax Training		
200	100	210010	Ground / landing zone personnel
200	100	210020	Other personnel onboard
Maintenance			
300	MX Procedures / Management		
300	10	301010	Failure of QA or supervisory oversight
300	10	301020	Inadequate documentation of aircraft records
300	10	301030	Mechanic insufficient training / experience
300	10	301040	Aircraft released in un-airworthy condition
300	10	301050	Pre Functional Check Flight maintenance settings lead to hazardous conditions
300	10	301060	No post maintenance Functional Check Flight
300	10	301070	Lack of Functional Check Flight procedures
300	Performance of MX Duties		
300	20	302010	Maintenance did not detect impending failure
300	20	302020	Failure to perform proper maintenance procedure
300	20	302030	Failure of personnel to coordinate
300	20	302040	Maintainer interrupted
300	20	302050	Intentional non-compliance
300	20	302060	Maintenance induced FOD
300	20	302070	Loss / degradation of flight control system due to inadequate maintenance
300	20	302080	Loss / degradation of tail rotor drive system due to inadequate maintenance
300	Aircraft Design		
300	30	303010	Lack of Equipment to detect impending part failure
300	Quality of Parts		
300	40	304010	Bogus or surplus or unapproved parts used
300	40	304020	Tracking / cert military / surplus parts
300	40	304030	Fuel Contamination
Infrastructure			
400	Oversight / Regulation		
400	50	405010	Fixed-wing to rotary wing transition training requirements
400	50	405020	Inadequate oversight / regulations
400	50	405030	Inadequate tower / wire markings
400	Equipment		
400	60	406010	Lack of compatible air / ground communications
400	60	406020	IFR system incompatible w / helo missions

Top Tier Identification	**Second Tier Identification**	**SPS Code**	**Standard Problem Statement Description**
400	60	406030	Weather information for departure / enroute / destination inadequate or not available
400	60	406040	Improper modification of weather / nav aids
Pilot Judgment and Actions			
500	Human Factors – Pilot's Decision		
500	10	501010	Poor resource management
500	10	501020	Disregarded cues that should have led to termination of current course of action or maneuver
500	10	501030	Pilot decision making
500	10	501040	Willful disregard of aircraft limitations
500	10	501050	Willful disregard for rules and SOPs
500	10	501060	Used unauthorized equipment
500	10	501070	Failed to follow procedures
500	10	501080	Disregard for rules and SOPs
500	10	501090	Pilot disabled warning system
500	10	501100	Pilot misjudged own limitations / capabilities
500	Human Factors – Pilot / Aircraft Interface		
500	20	502010	Sense of urgency led to risk taking
500	20	502020	Diverted attention, distraction
500	20	502030	Perceptual judgment errors
500	20	502040	Visual Illusions
500	20	502050	Crew Disregard of crew aeromedical factors
500	20	502060	Crew Disregard of human performance factors i.e., Duty / flight time, fatigue
500	Flight Profile		
500	30	503010	Pilot's flight profile unsafe for conditions
500	30	503020	Pilot's flight profile unsafe – Altitude
500	30	503030	Pilot's flight profile unsafe – Airspeed
500	30	503040	Pilot's flight profile unsafe – Unsuitable terrain
500	30	503050	Pilot's flight profile unsafe – Approach
500	30	503060	Pilot's flight profile unsafe – Takeoff
500	30	503070	Pilot's flight profile unsafe – Rotor rpm
500	Landing Procedures		
500	40	504010	Selection of inappropriate landing site
500	40	504020	Landing site reconnaissance
500	40	504030	Misperception of stability and motion cues in hover
500	40	504040	Inadequate Autorotation – Forced
500	40	504050	Inadequate Autorotation – Practice
500	40	504060	Improper termination of precautionary landing
500	Crew Resource		

