

# Helicopter Accident Trends in 8 ISASI Countries and How We Might Improve the Fatal Accident Even Further

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## Introduction

The helicopter safety community has had a good story to tell in recent years. Fatal accidents have decreased steadily while flight hours have increased by more than half from 2001 through 2015. The result has been a significant reduction in the fatal accident rate for helicopters, especially in the past 10 years. Part of the credit for this happy state of affairs can be attributed to several important efforts to reduce accidents. These efforts include the International Helicopter Safety Team, the European Helicopter Safety Team and the US Helicopter Safety Team, plus major efforts by regulatory authorities and industry groups, such as the Helicopter Association International (HAI) and the National EMS Pilots Association (NEMPSA).

The most promising efforts involve the International Helicopter Safety Team and several national or regional efforts, such as the US Helicopter Safety Team and a European effort. These efforts have accomplished a lot already, but they are still in relatively early stages. Consequently, a small ISASI team decided to conduct its own review of fatal helicopter accidents in several countries with large helicopter fleets and large numbers of ISASI members in order to develop an independent understanding and, perhaps, to identify selected characteristics of fatal accidents that might be useful targets for the various working groups to consider as they work to reduce the number and rate of accidents even further.

Our findings are consistent with early findings from the groups cited above, but our findings vary somewhat in their emphasis. For example, our study found that basic issues continue to be common in fatal helicopter accidents. Those basic issues include poor or no pre-flight planning or pre-flight inspection, conscious risk taking, piloting skills, and maintenance issues (most often a failure to obtain maintenance), taking off with known deficiencies or failing to ensure adequate fuel. These basic factors commonly express themselves in accidents involving visual flight at night, visual flight into weather, low-

altitude flight, fuel exhaustion, etc. The same factors also influence the most common and most lethal accident scenarios, i.e., loss of control (LOC) and controlled flight into terrain (CFIT). We also focus on differences in fatal accident rates among the three primary categories of helicopters (piston, single-engine turbines, and twin turbines), which may be somewhat overlooked in some cases.

Our suggested interventions also emphasize the basics. They include the development of and adherence to adequate procedures and the use of contemporary data monitoring, training and the need to continue emphasizing attention to procedure. However, multiple technological interventions also are recommended as valuable enhancements where feasible.

The report is organized as follows. Part One briefly outlines our process and the nature of the data, with a broad overview of basic trends. Part Two reviews the fundamental issues noted above, starting with fleet characteristics and differences in accident rates among categories of helicopters, followed by a review of several accident categories. The report concludes with recommendations and a summary.

## **Process, Data and Broad Trend**

The team limited itself to fatal accidents from 2001 through 2015 in the belief that, on balance, fatal accidents simply merit more attention, though we recognize that we can learn important lessons from non-fatal accidents as well. Since the team lacked the resources to search and analyze fatal accidents in every country, we focused on countries with large civil helicopter systems and those countries where all or at least most accident reports are easily available on line. For practical reasons, we also limited ourselves to countries where we could read reports in the local language, namely French and English. The resulting dataset initially included fatal accidents from seven countries: Australia; Canada; France; New Zealand; South Africa; the UK; and the USA. Ireland, which added just four fatal helicopter accidents over the 15-year study period, was added after searching Irish reports for G-registered helicopters. The study excluded amateur-built helicopters, gyrocopters and military operations.

The team consisted primarily of three members who relied mostly on official accident reports from the eight countries. However, to ensure that the search was as complete as possible, the team also reviewed the World Aircraft Accident Summary (WAAS) and several popular websites, particularly the Aviation Safety Network, to add information on any fatal accidents that did not appear on official sites or for accidents for which only cryptic summaries were available. Press reports also were searched in some of the more recent accidents to augment basic information on accidents for which only preliminary reports were available.

