



U.S. Joint Helicopter Safety Analysis Team

**The Compendium Report:
The U.S. JHSAT Baseline of Helicopter Accident Analysis**

Volume I

(CY2000, CY2001, CY2006)

**To
The International Helicopter Safety Team**

August 2011

Summary

The U.S.-JHSAT analyzed 523 U.S. registered helicopter accidents that occurred in CY2000, CY2001 and CY2006. This report establishes a baseline for future work by the U.S. Joint Helicopter Implementation Measurement Data Analysis Team (JHIMDAT). This report contains the combined JHSAT analysis of ALL accidents and introduces recommendations which may have prevented these particular accidents and if implemented potentially avoid similar accidents in the future.

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List of Acronyms

ADM	Aeronautical Decision Making
ADRM	Aerodrome
AHS	American Helicopter Society
AMAN	Abrupt Maneuver
BLM/MMS	Bureau of Land Management/Minerals Management Service
CAST	Commercial Aviation Safety Team
CICTT	CAST ICAO Common Taxonomy Terms
CFI	Certified Flight Instructor
CFIT	Controlled Flight into Terrain
CFR	Code of Federal Regulations
EHEST	European Helicopter Safety Team
EMS	Engine-Monitoring Systems
EP	Emergency Procedures
EXTL	External Load
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FDM	Flight Data Monitoring
FOQA	Flight Operational Quality Assurance
FTD	Flight Training Devices
GSE	Ground Support Equipment
HOMP	Helicopter Operations Monitoring Program
HAI	Helicopter Association International
HEMS	Helicopter Emergency Medical Service
HUMS	Health and Usage Monitoring Systems
ICA	Instructions for Continued Airworthiness
ICAO	International Civil Aviation Organization
IGE	In Ground Effect
IHSS	International Helicopter Safety Symposium
IHST	International Helicopter Safety Team
IMC	Instrument Metrological Conditions
IMSAFE	Illness, Medication, Stress, Alcohol, Fatigue, Eating
IP	Instructor Pilot
IR	Intervention Recommendation
JHIMDAT	Joint Helicopter Implementation Measurement Data Analysis Team
JHSAT	Joint Helicopter Safety Analysis Team
JHSIT	Joint Helicopter Safety Implementation Team
LOC	Loss of Control
LTE	Loss of Tail Rotor Effectiveness
LZ	Landing Zone
NTSB	National Transportation Safety Board
OEMs	Original Equipment Manufacturers
OGE	Out of Ground Effect
ORM	Operational Risk Management
PIC	Pilot in Command
PJ&A	Pilot Judgment and Actions
RTB	Return to Base
SCF	System Component Failure
SMS	Safety Management System
SOP	Standard Operating Procedures
SP	Student Pilot
SPS	Standard Problem Statement
SUPs	Suspected Unapproved Parts
VFR	Visual Flight Rules
VMC	Visual Metrological Conditions

U.S. JHSAT/JHIMDAT Members

Name	Company/Organization	Position
Jack Drake	Helicopter Association International	JHSAT Co-Chair (Industry)
Jim Grigg	FAA Rotorcraft Standards Staff	JHSAT Co-Chair (Gov)
Steve Gleason	Schweizer Aircraft	JHIMDAT Co-Chair (Industry)
Scott Tyrrell	FAA Rotorcraft Standards Staff	JHIMDAT Co-Chair (Gov)
Bill Wallace	Bill Wallace & Associates	Member
Curtis Dekeyrel	Bell Helicopter Textron	Member
Lee Roskop	FAA Rotorcraft Standards Staff	Member
Mark Colborn	Dallas Police Department	Member
Munro Dearing	NASA	Member
Roy Fox	Bell Helicopter Textron – Retired	Member
Tom Caramancio	Boeing Military Aircraft	Member
Vernon Albert	Albert & Associates	Member
Eric Barnett	FAA Rotorcraft Standards Staff	Member

Table 1. U.S. JHSAT/JHIMDAT Members

EXECUTIVE SUMMARY

Recognizing that the U.S and international helicopter accident rates were too high and as a result of the industry mandate expressed in 2005 at the International Helicopter Safety Symposium in Montreal, the International Helicopter Safety Team (IHST) was formed by helicopter operators, helicopter and engine manufacturers and Government Aviation regulators, (U.S. Federal Aviation Administration (FAA)). The IHST is committed to an ambitious program with the goal to reduce the worldwide helicopter accident rate by 80% in 10 years (by 2016). The IHST established several teams to carry out the work: U.S. Joint Helicopter Safety Analysis Team (U.S. JHSAT) and the U.S. Joint Helicopter Safety Implementation Team (U.S. JHSIT). The U.S. Joint Helicopter Safety Analysis Team (U.S. JHSAT) was tasked with analyzing National Transportation Safety Board (NTSB) accident reports and based on the expert analysis providing recommendations leading to prevention. The U.S. JHSAT analyzed 523 accidents and completed extensive reports on each of the respective years, 2000, 2001 and 2006 while making hundreds of recommendations aimed at the reduction of the helicopter accident rate. The U.S. JHSAT used the same methodology of analysis for the 3 Calendar Year reports and determined the need to have the ability to look at the accident data as a single set versus independent years. By combining the previous reports into a single dataset it becomes increasingly more statistically relevant. This Compendium Report provides a discussion of the original analysis of the three years combined into a single report and most importantly establishes a baseline for the U.S. helicopter accidents analyzed by the U.S. JHSAT. The U.S. JHSIT was tasked with prioritizing those recommendations from the U.S. JHSAT and developing implementation strategies to reduce the accident rate.

Helicopter accident trends have remained relatively constant over the years and the U.S. JHSAT work reinforces that observation. Injury data from the three-year rollup of helicopter accidents show that 16% of the accidents produced a fatal injury of at least one or more of the occupants and 54% resulted in no injuries. This study analyzed these accidents in four separate categories; Missions, Occurrences, Activities and Flight Phases. The Personal/Private "Mission" category produced the highest number of accidents, 98, with 19 being fatal accidents. The classification of "Activity" was developed to further clarify what the helicopter was doing at the time of the accident. Instructional Training (Dual) Activity had the highest accident count with 72 (14%) and Positioning/Return to Base second at 69 accidents (13%). The Accident Occurrences grouping provides an idea of what actually happened leading to the crash. Loss of Control (LOC) was identified in 41% of the accidents. Due to the increased count in the category of Phase of Flight, further identification was required and sub-categories were developed. The sub-category of Landing accumulated the most accidents, 108 with four fatal and Enroute accounted for the most fatal accidents, 34 out of 102.

The majority of the accident helicopters (70%) were operated under FAR Part 91: (General Operating and Flight Rules).

The majority of accidents occurred during Day VMC conditions (87%).

Of the accident pilots, 246 reported over 2,000 Total Hours, however the reported hours for Make/Model for the Pilot in Command (PIC) was less than 500 hours in 237 of the accidents.

The findings for the three years of combined data, reflects that the majority of accidents (84%) had a Standard Problem Statement of "Pilot Judgment and Actions" with "Safety Management" second at 43%. The significant Intervention Recommendations (IRs) as a result of this Compendium report were directed towards an increase in pilot training (79%) and incorporation of Safety Management concepts (64%).

The conclusions of this report indicate there was a greater need for Aeronautical Decision Making (ADM) training and use of Risk Analysis tools by pilots. The incorporation of a scalable Safety Management program in every company is also very important to an effective safety program.

A milestone was achieved when the U.S. JHSAT successfully completed the initial analysis phase. As this team stands down, its members will provide the core participants for the U.S. Joint Helicopter Implementation Measurement and Data Analysis Team (JHIMDAT) designed to measure the effectiveness of the mitigations implemented by the U.S. JHSAT. The U.S. JHIMDAT will provide analysis and metrics detailing the progress towards meeting the goal of an 80% reduction in U.S. helicopter accidents.

IHST OVERVIEW

The INTERNATIONAL HELICOPTER SAFETY TEAM (IHST) was formed in late 2005 in response to a consensus of government regulators, manufacturers, and helicopter operators at the International Helicopter Safety Symposium (IHSS) in Montreal, Canada that the rate of worldwide helicopter accidents was unacceptably high and must be reduced. The model for IHST was the COMMERCIAL AVIATION SAFETY TEAM (CAST) that was successful in motivating a reduction of the large air carrier (United States Code 14 CFR Part 121) fatal accident rate by 80% in 10 years. The IHST accepted this accident-reduction mandate and formed industry and government teams to conduct a similar effort to reduce the worldwide helicopter accident rate by 80% in 10 years (by 2016). The process adopted was data-based and focused on identifying and removing links in the accident causal chain, rather than focusing on "probable cause" determinations.

Key representatives from the Helicopter Association International (HAI), the American Helicopter Society (AHS) International, the Federal Aviation Administration (FAA), and leading U.S. helicopter manufacturers engaged in collaboration to solidify the core International Helicopter Safety Team (IHST). These teams were staffed by government and industry experts and stakeholders, and targeted team members with substantial work experience in the following disciplines: Engineers, pilots, aircraft accident investigators,

trainers, type certification and power plant experts, and persons experienced in helicopter safety research. The IHST formed the Joint Helicopter Safety Analysis Team (JHSAT) to analyze helicopter accident reports and produce recommendations, and the Joint Helicopter Safety Implementation Team (JHSIT) to implement cost-effective strategies and action plans to reduce accidents. The U.S. JHSAT initiated its effort by adapting the CAST process of using government/industry groups to analyze helicopter accident reports. A detailed explanation of the JHSAT methodology may be found in Appendix A of the U.S. JHSAT Compendium Report Vol. II. This section of the Compendium Report is available at <http://ihst.org/>.

Accident Trends

The reasons for forming the IHST and its 80% accident rate reduction goal in 10 years were twofold: roughly the same number of accidents continued to occur every year and an adverse public opinion existed of helicopter safety. The number of civil helicopter accidents during the 15 years (1991 through 2005) prior to the formation of IHST remained consistent in the U.S. and worldwide as depicted in Figure 1.