Top Tier Identification	**Second Tier Identification**	**SPS Code**	**Standard Problem Statement Description**
	Management		
500	50	505010	Inadequate and untimely Pilot in Charge action to correct 2nd pilot action
500	50	505020	Inadequate and untimely CFI action to correct student action
500	Procedure Implementation		
500	60	506010	Pilot improper action due to misdiagnosis
500	60	506020	Pilot control / handling deficiencies
500	60	506030	Inadequate response to Loss of tail rotor effectiveness
500	60	506040	Inappropriate Energy / power management
500	60	506050	Improper recognition and response to dynamic rollover
500	60	506060	Lack of in-flight fuel quantity monitoring
Communications			
600	Controlling Agencies		
600	10	601010	Coordination with ground / landing zone personnel
600	10	601020	Coordination with ATC
600	Other Crewmembers		
600	20	602010	Coordination with other pilots
600	20	602020	Coordination with other crewmembers
600	20	602030	Handoff of aircraft from one pilot to another pilot on ground
600	20	602040	Lack of positive transfer of control
600	Inadequate Procedures		
600	30	603010	Hot expedited loading process inadequate
600	30	603020	Inadequate flight following / operational company communications
600	30	603030	Inadequate coordination with tactical operations control
Pilot Situation Awareness			
700	Visibility / Weather		
700	10	701010	Reduced visibility – darkness
700	10	701020	Reduced visibility – fog, rain, snow, smoke
700	10	701030	Reduced visibility – whiteout, brownout
700	10	701040	Reduced visibility – sun / glare
700	10	701050	Local and enroute weather
700	External Environment Awareness		
700	20	702010	Aircraft position and hazards
700	20	702020	Altitude
700	20	702030	Aircraft state

Top Tier Identification	**Second Tier Identification**	**SPS Code**	**Standard Problem Statement Description**
700	20	702040	Lack of knowledge of aircraft's aerodynamic state (envelope)
700	20	702050	Pilot unaware aircraft restrained by the ground or ground obstruction
700	20	702060	Failed to recognize cues to terminate current course of action or maneuver
700	20	702070	Low flight near wires
700	Internal Aircraft Awareness		
700	30	703010	Unaware of low fuel status leading to fuel exhaustion
700	Crew Impairment		
700	40	704010	Pilot / crew impaired
Part / System Failure			
800	Aircraft		
800	10	801010	Airframe component failure
800	10	801020	Main rotor drive system component failure
800	10	801030	Main rotor blade failure
800	10	801040	Tail rotor drive system component failure
800	10	801050	Tail rotor blade failure
800	10	801060	TR Gearbox lubrication starvation
800	10	801070	Transmission system component failure
800	10	801080	Gearbox Lubrication starvation
800	10	801090	Flight control (non-AFCS) Failure
800	10	801100	Components used did not conform to type design
800	10	801110	Avionics system component failure (incl. AFCS)
800	10	801120	Electrical system component failure
800	10	801130	Hydraulic system component failure
800	10	801140	Hydraulic fluid loss
800	10	801150	Fuel System Failure (Fuel Starvation)
800	10	801160	Landing Gear / Skids
800	10	801170	Fuel Quantity System Failure
800	Powerplant		
800	20	802010	Engine Component failure
800	20	802020	Engine Oil Starvation
800	Operational FOD		
800	30	803010	Operational FOD (not maintenance-related)
800	Mission Specific Equipment		
800	40	804010	Mission specific equipment
Mission Risk			
900	Terrain / Obstacles		
900	10	901010	Mission involves flying near hazards, obstacles, wires
900	10	901020	Mission involves selection of remote landing sites
900	10	901030	Mission involves flight over unsuitable emergency landing