Counting accidents each year does not account for the amount of exposure (e.g. hours flown) so the true metric for the IHST effort was determined to be the accident rate expressed as accidents/100,000 flight hours. Thus the annual accident rate can be compared to the accident rate for the 5-year period prior to IHST and used to measure progress toward the final IHST goal. The initial U.S. helicopter accident rate for the 5 years prior (2001 through 2005) was 9.1 accidents per 100,000 flight hours. Thus the IHST Goal for 2016 was established as 1.8 per 100,000 flight hours. The annual accident rates for U.S. registered civil helicopter for CY2000, CY2001, and CY2006 were 9.1, 8.0, and 5.7 accidents/100,000 flight hours, respectively. Figure 2 shows the U.S. registered helicopter progress towards the IHST goal of an 80% reduction in the helicopter accident rate by 2016.

Figure 3 shows a 29 year history of U.S. registered helicopter accidents from CY1982 to CY2010; including fatal accidents.

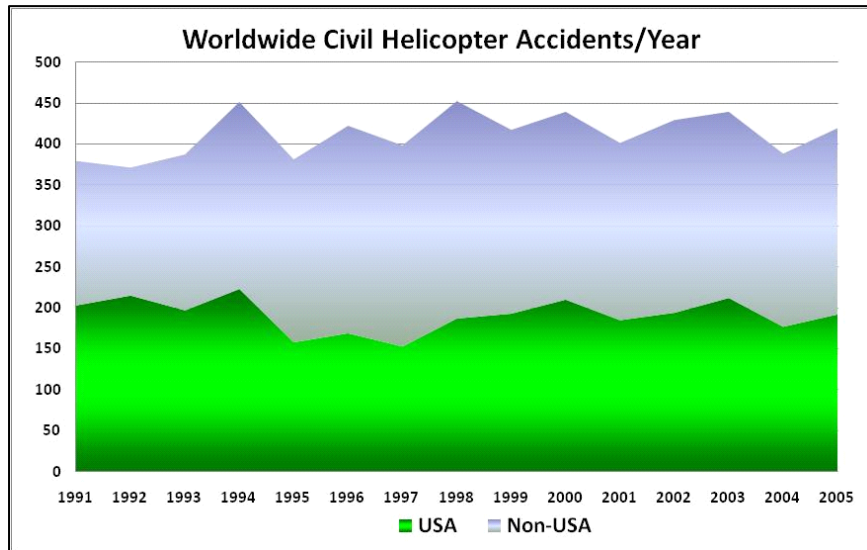


Figure 1. Worldwide Civil Helicopter Accidents/Year

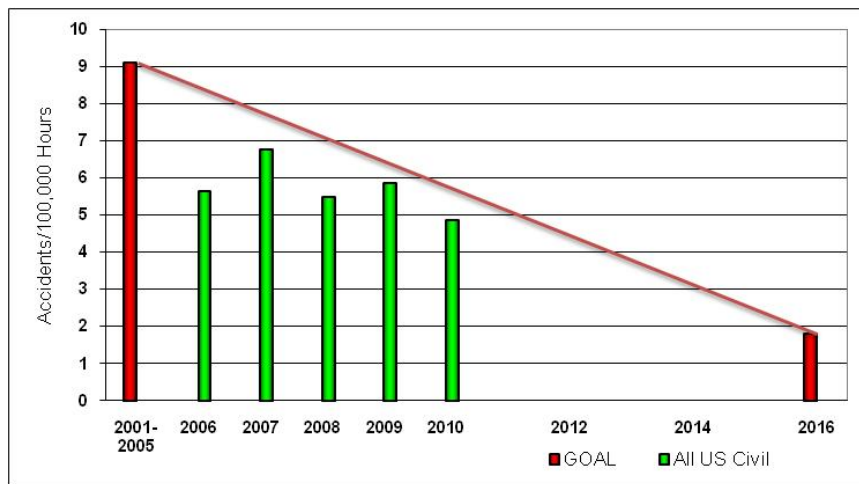


Figure 2. U.S. IHST Accident Rate Reduction Goal and Progress

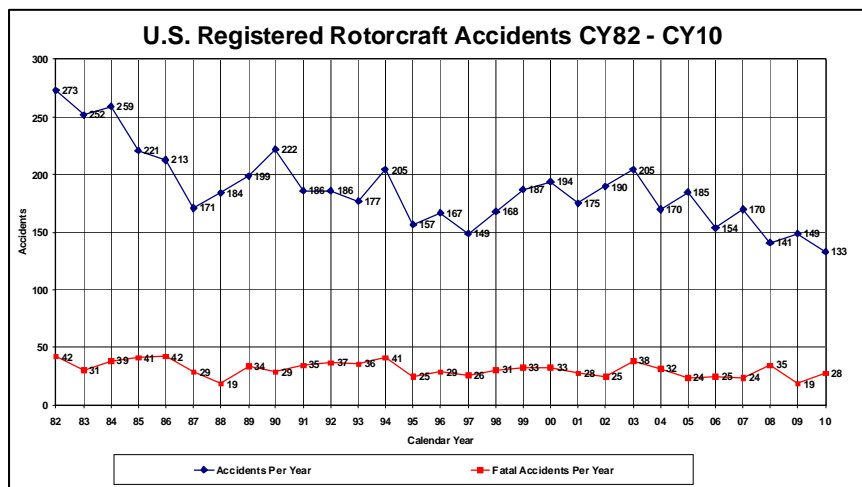


Figure 3. U.S. Registered Rotorcraft Accidents CY82 – CY10

Note: Source FAA Rotorcraft Directorate, Safety Management Group – ALL accidents

DEMOGRAPHICS

HELICOPTER FLEET/ACCIDENT DEMOGRAPHICS

Figure 4 shows that the majority of the helicopter accidents analyzed did not result in a fatal injury.

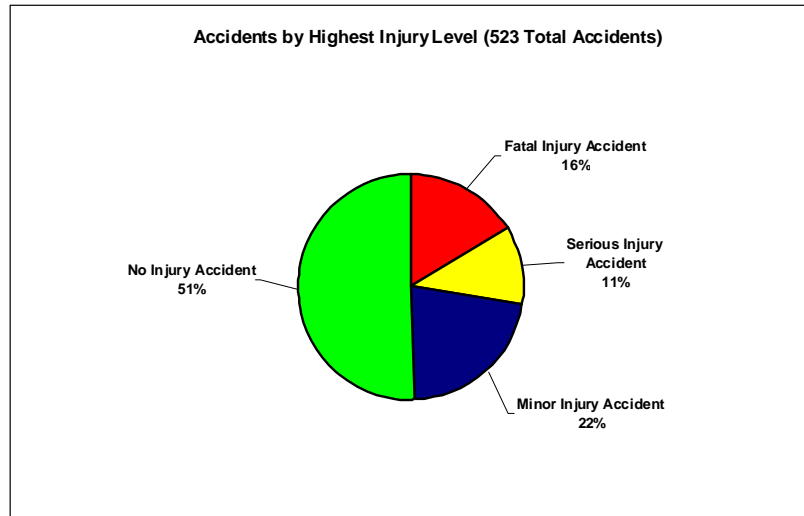


Figure 4. Accidents by Highest Injury Level (523 Total Accidents)

For the accidents analyzed, the majority of occupants survived, while 13% experienced a fatal injury as depicted in Figure 5.

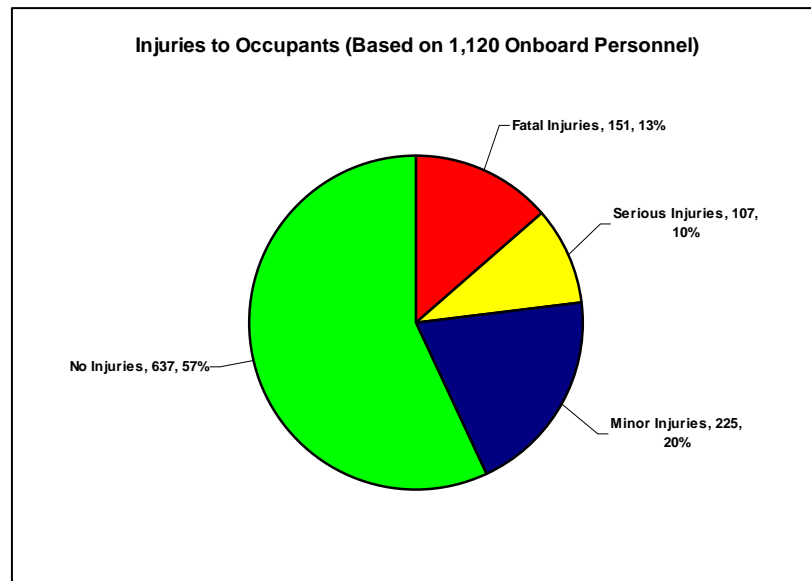


Figure 5. Injuries to Occupants (Based on 1,120 Onboard Personnel)

Helicopter Operation

Over the three years of analysis the accidents have been grouped by mission (CY2000) or by operation (CY2001, CY2006). Because of the differences in categorization of the operations by NTSB and the missions/operations identified by JHSAT between years, a single categorization was needed to analyze the dataset. Each accident was reviewed and placed in a consistent grouping. This new grouping was referred to as Industry Segment and has changed the “labeling” of a small percentage of the accidents, but allowed a consistent comparison across the years.

The versatility of helicopters is reflected in the variety of Industry Segments in which they operate; from personal and commercial flying to emergency medical transport, logging, and law enforcement. Figure 6 shows that the highest number of helicopter accidents occurred during Personal/Private flight (18.5%), Instructional/Training (17.9%) and Aerial Application (10.9%). The number of aircraft flying in each of these different Industry Segments varies widely. It should be noted flight hour exposure rates are not available for each of these Industry Segments due to insufficient data available. Since exposure rates were unknown for this analysis, comparison of these statistics alone should not be used to rank the relative safety record between different segments. If Industry segment flight hour models were available in the future, analyses may allow for those comparisons to be made.