Top Tier Identification	**Second Tier Identification**	**SPS Code**	**Standard Problem Statement Description**
			terrain
900	10	901040	Lack of job site recon
900	Pilot Intensive		
900	20	902010	Mission involved flying in inclement weather conditions
900	20	902020	Mission involves flight in high traffic areas
900	20	902030	Mission requirements place pressure on crew to fly
900	20	902040	Mission requires low / slow flight
900	Aircraft Intensive		
900	30	903010	Mission involves repeated heavy lift
Post-Crash Survival			
1000	Safety Equipment		
1000	10	1001010	Safety equipment not installed
1000	10	1001020	Safety equipment installed by OEM removed
1000	10	1001030	Safety equipment failed
1000	10	1001040	Pax / crew survival gear not used
1000	10	1001050	Vehicle did not withstand impact
1000	Crashworthiness		
1000	20	1002010	Vehicle sank and / or capsized
1000	20	1002020	Post-crash fire
1000	Delayed rescue		
1000	30	1003010	ELT inop / damaged by impact
1000	30	1003020	Inaccessible accident site
1000	30	1003030	Bad Weather
1000	30	1003040	No flight following – slow to locate site
1000	30	1003050	Night-Darkness
1000	30	1003060	Inadequate communications between survivor(s) and rescue
Data Issues			
1100	Inadequate Information in Report		
1100	10	1101010	Information missing / incomplete in report
1100	10	1101020	Information unavailable to investigators
1100	10	1101030	Inadequate human factors information
1100	10	1101040	Inadequate control of accident scene
1100	10	1101050	Use and availability of info for flight path unknown
1100	10	1101060	Inadequate Investigation
Ground Personnel			
1200	Ground Personnel		
1200	10	1201010	Failure to disconnect
1200	10	1201020	Fuel servicing
1200	10	1201030	Marshalling

Top Tier Identification	**Second Tier Identification**	**SPS Code**	**Standard Problem Statement Description**
Regulatory			
1300	Accident Prevention		
1300	10	1301010	Failure to require data recording capability sufficient to understand accident sequence
1300	10	1301020	Insufficient analysis of previous incidents and lack of available incident information to the operators due to lack of oversight on the part of the regulator(s)
1300	Safety Culture		
1300	20	1302010	Lack of a formalized system for threat free reporting of safety-related incidents from operators to manufacturers
1300	20	1302020	Lack of a formalized system for threat-free reporting of safety-related incidents from operators to the FAA
1300	Safety System		
1300	30	1303010	Lack of a reliable process for reviewing / revising safety decisions based on field data collected after certification
1300	30	1303020	Failed to disseminate pertinent flight safety information
1300	30	1303030	Inadequate Regulatory Oversight / Regulations For Part 91 Sightseeing Operations
1300	Oversight		
1300	40	1304010	Inadequate application of government / industry standards
1300	40	1304020	Inadequate government / industry standards
1300	40	1304030	Regulations inadequate to ensure proper flight crew proficiency for the type of operations being conducted.
1300	40	1304040	Inadequate FAA Flight Standards oversight
1300	40	1304050	FAA control of military surplus aircraft / parts
1300	40	1304060	GSA control of military surplus aircraft / parts
1300	Operations		
1300	50	1305010	Part 91 vs Part 135 passenger-carrying operations
1300	50	1305020	Transition from one engine type to another training requirements
Aircraft Design			
1400	Aircraft Design		
1400	10	1401010	Cockpit design allowed critical controls to be selected inadvertently / inappropriately
1400	10	1401020	Safety assessments did not adequately identify system failure consequences
1400	10	1401030	Lack of wire strike protection
1400	10	1401040	Lack of annunciation / caution / warning of critical condition
1400	10	1401050	Engine flameout from snow / ice ingestion

Appendix D: Intervention Category and Sub-Category List

Category	Sub-Category	Total
Systems and Equipment	Cockpit Indication	28
	Crash Resistant Fuel System	11
	Design Improvement	2
	Dynamic Rollover	1
	ELT	3
	Enhanced Vision Systems	11
	HTAWS	2
	PAH Corrective Action	9
	PAH QA	1
	Part Lifing	1
	Pilot Aid	3
	Procedure	1
	Proximity Awareness	7
	Proximity Detection	19
	Radar Alt	3
	Safety Equipment	1
	WSPS	7
	Cockpit Warning	8
Systems and Equipment Total		**118**
Information	Disseminate Safety Info	15
	Investigation	36
	Recorder	123
Information Total		**174**
Infrastructure	ADS-B	1
	Aeromedical Factors	2
	Communications	4
	Emergency Response	2
	Ground Support	5
	Pilot History	9
	Safety Equipment	1
	Windsock	1
	Weather Info	4
Infrastructure Total		**29**
Instructional	CFI	20
	Preflight	5
	Preflight / Transfer Protocols	6
	SOP	1
Instructional Total		**32**