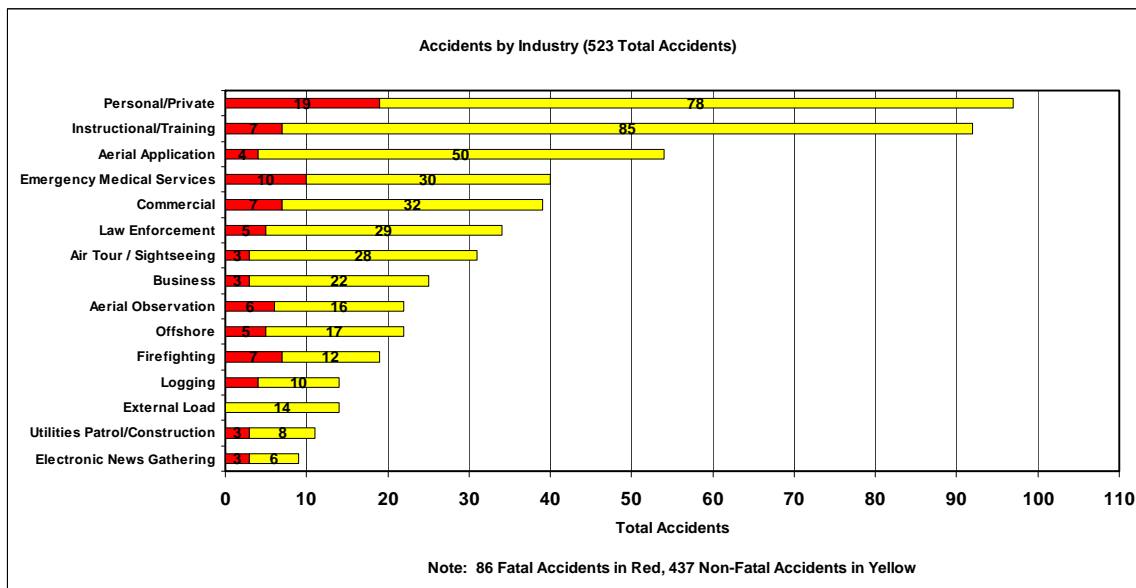


Figure 6. Accidents by Industry (523 Total Accidents)
 Note: 86 Fatal Accidents in Red, 437 Non-Fatal Accidents in Yellow

Accidents by Activity

During the analysis, the team also grouped the data by “Activity”. This additional category describes what specific activity the helicopter was completing on the specific flight

that ended in the accident shown, in Figure 7. These activities are independent of Industry Segment. Dual Instruction/Training accounted for 13.8% of all accidents. Dual Instruction/Training was assigned as an Activity whether the aircraft belonged to a training operation or was being used to give check rides for law enforcement or emergency medical industry related aircraft. The second highest Activity by number of accidents was Positioning/RTB (Return to Base) at 13.2%, and is unique in that it crosses all Industry Segments. Both Positioning/RTB and the third highest Activity of Personal/Private are predominately flown under FAR Part 91.

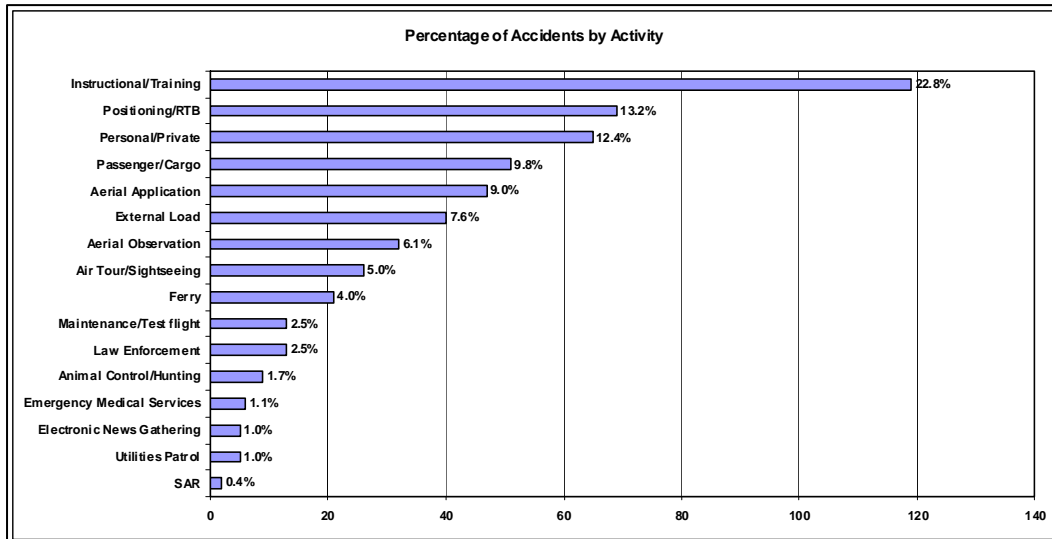


Figure 7. Percentage of Accidents by Activity

Accidents by Occurrence

Each accident cause can be further divided into categories that define “what happened”. Occurrences cross the boundaries between Industry Segments or reported Activity. The Occurrence categories most frequently observed were: Loss of Control (41%), Autorotations both Practice and Emergency (32%), and System Component Failure (SCF) (28%). Accidents by Occurrence are charted in Figure 8.

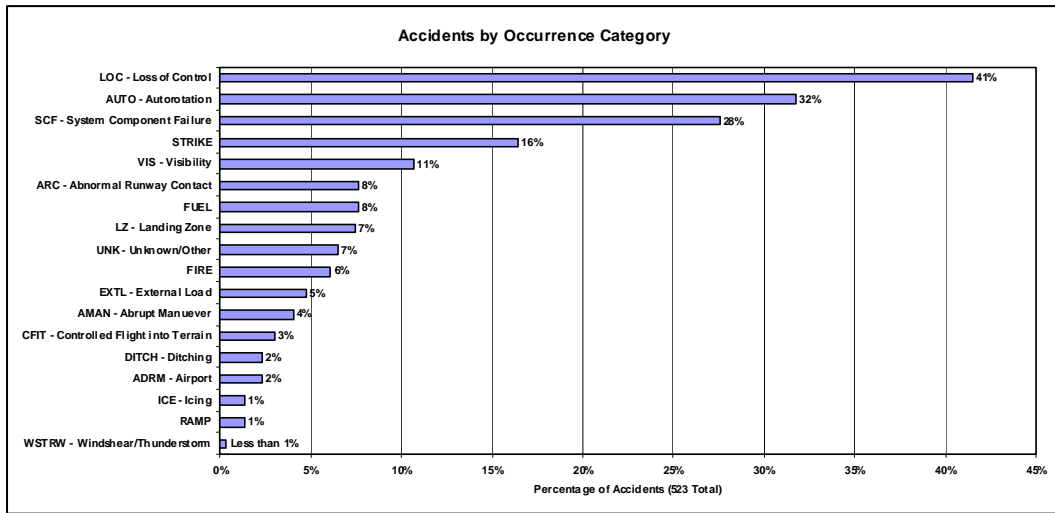


Figure 8. Accidents by Occurrence Category

As Loss of Control (LOC) accounted for 41% of total accidents it demands additional comments. The LOC type is charted in Figure 9. LOC occurrences are defined as the pilot losing control of the aircraft for any of the following reasons:

- Performance Management - pilot maintaining insufficient power or rotor RPM for conditions.
- Dynamic Rollover – the tendency of the helicopter to continue rolling when the critical angle is exceeded, if one gear is on the ground, and the helicopter is pivoting around that point.
- Exceeding Operating Limits - helicopter is operated near the established limitations of the model/type.
- Emergency Procedures - improperly responding to an onboard emergency.
- Interference with Controls - interference by pilots, passengers, loose baggage, or factors related to maintenance.
- Ground Resonance
- Loss of Tail Rotor Effectiveness (LTE) or Unanticipated Yaw is an occurrence of an uncommanded yaw, which, if not corrected, can result in loss of control
- Tie-downs/Hoses
- Settling with Power

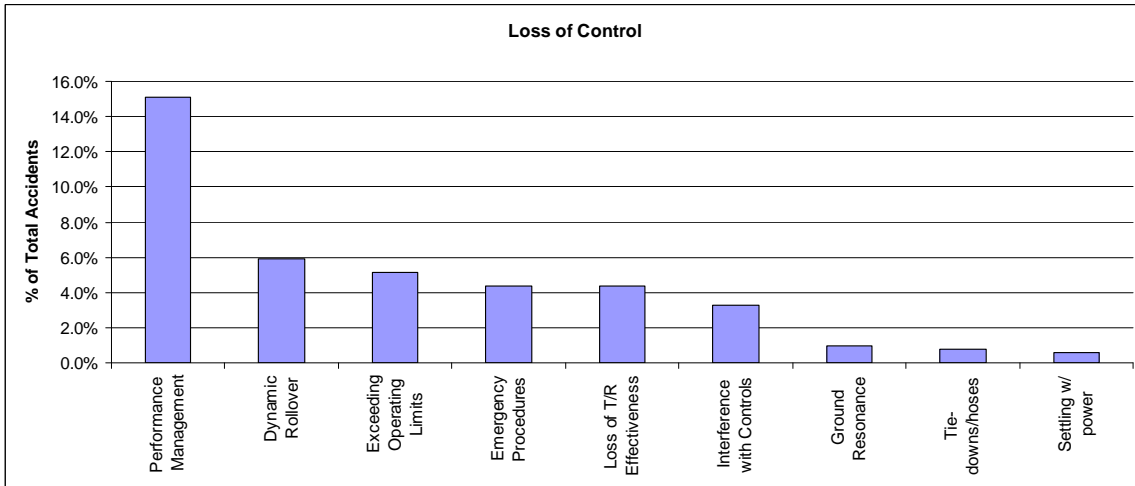


Figure 9. Loss of Control - Occurrence Category

Note: Categories are a percentage of the total of 523 accidents

Accidents by Phase of Flight

Phase of Flight was determined as the flight profile the aircraft was in when the accident sequence was initiated. Hover includes In Ground Effect (IGE) and Out of Ground Effect (OGE) operations. For identification purposes Maneuvering was considered a Phase of Flight which was NOT classified as Landing, Enroute, Hover, Take-off, Approach, Standing and Taxi. In general, Maneuvering is considered to be a change of direction whether in low speed or high speed flight. Figure 10 identifies Enroute as the Phase of Flight where the majority of fatal accidents occurred. These fatalities can be attributed to potentially higher velocity speeds at impact.

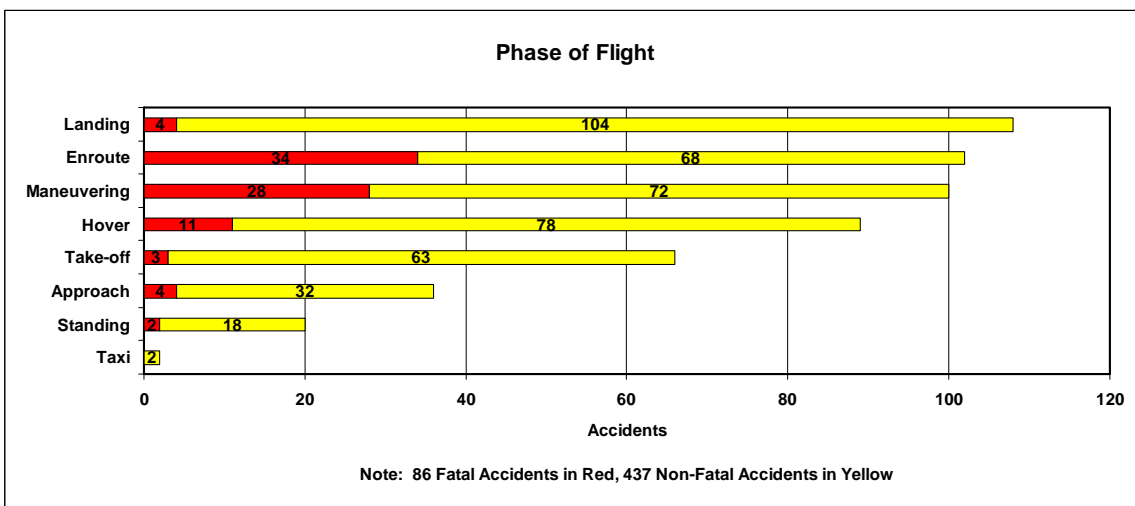


Figure 10. Phase of Flight (523 Accidents)

Note: 86 Fatal Accidents in Red, 437 Non-Fatal Accidents in Yellow

Type of Helicopter

For purposes of analysis, three types of helicopters have been defined: Single-Engine – reciprocating (SE recip), Single-Engine – turbine (SE turbine), and Multi-Engine (ME). The data indicated that in general the split between types remained consistent over the 3 years analyzed. Multi-Engine was 8 to 10% of all accidents, Single-Engine turbine was 45 to 51%, and Single-Engine reciprocating (piston) varied from 39 to 45% of total accidents per year.

Flight Rules

Helicopters operate under various Federal Aviation Regulations (FARs) – **Part 91**: General Operating & Flight Rules, **Part 133**: Rotorcraft External Load Operations, **Part 135**: Commuter & On Demand Operations, **Part 136**: Air Tour and **Part 137**: Agricultural Operations. In addition, portions of the U.S. helicopter fleet operate under Public Aircraft Operations rules, commonly referred to as Public Use. The majority of accidents and the highest number of fatalities occurred during flight under Part 91 (70%) as found in Figure 11.

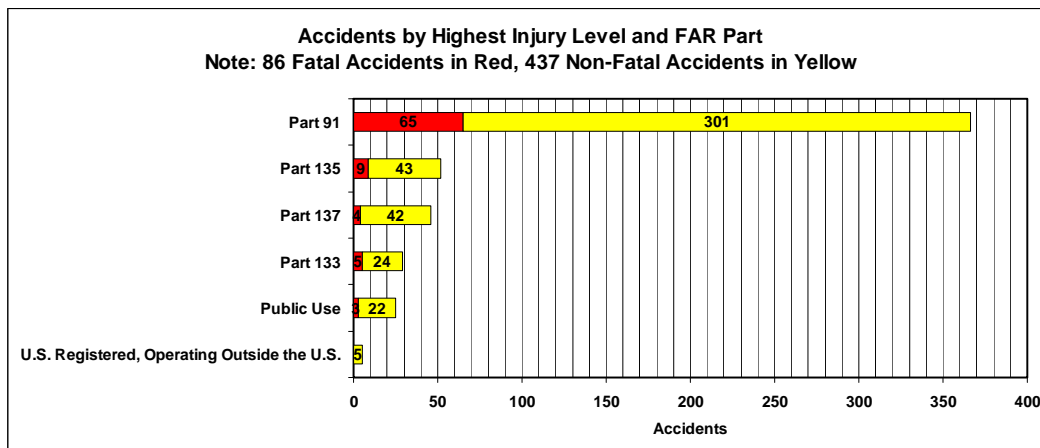


Figure 11. Accidents by Highest Injury Level and FAR Part

Note: 86 Fatal Accidents in Red, 437 Non-Fatal Accidents in Yellow

Flight Conditions

Most helicopter accidents occurred during daylight hours under visual meteorological conditions. This is not surprising since most helicopter operations are performed in these conditions. Accidents during instrument meteorological conditions accounted for about 6% of all 523 accidents. Night operations accidents accounted for 11%.

PILOT-RELATED ACCIDENT FACTORS

The following charts were derived from those accidents that had pilot flight hours reported. Pilot flight hours were not available for every accident.

Rotorcraft Flight Hours

The overall helicopter flight hours logged by accident pilots are shown in Figure 12. The scales of both charts in this section indicate both pilot flight time in ALL accidents and Fatal accidents. Please use extreme caution in making conclusions solely on the data presented in this figure. Since there was not any flight hour data available for the pilots who were not involved in accidents, conclusions based on the data presented regarding accidents pilots would be one-sided.

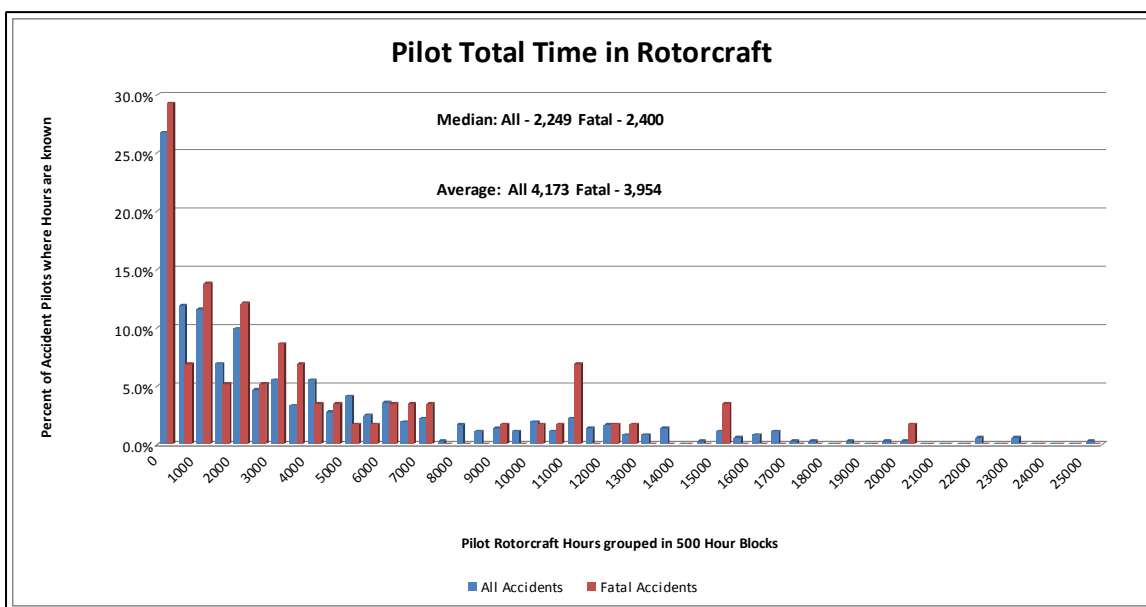


Figure 12. Pilot Total Time in Rotorcraft

Flight Hours in Make/Model

Figure 13 is a summary of Make/Model time. Pilots with 101 to 500 hours in Make/Model accounted for 28.9% of the total and 31.4% of the 86 fatal accidents. Additional charts on Pilot Flight Times are available in the Compendium Report Volume II.

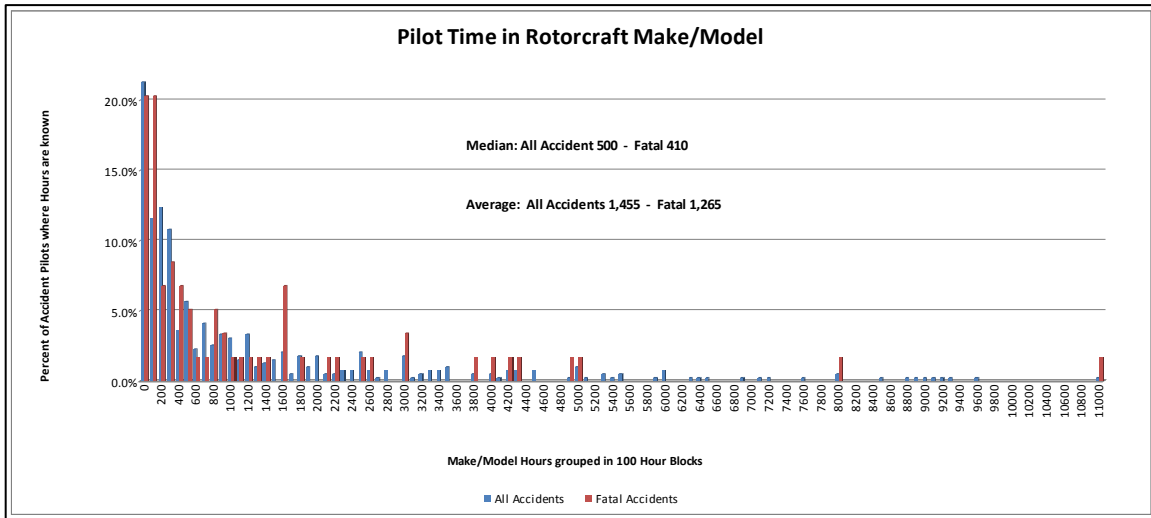


Figure 13. Pilot Time in Rotorcraft Make/Model

U.S. JHSAT ANALYSIS FINDINGS

The accident analysis revealed that the majority of accidents included a Standard Problem Statement (SPS) of Pilot Judgment & Actions (PJ&A). The initiating event in the accident sequence was the absence of adequate preparation or planning by the pilot. Other times, the initiating event was the pilot's incorrect judgment in reaction to the situation or to a problem encountered during the flight. Improving pilot judgment and the ability to safely handle problems may be the most effective way to improve helicopter safety. The individual pilot has the greatest opportunity to change the outcome of a sequence of events; therefore, most interventions must affect pilot performance in a positive way. Specific problems with pilot situational awareness are often connected in accidents to Pilot's Judgment & Action. Inadequate pilot judgment and the subsequent poor decision(s) or non-decision were found to be pervasive in most non-material failure types of accidents and must be addressed.