Category	Sub-Category	Total
Maintenance	Compliance	2
	Corrosion	1
	FCF	9
	Intervals	2
	Mechanic training	1
	Mil Surplus	7
	Quality Assurance (QA)	68
	Quality Control (QC)	9
	Recorder	34
	Records	8
	Remote Mx Oversight	2
Maintenance Total		**143**
No Recommendation	(blank)	36
No Recommendation Total		**36**
Regulatory	Aircraft Registry	3
	Disciplinary Action	7
	Field Approvals	1
	Guidance	2
	Mil Surplus	3
	Oversight	13
	PAH Corrective Action	2
	Public Use	4
	Requirements	3
	Rulemaking	3
	Standards	2
Regulatory Total		**43**
Safety Management	Aircraft Performance	1
	Decision-Making Aids for Pilots	4
	Disciplinary Action	10
	Employee Performance	5
	Flight Ops Management	13
	HOMP	12
	Mission Specific	3
	Oversight	4
	RFM Compliance	1
	Risk Assessment	64
	Risk Management	41
	Safety Culture	6
	Safety Equipment	5
	SOP	11
	SOP – Flight Following	2
	SOP – Inadvertent IMC	3
	SOP – LZ	15
	SOP – Mission Planning	6

Category	**Sub-Category**	**Total**
	SOP – Preflight	20
	SOP – Refueling	4
	SOP – Wx	26
	SOP Compliance	7
	Flight Ops Management – Remote	6
	SOP – Checklist	9
Safety Management Total		**278**
Training	ADM	12
	Aircraft Performance	19
	Aircraft Systems	15
	Autorotation	47
	CFI	16
	Critical Cues	13
	CRM	12
	Dynamic Rollover	14
	Ground Ops	2
	Ground Resonance	1
	Inadvertent IMC	10
	LTE	35
	M / M Transition	18
	Mission Specific	34
	New Pilot Training	4
	Preflight	23
	Proximity Awareness	5
	Quickstop	2
	Risk Assessment	37
	Risk Management	8
	Safety Education	3
	Simulators	31
	Emergency Procedure	11
Training Total		**372**
(blank)	(blank)	
(blank) Total		
Grand Total		**1225**

Appendix E: Glossary

A&P	Airframe and Powerplant
AAMS	Association of Air Medical Services
AC	Advisory Circular
ADM	Aeronautical Decision Making
AFCS	Automatic Flight Control System
AFM	Aircraft Flight Manual
AGARD	Advisory Group for Aerospace Research and Development
AGL	Above Ground Level
AHS	American Helicopter Society, International
AIA	Aerospace Industries Association
AIM	Airman's Information Manual
ALEA	Airborne Law Enforcement Association
AMRM	Air Medical Resource Management
APS	Accident Prevention Strategy
ASIST	Aviation Safety Investment Strategy Team
ATC	Air Traffic Control
ATP	Airline Transport Pilot
AU	Australia
AWOS	Automated Weather Observing System
CA	Canada
CAR	Civil Aviation Regulation
CASST	Commercial Aviation Safety Strategy Team
CAST	Commercial Aviation Safety Team
CFI	Certified Flight Instructor
CFR	Code of Federal Regulations
CG	Center of Gravity
CIR	Cockpit Image / Information Recorder
CMTE	Certified Medical Transport Executive
CRM	Crew Resource Management
CVR	Cockpit Voice Recorder
CY	Calendar Year
DER	Designated Engineering Representative
DOD	Department of Defense
EASA	European Aviation Safety Agency
EHA	European Helicopter Association
ELT	Emergency Locator Transmitter
EMS	Emergency Medical Services
EMS	Engine Monitoring Systems
ENG	Electronic News Gathering
EPIRB	Emergency Position-Indicating Radio Beacon
EU	European Union
EVS	Enhanced Vision System
FAA	Federal Aviation Administration
FAAST	Federal Aviation Administration Safety Team
FAR	Federal Aviation Regulation
FDR	Flight Data Recorder
FOD	Foreign Object Damage
FOQA	Flight Operational Quality Assurance
FSDO	Flight Standards District Office
FTD	Flight Training Device
GAMA	General Aviation Manufacturers Association
GOM	Gulf of Mexico
GPS	Global Positioning System
GSA	General Services Administration
HAAT	Helicopter Accident Analysis Team
HAC	Helicopter Association of Canada
HAI	Helicopter Association International
HEMS	Helicopter Emergency Medical Services
HFOQA	Helicopter Flight Operational Quality Assurance
HOGE	Hover Out of Ground Effect
HOMP	Helicopter Operations Monitoring Program
HSAC	Helicopter Safety Advisory Conference
HTAWS	Helicopter Terrain Avoidance and Warning System
HUMS	Health and Usage Monitoring System
HV	Height-velocity
IATA	International Air Transport Association