The SPS category of Safety Management Systems (SMS) continues to highlight the need to address organizational and safety culture issues. Improvement in this area will not only reduce the risk of accidents but also provide for continuous operational safety improvement. SMS can provide the structure that enables other specific interventions to succeed. Safety Management was cited as an Intervention Recommendations (IR) in 64% of the 523 accidents.

System Component Failures (SCF) was cited in 28% of the accidents. Within this 28%, there were 20% of SCF accidents that were maintenance related, most often attributable to the failure of maintenance facilities to comply with Instructions for Continued Airworthiness (ICA) or lack of quality oversight of maintenance practices.

Autorotations were a frequent occurrence in the accident analyzed. Autorotations were regularly involved because they became necessary during the execution of an Emergency Procedure (EP). Whether due to an actual emergency or during the training for such an event, they often resulted in an accident in which the pilot failed to perform the maneuver correctly. Lack of experience was involved in 9% of these accidents. Primarily these accidents were due to the pilots' lack of experience in Make/Model or the Instructor Pilot (IP) failure to intervene in time to prevent the accident.

Analyses revealed that deficient preflight preparation and inspections missed impending failures. In some situations, impending failure may have been detected during a thorough helicopter preflight inspection. Increased emphasis on conducting a thorough helicopter preflight and any mission specific equipment can have a significant impact on reducing System Component Failure accidents (SCF). SOPs for preflight inspections would reduce the risk of an oversight or omission that might result in an accident. Likewise, improved Safety Management can be accomplished through better SOPs, Operational Risk Management (ORM), improved supervisory and operational oversight, and training. Accident data shows that operations at low altitude and near hazardous objects require both greater assessment of risk during planning and periodic reassessment during the flight.

The inability of pilots to detect wires was a noted problem as was the decision to operate, unnecessarily sometimes, in a low altitude environment. Lack of situational awareness of surrounding objects led to improper clearance and the subsequent failure to avoid tree or obstacle strikes. Other than strikes during a forced landing, this occurrence category can be mitigated by improved Risk Assessment, Aeronautical Decision Making (ADM), establishment and oversight of company SOPs, and specific mission training.

When a pilot entered inadvertent IMC, it was frequently due to the pilot's decision to continue Visual Flight Rules (VFR) when indications of deteriorating weather were present. When an accident occurred after continued flight in marginal or deteriorating weather conditions, it was typically because of a collision with an unobserved object or obstruction, or Controlled Flight into Terrain (CFIT). These and other accidents may be prevented by improved preflight preparation or mission training, with special emphasis on techniques for maintaining cues critical to safe flight, and techniques for maintaining visual contact and alertness. Also essential to accident reduction methodologies are specific inadvertent IMC recognition/response training. Improved Go-No-Go decision making training and weather risk management tools or policies are needed. Training must continually reinforce the potentially catastrophic results of continuing VFR flight into adverse weather conditions.

With regard to Survivability, the analysis revealed that each accident environment was unique with regard to the impact load direction, magnitude of impact loads, aircraft attitude, crash environment (water, trees, desert, etc.), object penetrations of the

cockpit/cabin, occupant shoulder harness available and/or used, post-crash fire protection systems, water egress, and each occupant’s tolerance to impact load. Overall, 86.4% of the occupants survived the accidents. Enroute and Maneuvering generated the highest fatality ratio; potentially attributed to the higher velocities encountered in these phases of flight. High impact speeds can cause massive structural destruction and could increase the possibility of compromising the fuel system leading to a post crash fire. Only 9.0% of the accidents involved a post crash fire; however these accidents accounted for 48.0% of all fatalities.

Standard Problem Statements (SPS)

As depicted in Figure 14, the SPS indicated most helicopter accidents in the data set were the result of pilot-related factors: Pilot Judgment & Actions, Ground Duties and Pilot Situational Awareness.

Safety Management issues were identified in 43% of the accidents. System Component Failure problems were identified in 28% and Maintenance deficiencies were cited in 20% of accidents analyzed.

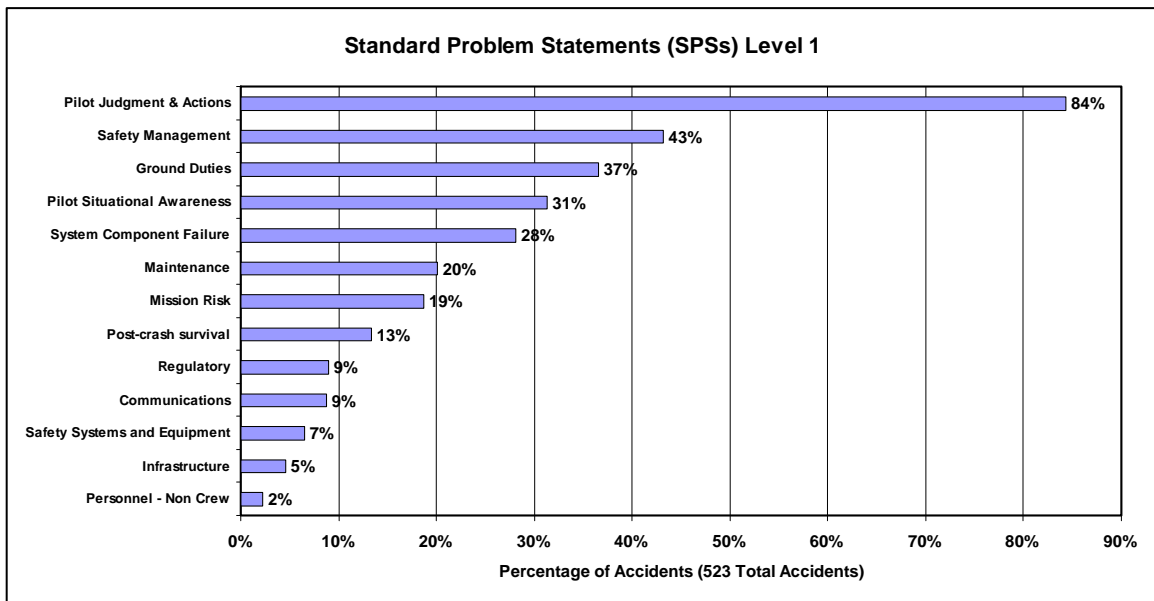


Figure 14. Standard Problem Statements (SPSs) Level 1

An examination of the Standard Problem Statements in greater detail at the Level 2 SPS, can be found in Figures 15 - 18.

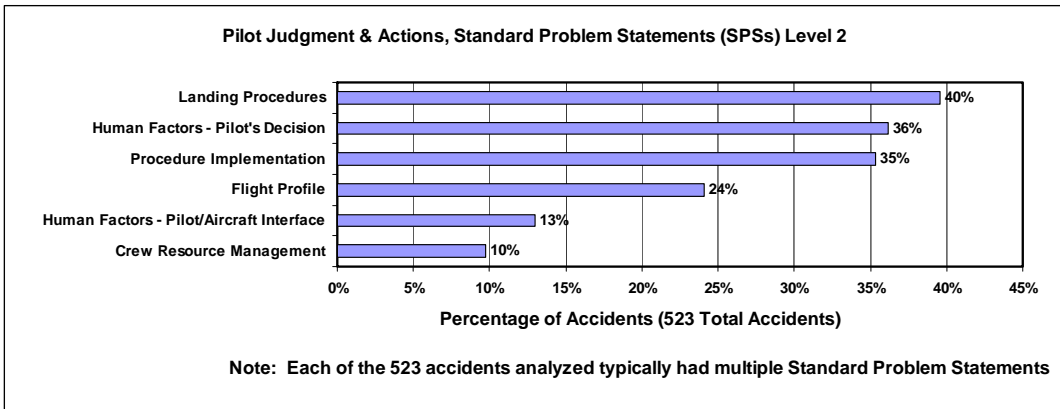


Figure 15. Pilot Judgment & Actions, Standard Problem Statements (SPSs) Level 2

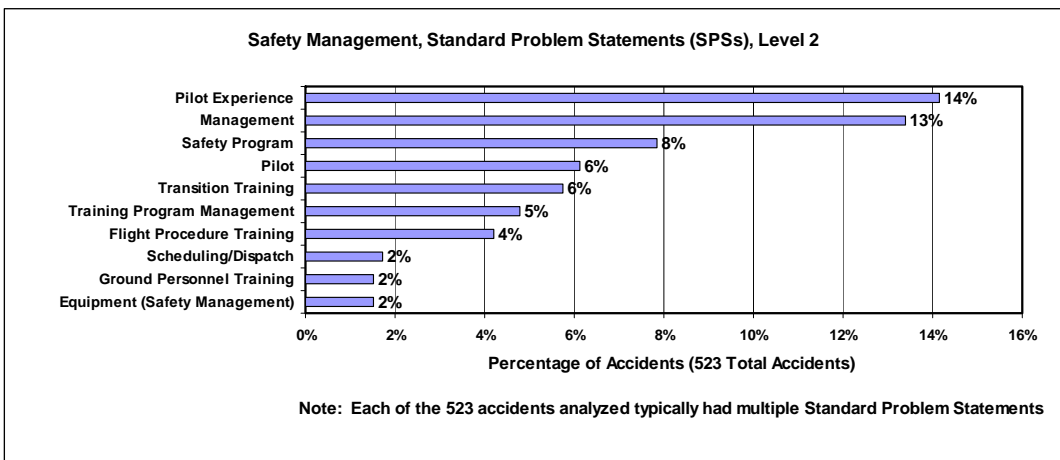


Figure 16. Safety Management, Standard Problem Statements (SPSs) Level 2

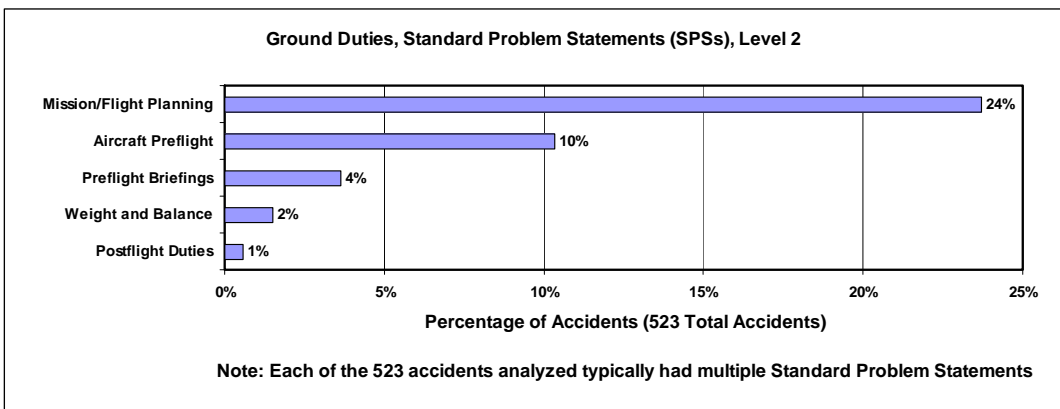


Figure 17. Ground Duties, Standard Problem Statements (SPSs) Level 2

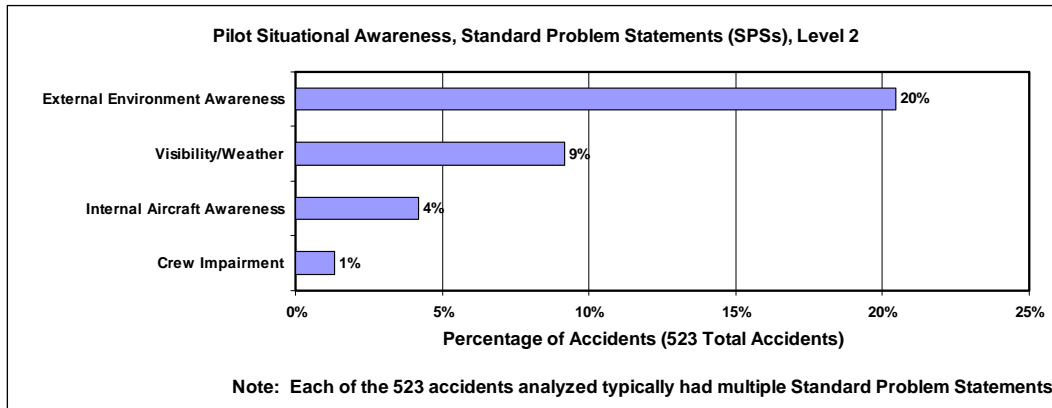


Figure 18. Pilot Situational Awareness, Standard Problem Statements (SPSs) Level 2

Intervention Recommendations (IR)

Recommendations to prevent accidents are predominantly related to the Training/Instruction and Safety Management interventions. The number of accidents in which an Intervention Recommendation (IR) was used as a percentage of all 523 accidents is shown in Figure 19.

Data/Information recommendations include some sort of data recording that can be reviewed for events, used in training, Flight Operational Quality Assurance (FOQA) and for accident investigations.

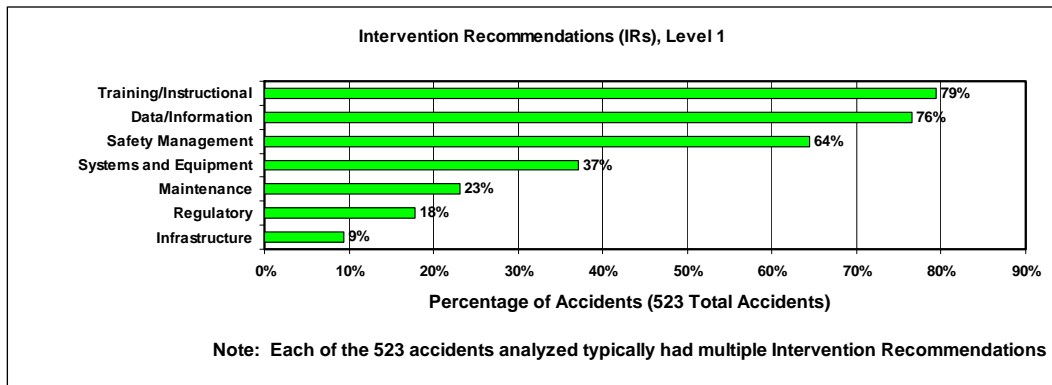


Figure 19. Intervention Recommendations (IRs) Level 1

Examination of Intervention Recommendations at the Level 2 IR, details more specific Recommendations for each Level 1 group as shown in Figures 20 – 25.