ICA	Instructions for Continued Airworthiness
ICAO	International Civil Aviation Organization
IEEE	Institute of Electrical and Electronics Engineers, Inc.
IHSS	International Helicopter Safety Symposium
IHST	International Helicopter Safety Team
IIMC	Inadvertent Flight into Instrument Meteorological Conditions
IMC	Instrument Meteorological Conditions
JHSAT	Joint Helicopter Safety Analysis Team
JHSIT	Joint Helicopter Safety Implementation Team
JSASC	Joint Safety Analysis Steering Committee
JSAT	Joint Safety Analysis Team
LOC	Loss of Control
LOFT	Line Oriented Flight Training
LTE	Loss of Tail Rotor Effectiveness
LZ	Landing Zone
M / R	Main Rotor
MM	Make and Model
MMIR	Maintenance Malfunction Incident Report
Mx	Maintenance
NAAA	National Agricultural Aircraft Association
NASA	National Aeronautics and Space Administration
NATCA	National Air Traffic Controllers Association
NATO	North Atlantic Treaty Organization
NCARC	National Civil Aviation Review Commission
NTSB	National Transportation Safety Board
NUSC	Non-U.S. Scheduled Commercial
NUSN	Non-U.S. Non-Scheduled Commercial
NVG	Night Vision Goggles
NZ	New Zealand
OEM	Original Equipment Manufacturer
OEI	One Engine Inoperative
PAH	Production Approval Holder
PAX	Passenger
PIC	Pilot in Command
PINC	Procedural Intentional Non-Compliance
PIREP	Pilot Report
PJ&A	Pilot Judgment and Actions
PMA	Parts Manufacturer Approval
PRIA	Pilot Records Improvement Act
PUBU	Public Use Operations
QA	Quality Assurance
QAR	Quick Access Recorder
QC	Quality Control
RFI	Risk of Fatal Injury
RFH	Rotorcraft Flying Handbook
RFM	Rotorcraft Flight Manual
RHL	Repeated Heavy Lift
RIN	Retirement Index Number
rpm	Revolutions per Minute
RO	Roll Over
SA	South / Central America
SA	Situation Awareness
SAE	Society of Automotive Engineers
SDR	Service Difficulty Report
SIA	Safety Investment Area
SM	Safety Management
SMS	Safety Management System
SOP	Standard Operating Procedure
SPS	Standard Problem Statement
STC	Supplemental Type Certificate
SVS	Synthetic Vision System
TC	Type Certificate
TOPS	Tour Operators Program of Safety
TR	Tail Rotor
U.S.	United States
VMC	Visual Meteorological Conditions
VFR	Visual Flight Rules
WSPS	Wire Strike Protection System
Wx	Weather

Appendix F: Lessons Learned

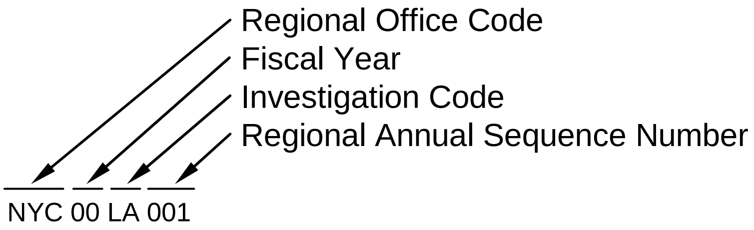
During the 16 months that the JHSAT met to analyze and interpret accident data, many lessons were learned. The following list is a summary of the more important issues and is provided for consideration by future JHSAT teams.

1. The team developed a scoring system based on that used by the CAST / JSAT; however, it was underutilized in the overall wrap-up of the accident recommendation data. The team did use it effectively as a tool for understanding and discussion of problem and intervention areas. Several attempts were made to use the scoring values to rank the overall intervention output; an acceptable final ranking method was not developed because the team was not convinced that the SPS and intervention scoring data was as significant as frequency of occurrence as measures of the importance of resultant intervention recommendations. The team used frequency of SPSs and Interventions to rank the data, since it produced prioritized lists with the best possibility of reaching an 80% reduction in accident rate. 80% of safety interventions were found to be non-mission specific.
2. Future JHSATs should consider conducting analyses in special problem areas such as weather, maintenance, part / component failures, Aeronautical Decision Making (ADM), handling qualities, aircraft performance exceedance, etc. Identifying problem areas to be analyzed should be frequency driven; those with the highest frequency get top priority.
3. The entire team needs to be fully practiced in the use of the JHSAT analysis process to ensure consistent understanding and use of the process. Once this is accomplished, the team may be split into sub-teams in order to increase efficiency, but steps must be taken to ensure that the sub-teams' efforts are well coordinated and consistent. Make sure that sub-groups have good technical balance, especially when the group is split for processing accidents. As standard problem statements and interventions are developed, they should be distributed to the other sub-groups, so that multiple versions are not generated. It may also be helpful to rotate some personnel between the various sub-groups.
4. Don't change the SPS numbering system in the middle of the analysis; attempt to have a numbering system in place at the start that will carry through until the process is complete.
5. Record accident missions, keywords, model, data, attributes, demographics, etc. on one common data sheet as accidents are reviewed. This was done piecemeal, which was somewhat confusing and more labor intensive than it had to be.
6. The group noted that a significant number of accidents occurred while flying outside the primary mission. For example, an EMS helicopter flying a maintenance check flight crashed, or a public use firefighting aircraft would crash while being repositioned to a different base. The JHSAT did not make comprehensive use of data on flight outside of the primary mission. Future JHSAT analyses should determine if more emphasis should be put on this issue.
7. Have full NTSB docket (accident investigation report data) packages ready before analysis begins.
8. Have more representation on the JHSAT from the General Services Administration and public service sector.
9. The Bell Microsoft Access database was useful for drawing mission analyses together.
10. Teams should try to develop interventions that are less reliant on training.
11. The JHSAT concluded that conduct of meetings via teleconference was not workable in its formative meetings and very inefficient for accident analysis and report preparation discussions. Given the cost of travel and limited resources of JHSAT member organizations, this matter should be considered further by future JHSATs.
12. SPSs not used in the 2000 dataset should be made available for future JHSAT use in the latest format.

13. Experts in the JHSAT were aware of issues important to the helicopter industry that were not apparent in the CY2000 data. The team decided to include reference to these issues here to provide possible focus areas for future JHSAT teams:

    - Recommend all Part 135 operators be required to have an SMS function and establish an employee (safety director or manager) specifically responsible for the function.
    - Consider requiring regulating non-military public use operations in the same manner as similar civil flight operations.
    - No type rating required for normal type helicopters.
    - Require transition training for pilots moving to other machines.
    - Require training for pilots prior to use of advanced avionics.
    - Recommend developing and implementing procedures for prevention of improper use of crash damaged parts.