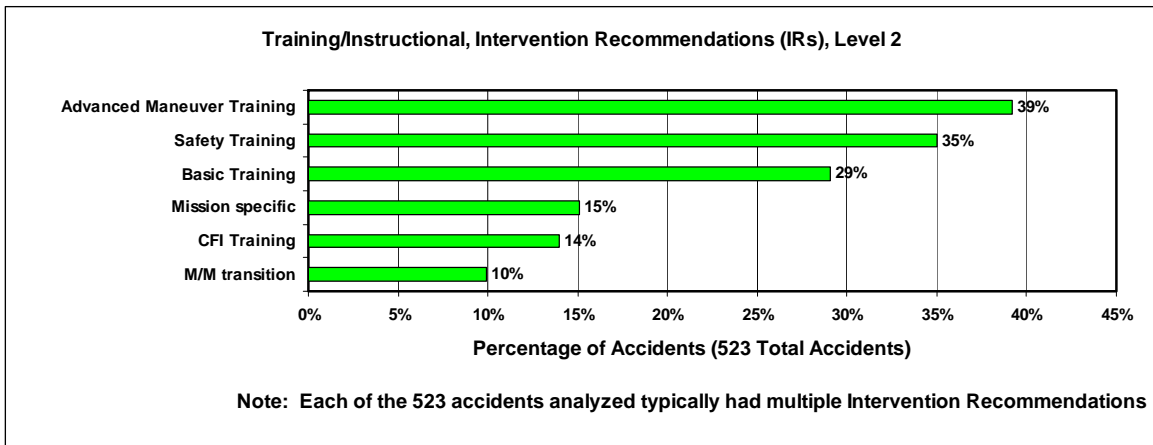


Figure 20. Training/Instructional, Intervention Recommendations (IRs) Level 2

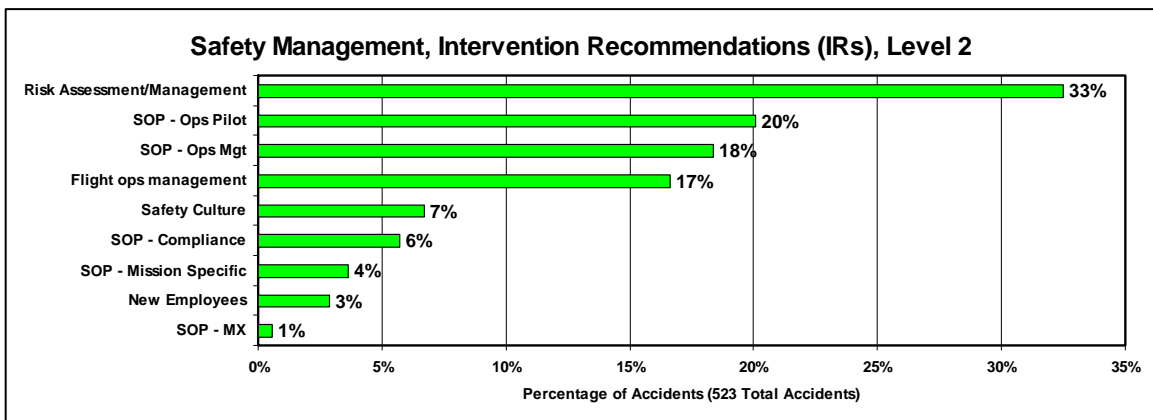


Figure 21. Safety Management, Intervention Recommendations (IRs) Level 2

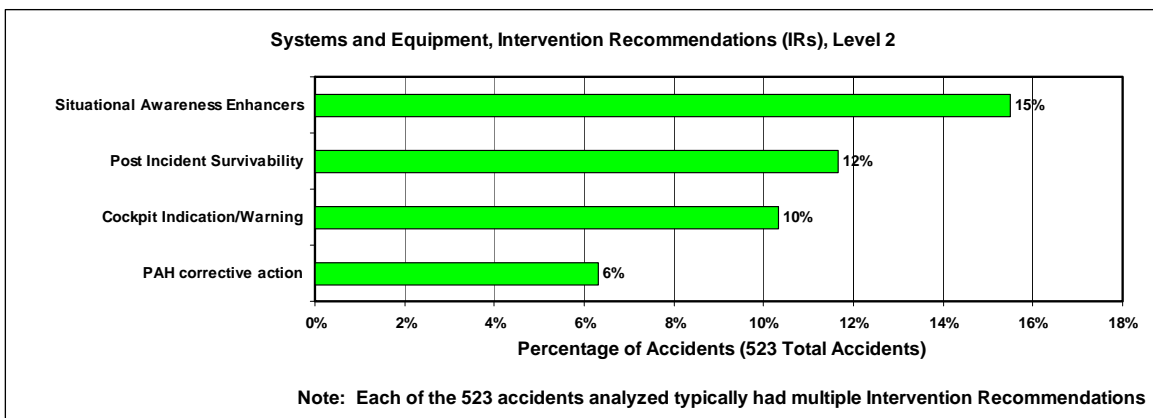


Figure 22. System and Equipment, Intervention Recommendations (IRs) Level 2

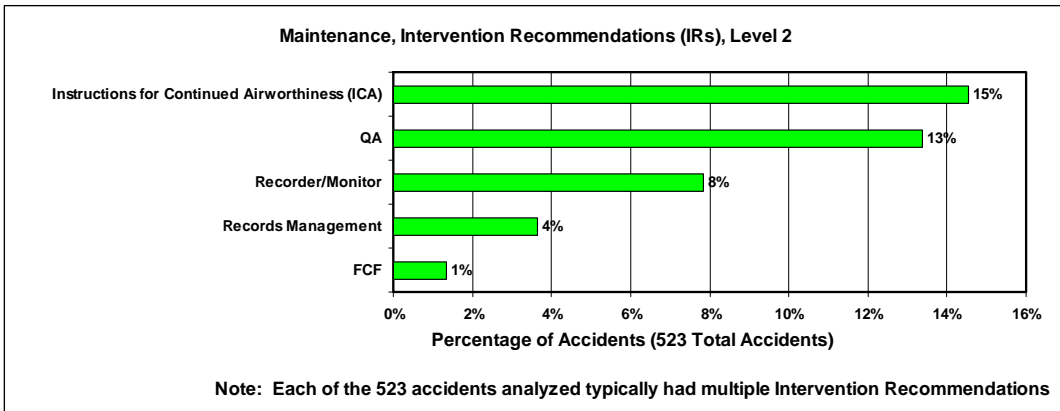


Figure 23. Maintenance, Intervention Recommendations (IRs) Level 2

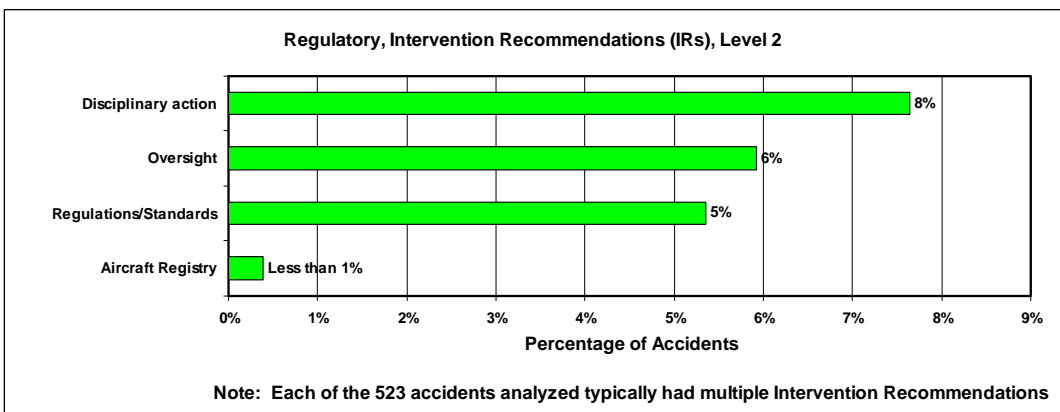


Figure 24. Regulatory Intervention Recommendations (IRs) Level 2

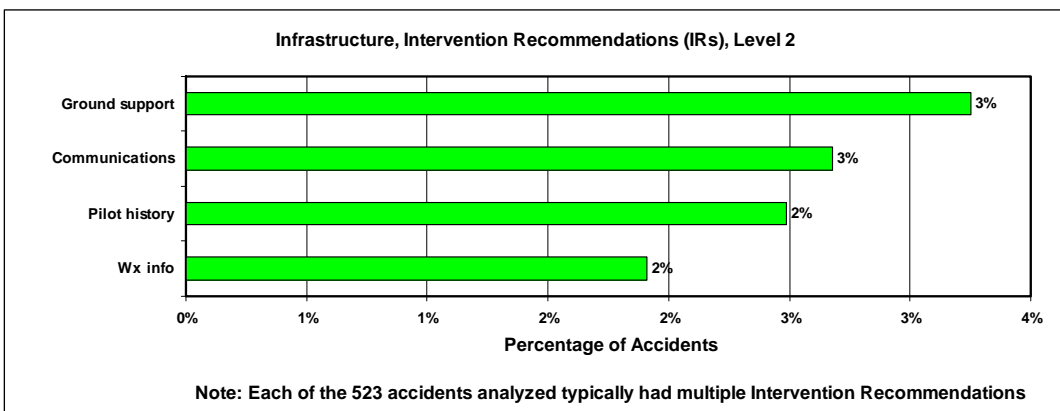


Figure 25. Infrastructure, Intervention Recommendations (IRs) Level 2

SPS vs. IR pairs matrix

Direct comparison of the Interventions associated with the most frequent SPS shows where the emphasis for reduction may be the most beneficial. Table 2 identifies the areas that have a significant opportunity for accident prevention as represented in bold type.

SPS Level 1	Interventions Level 1							
	Data/Information	Infrastructure	Maintenance	No Recommendation	Regulatory	Safety Management	Systems and Equipment	Training/Instructional
Communications	0.4%	1.1%		0.2%		4.0%	0.2%	4.2%
Data issues	73.0%	0.4%		0.2%				
Ground Duties	1.0%	0.6%	0.6%	0.2%		22.4%	1.7%	16.6%
Infrastructure	0.2%	2.7%		0.2%	0.4%	0.8%	0.2%	0.4%
Maintenance	0.2%		18.7%		2.5%	1.7%	1.3%	0.2%
Mission Risk	0.4%		0.2%	7.8%		5.7%	1.7%	4.8%
System Component Failure	1.7%		14.1%	5.2%	1.3%	1.9%	6.1%	1.1%
Personnel - Non Crew		0.4%				1.0%	0.4%	0.6%
Pilot Judgment & actions	1.9%	0.4%	0.4%	14.1%	5.9%	35.9%	7.5%	64.8%
Pilot Situational Awareness		1.1%	0.2%	1.5%	0.6%	9.4%	11.9%	16.1%
Post-crash survival		0.2%		4.4%	0.4%	1.5%	8.6%	1.0%
Regulatory	1.7%	0.2%	0.2%		6.9%	0.2%	0.4%	0.2%
Safety Management	1.0%	3.3%	0.8%	2.1%	2.5%	24.7%	1.7%	18.5%
Safety Systems and Equipment	0.2%			0.6%	0.4%	0.2%	5.5%	

Table 2. SPS level 1 vs. IR level 1

Examining the SPS vs. IR pairing to Level 2 for the largest percentage intersect shows that there are numerous areas needing attention and that there is no single “silver bullet”. Table 3 presents the complete data and identifies the areas with the highest percentages. Prioritizing resources in the high percentage areas may either reduce or eliminate these particular combinations. It is a dual benefit in that addressing the IR

positively impacts the associated SPSs. An example may be that increased work on Advanced Maneuvers Training of Landing Procedures may also improve pilot's Flight Profiles and Pilot's Decision Making, resulting in fewer landing accidents.

Pilot Judgment & Actions SPS Level 2	Training Instructional Intervention Recommendation Level 2					
	Advanced Maneuver Training	Basic Training	CFI Training	M/M transition	Mission specific	Safety Training
Crew Resource Management			9%			1%
Flight Profile	2%	2%	2%	0%	3%	3%
Human Factors - Pilot/Aircraft Interface	1%	1%	0%		2%	3%
Human Factors - Pilot's Decision	2%	2%	3%	1%	3%	11%
Landing Procedures	17%	2%	1%	0%	1%	2%
Procedure Implementation	17%	10%	2%	3%	2%	4%

Table 3. SPS vs. IR Level 2 for PJ&A vs. Training/Instructional

FUTURE

The U.S. JHSAT analyzed three years of accident data and wrote three reports reflecting the findings of the analysis. This Compendium combined the information from these three reports and presented it as a baseline for future comparison.

Following the CAST model the U.S. JHSAT officially disbanded and a measurement team, the U.S. Joint Helicopter Implementation Measurement and Data Analysis Team (JHIMDAT) was commissioned to measure the effectiveness of the mitigations implemented by the U.S. JHSIT. The expectations are that many of the U.S. JHSAT members will continue their involvement with the IHST and become members of the JHIMDAT. The JHIMDAT will continue its analysis of accident reports in an effort to provide the U.S. JHSIT feedback on the interventions. That data will be entered in the database and compared to the information presented above. A comparison of the latest accident data will be made against the Compendium report baseline and used in the measurement of improvement and expectantly will indicate the positive impact of the various IHST, JHSIT, JHSAT and JHIMDAT efforts.

CONCLUSIONS

There are many methods to reduce the rate of accidents that will require industry and government actions. Early efforts used existing studies to start implementation approaches. This Compendium Report reprioritizes and restates the findings of the three previous U.S. JHSAT reports by combining the data into a single data set. This combined data set establishes the baseline of U.S. helicopter accidents for future IHST efforts.

A listing of the U.S. JHSAT Compendium Top 20 Intervention Recommendations (IRs) is available at the end of this report. Also a complete appendix of the reference data is in the Compendium Volume II which is available in the IHST Reports section at <http://ihst.org/>.

An examination of the demographics data may provide focus to the prevention efforts on the proper sectors of the industry:

The highest number of accidents occurred in the Personal/Private (18.5% of total 523) and Instructional/Training (17.9%) in the Industry Segments, with the majority being flown under FAR Part 91.

When analysis was directed towards the results by Activity it indicated that Instructional Training (Dual) (22.8%), Return to Base (RTB) (13.2%) and Personal/Private (12.4%) were leading Activities at the time of accident. Again, the majority of these accidents were primarily flown under FAR Part 91.

When the focus of the U.S. JHSAT was turned to the Occurrence category, indications pointed directly to Loss of Control (LOC), applied in 41% of the accidents. Autorotation (Auto) (forced and practice) (32%) and System Component Failure (SCF) (28%) were second and third respectively as significant occurrences leading to accidents.

Slightly over 20% of the accidents occurred in the Landing Phase of flight. Enroute and Manuevering followed closely as second and third with slightly less than 20%.

Under the category of flying hours; 45% of the accident pilots had less than 500 hours in Make/Model, 16% had less than 100 hours in Make/Model.

Overall, 70% of the accidents happened while flying under FAR Part 91.

Examining the data by the Standard Problem Statements (SPS) and the Intervention Recommendations (IR) may be useful in targeting the type of prevention efforts for application.

- In 84% of the accidents, the SPS of Pilot Judgment and Actions (Insufficient) was assigned.
- A more detailed sub-analysis of the Pilot Judgment & Actions SPS, Landing Procedures was identified in 40% of accidents, Human Factors-Pilot's Decisions 36% and Procedure Implementation 35%.
- The JHSAT assigned 43% of the 523 accidents an SPS indicating a Safety Management System (SMS) was not in place at the time of the accident.
- At a more detailed sub-analysis of the SMS SPS (Level 2) Pilot Experience was cited in 14% and Management (inadequate) in 13% of the accidents.
- The SPS of Ground Duties was identified in 37% of accidents.
- At a more detailed sub-analysis of the SPS (Level 2) Ground Duties, Mission and Flight Planning was indicated in 24% of all accidents.
- For Intervention Recommendations (IR) the JHSAT assigned 79% of accidents an IR of Training/Instructional at Level 1. At a more detailed sub-analysis of the IR (Level 2):
 - Advanced Maneuver training was assigned in 39% of accidents.
 - Safety Training was assigned in 35% of accidents.
 - Basic Training was assigned in 29% of accidents.
- An IR for an SMS program was used in 64% of all accidents. At a more detailed sub-analysis of the IR (Level 2) for SMS, the following were the most common:
 - Risk Assessment/Management 33%
 - SOP Ops Pilot 20%
 - and SOP Ops Management 18%

Other significant areas to address include the following:

Encourage ALL pilots, but most importantly those flying under Part 91, to implement the use of a Risk Assessment document, similar to the risk assessment used by the Gulf of Mexico operators. Provide industry briefings and success stories on the benefits of a Risk Assessment program and detailed instructions for the successful implementation of the Risk Assessment tool. An additional suggestion would be to create several templates for use on routine or recurring flights.

Provide a specialized Risk Assessment checklist to Flight Instructors and describe the benefit of such a document. Emphasize how to reinforce proper procedures during flight training, and best practices for decision making training for students. Recommend procedures, techniques and best practices on how to maintain aircraft control during the training instruction, essentially staying ahead of the student.

The IHST has developed a Risk Assessment Toolkit and it is available at the following location: <http://ihst.org/>

Produce and distribute a list of common Loss of Control (LOC) events/types with Risk Assessment for flight ops (prevention), early warning signs of the event (recognition) and best practice for corrective action should the event get started.

Review IHST SMS program and update/modify to introduce best practices to larger industry audience (Part 91 operators).

Produce and distribute advanced autorotation procedure documents.

Promote the concept of table top simulator/training devices to reinforce practices for advanced maneuvers. Recommend commercial flight simulator software programs that analyzes the last scenario and reports to the pilot rates of descent, airspeeds and potential emergency landing zone decisions.

Establish best practices pamphlets for Pilots on Standard Operating Procedures for various typical flights. Create the same type document for company operations personnel or customers to use when planning or bidding flights.

U.S. JHSAT Compendium Top 20 Intervention Recommendations (IRs)

Note: The figure in the parenthesis indicate the percentage of accidents in which the IR was used at least once in the dataset of the 523 rotorcraft accidents.

1. **D2010 - Install cockpit recording devices.** (52.8%) Develop and install FDM equipment to record the actions of the flight crew. Data can be used as local immediate feedback to trainers, operators and flight crews. The data could also aid in the event of accident investigation to support a more complete analysis and future safety recommendations.
2. **D1010 - Improve quality and depth of NTSB investigation and reporting.** (35.9%) Many accidents are not receiving in-depth, onsite investigation by NTSB investigators. Investigations are being performed by telephone interview or by personnel whose primary function is not accident investigation. Increase the degree of Human Factors investigations to include detailed personnel information, assess the extent of operator oversight.
3. **T2010 - Autorotation Training Program.** (13%) Improve autorotation training in both primary and advanced flight training and develop simulator programs to improve autorotation skills.
4. **M3010 - Follow ICA Procedures with Confirmation of Compliance.** (11.9%) Ensure that maintainers and operators are aware of the importance of following the manufacturer's maintenance manuals and practices. Require Regulators to enforce regulations that require the use of the manufacturer's maintenance manuals and practices.
5. **T2060 - Simulator Training - Advanced Maneuvers.** (10.9%) Incorporate simulator programs into training program that would include dynamic rollover, Emergency Procedures Training, Ground resonance, quick stop maneuvers, targeting approach procedures and practice in pinnacle approaches, unimproved landing areas, and elevated platforms
6. **S8050 - Personal Risk Management Program (IMSAFE).** (10.1%) Encourage the implementation and use of a personal Risk Management program and utilize the IMSAFE checklist.
7. **T6019 - Training emphasis for maintaining awareness of cues critical to safe flight.** (9.0%) Establish training programs that train and evaluate proficiency of critical issues such as systems failures, impending weather concerns, effects of density altitude, and wind and surface conditions that can become critical to safe flight.

8. **M1010 - Better Maintenance/Quality Assurance oversight to ensure adherence to the ICA/Manual.** (8.2%) Encourage operators and maintainers to implement a robust Quality Assurance program that ensures the use of manufacturers maintenance manuals, service bulletins, and procedures.
9. **S8040 - Mission Specific Risk Management Program.** (7.8%) A formal Safety Management System (SMS) requires training for specific missions, the establishment and enforcement of standard operating procedures, provisions and training of personnel to use risk assessment tools, and most importantly changing the safety culture to ensure that all personnel put "Safety" first.
10. **T1020 - Enhanced Aircraft Performance & Limitations Training.** (7.1%) Operators should provide robust training and continual evaluation of their pilots on aircraft performance. This training should include the effects of density altitude, gross weight and flight manual limitations.
11. **T2050 - Emergency Procedures Training.** (6.9%) Encourage the use of EP trainers with the emphasis on Loss of System, Recognition and Recovery training.
12. **T3030 - CFI judgment and decision making training to follow student more closely.** (6.9%) Require CFIs to participate and show proficiency in Aeronautical Decision Making (ADM) training programs and recognize the typical student errors training before they exercise the privileges of their certificate.
13. **E2050 - Install Proximity Detection System.** (6.7%) Utilization of this technology would provide proximity detection equipment that would aid in identifying ground obstructions. This operational enhancement would prove to be valuable due to the requirement of helicopters to operate in close proximity to obstacles.
14. **T1050 - In-flight Power/Energy Management Training.** (6.5%) Require increased training and documented proficiency evaluation of power/energy management issues. This training improvement should include detailed training on flight manual information related to density altitude, and weight and performance issues of each aircraft the pilot will operate.
15. **S8005 - Establish/Improve Company Risk Management Program.** (6.5%) Require the establishment and/or improvement of company risk management programs which would include the hazard identification and analysis and risk assessment and control. IHST SMS Toolkit provides a scalable SMS program for any size of operation. The IHST SMS Toolkit is available at <http://ihst.rotor.com/SMS Toolkit Ed 2>.

16. **D2020 - Install Data Recording Devices.** (6.3%) Develop and install FDM equipment to record the actions of the flight crew. Data can be used as local immediate feedback to trainers, operators, and flight crews. The data could aid in investigations to support more complete analysis and future recommendations. The IHST FDM Toolkit is available at <http://www.ihst.org/portals/54/hfdm.pdf>.
17. **S8010 - Use Operational Risk Management Program (Preflight).** (6.1%) The use of a continual cyclic process which includes risk assessment, risk decision-making, and implementation of risk controls, would have positive results in the area of acceptance, mitigation, or avoidance of risk and is essential for aviation safety.
18. **S8020 - Use Operational Risk Management Program (In-flight).** (5.7%) Develop and incorporate into flight operations a risk management tool that provides pilots and crews with a method of evaluating the various hazards and risk of each mission. Include a checklist for use while airborne on the use of decision-making.
19. **T1060 - Simulator Training - Basic Maneuvers.** (5.4%) Develop and implement a standard for pilot training focusing on operational specific scenarios, human factors, and the use of simulators and flight training devices (FTDs). The IHST Training Toolkit is available at http://www.ihst.org/portals/54/2009_Training_Toolkit_Final.pdf
20. **T6017 - Risk Assessment/Management Training.** (5.4%) Require the establishment and/or improvement of the company safety training which includes risk management programs emphasizing weather decision- making tools.

Appendixes

(Available in the Compendium Report Volume II)

APPENDIX A – U.S. JHSAT METHODOLOGY

APPENDIX B – OCCURRENCE CATEGORY BY MISSION

APPENDIX C – TOP 20 – STANDARD PROBLEM STATEMENT (SPS) LEVEL 3

APPENDIX D – TOP 20 - INTERVENTION RECOMMENDATION (IR) LEVEL 3

APPENDIX E – INTERVENTION RECOMMENDATION (IR) SUMMARY

APPENDIX F – PILOT FLIGHT TIMES



GOAL - THE IHST HAS SET AN AGGRESSIVE GOAL OF REDUCING THE WORLDWIDE CIVIL HELICOPTER ACCIDENT RATES BY 80% IN 10 YEARS.



IHST

217 N. Washington Street
Alexandria, VA 22314-2538 USA

TEL: 703-684-6777 FAX: 703-739-9279

<http://ihst.org/>