Appendix G: NTSB Code Nomenclature



Investigation Codes (to indicate scope and type of investigation):

LA	aviation limited accident investigation
FA	aviation field accident (usually fatal)
CA	aviation data collection, very limited (used when causes are already known at notification)
IA	aviation incident
MA	aviation major accident investigation (usually a team investigation because of complexity or high public interest)
TA	aviation public use, limited investigation
GA	aviation public use, field investigation
WA	aviation foreign accident, no U.S. investigation, Accredited Representative traveled
RA	aviation foreign accident, U.S. investigation, Accredited Representative traveled
AA	aviation go-team major investigations (old code – no longer used)
DA	aviation accident investigation delegated to FAA
SA	aviation special investigation (not an accident)

Appendix H: Dataset – Calendar Year 2000 NTSB Docket Numbers

ANC00LA053
ANC00LA055
ANC00LA132
ANC00TA039
ANC01LA020
ATL00FA048
ATL00FA069
ATL00LA034
ATL00LA038
ATL00LA043
ATL00LA058
ATL00LA059
ATL00LA063
ATL00LA086
ATL00TA080
CHI00FA110
CHI00FA111
CHI00FA262
CHI00FA266
CHI00GA160
CHI00LA060
CHI00LA121
CHI00LA131
CHI00LA132
CHI00LA133
CHI00LA134
CHI00LA204
CHI00LA230
CHI00LA250
CHI00LA277
CHI00TA306
DEN00FA074
DEN00FA082
DEN00FA084
DEN00GA050
DEN00LA045
DEN00LA069
DEN00LA083
DEN00LA113
DEN00LA124
DEN00LA176
DEN00TA042
DEN00TA160
DEN01LA002
DEN01LA012
DEN01TA019
FTW00FA091
FTW00LA077
FTW00LA100
FTW00LA105
FTW00LA137
FTW00LA140
FTW00LA145
FTW00LA153
FTW00LA161
FTW00LA181
FTW00LA206
FTW00LA216
FTW00LA252
FTW00LA269
FTW00TA116
FTW00WA112
FTW01FA017
FTW01FA021
FTW01FA043
FTW01FAMS1
FTW01LA004
FTW01LA036
FTW01LA038
FTW01LA039
FTW01LA042
IAD00LA015
IAD00LA052
IAD00LA054
IAD00LA056
IAD00WA020
IAD01WA011
IAD01WA018
LAX00FA123
LAX00FA130
LAX00FA134
LAX00FA136
LAX00FA160
LAX00FA306
LAX00FA342
LAX00GA073
LAX00GA114
LAX00GA286
LAX00GA297
LAX00LA076
LAX00LA077
LAX00LA079
LAX00LA086
LAX00LA089
LAX00LA100
LAX00LA103
LAX00LA107
LAX00LA109
LAX00LA116
LAX00LA118
LAX00LA124
LAX00LA129
LAX00LA156
LAX00LA167
LAX00LA172
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LAX00LA195
LAX00LA216
LAX00LA220
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LAX00LA239
LAX00LA245
LAX00LA262
LAX00LA276
LAX00LA279
LAX00LA280
LAX00LA288
LAX00LA326
LAX00LA328
LAX00LA343
LAX00MA273
LAX00TA163
LAX00TA186
LAX00TA318
LAX00TA355
LAX01FA006
LAX01LA002
LAX01LA009
LAX01LA013
LAX01LA016
LAX01LA025
LAX01LA039
LAX01LA042
LAX01LA053
LAX01LA058
LAX01LA061
LAX01LA063
MIA00FA060
MIA00FA102
MIA00GA121
MIA00GA184
MIA00GA264
MIA00LA007
MIA00LA095
MIA00LA097
MIA00LA098
MIA00LA111
MIA00LA134
MIA00LA135
MIA00LA145
MIA00LA170
MIA00LA176
MIA00LA222
MIA00LA227
MIA00LA257
MIA00TA070
MIA00TA189
MIA00TA200
MIA00WA101
MIA00WA142
MIA01FA004
MIA01FA006
MIA01LA039
MIA01LA049
NYC00FA127
NYC00FA136
NYC00LA105
NYC00LA152
NYC00LA174
NYC00LA191
NYC00LA263
NYC01FA053
NYC01LA035
NYC01LA043
NYC01LA059
SEA00FA038
SEA00FA061
SEA00LA092
SEA00LA097
SEA00LA101
SEA00LA103
SEA00LA117
SEA00LA121
SEA00LA124
SEA00LA129
SEA00LA170
SEA00LA188
SEA00LA189
SEA00LA193
SEA00LA197
SEA00TA182
SEA00WA135
SEA01FA032
SEA01LA003
SEA01LA024
SEA01LA029

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