Information on each accident then was summarized in an Excel file that identified typical data fields, such as: date; location; make-model; fatalities; serious injuries; basic weather; etc. The spreadsheet also included a text field to summarize the narrative for each accident, plus multiple fields that identified various problems and potential interventions. The team of three then reviewed each accident. The accidents also were divided equally among an additional team of six volunteers, including five

professional helicopter pilots and one professional safety analyst, for an independent review and a reality check. In short, each accident was assessed by at least three people, while most accidents in the dataset were assessed by four people and some by five people.

The data captured 672 fatal accidents from 2001 through 2015 that involved 678 helicopters and 1,308 fatalities. The eight countries may not define the experience of all ISASI member countries but they constitute a dominant share of ISASI-wide helicopter fleets and flight hours and a large share of world-wide operations. Data from Flight Global suggests the eight countries include the world's two largest national helicopter systems as of 2015, (USA and Canada) plus the fourth, sixth and seventh largest (Australia, UK and France). Combined, FlightGlobal indicates the eight countries account for 63 percent of the world's piston helicopters and 47 percent of its turbine fleet, or just over half of the total fleet.<sup>i</sup>

The paper used available data on flight hours and fleet composition from several countries to place a sense of scale on fatal accident rates, including fatal accident rates by class of aircraft. However, some countries provide only limited public access to data on fleets and flight hours in deference to privacy. In addition, where data is available, countries often summarize their respective datasets in ways that are not directly comparable. Consequently, summary data in this paper sometimes will be presented with variations in the number of years addressed and some comparisons will include only selected countries.

Given the size of its system, the U.S. dominates the accident data and other data among the eight countries. Figure 1 shows the distribution of the accident dataset by country. The U.S. accounts for 380 of 672 fatal accidents in the dataset, or 56.5 per cent. Nevertheless, the remaining 292 fatal accidents (43.5 percent) influence findings and illustrate some differences in national characteristics.

## Overall Trends

Perhaps the most basic measures of helicopter safety are the number of fatal accidents and fatal accident rates. Those numbers show persistent improvement over the past decade. Figure 2 shows that the number of fatal helicopter accidents for the eight countries continue to decrease despite steady growth in fleets and flight hours, which Figure 3 shows for four countries for which adequate data was available (Australia, Canada<sup>ii</sup>, New Zealand and USA). Given the combined size of these national systems, they are assumed to indicate trends among all eight countries. From 2001 to 2015, the helicopter fleet in the four countries increased by two-thirds while flight hours increased by 54 percent.

With a steady increase in flight hours and a steady decrease in fatal accidents, the result is straight forward: the fatal accident rate for those four countries, and by extension all eight countries, has improved dramatically over the past 15 years, as shown in Figure 4. For decades the fatal accident rate for helicopters had been considerably higher than the rate for fixed-wing aircraft in general aviation, at least as measured by flight hours. That is no longer true as fatal accident rates in helicopters, measured by flight hours, now are well below fixed-wing rates.

Again, this is a good story to tell but the good overall trends obscure important differences in fatal accident rates between classes of helicopters and the persistence of several age-old and fundamental factors among the fatal accidents that we continue to see. For example, piston-powered helicopters account for 40 percent of the fatal accidents in our eight-country dataset though they account for less than 25 percent of flight hours. Data for 2006 through 2015 (10 years) from the U.S. suggests that piston-powered helicopters continue to have a fatal accident rate that is twice the rate for turbine helicopters (1.16 versus 0.59 fatal accidents per 100,000 hours).<sup>iii</sup> Similarly, the fatal accident rate for single-engine turbines is nearly twice the rate for twin turbines (0.66 versus 0.35). Data from Australia and New Zealand appear to be consistent with U.S. data, though a direct comparison by type of power plant is precluded by slight differences in the manner in which the three countries organize their published data on flight hours.

Disparities in accident rates among classes of helicopters are affected by multiple factors, such as differences in the percentage of hours flown in daylight or at night, differences in the mix of missions, broad variations in pilots' skills and experience, plus differences in helicopters' instrumentation and general capabilities. However, since fleet mix can vary significantly between countries, disparities in accident rates by class can inflate or deflate a country's overall fatal accident rate. The table, below, shows the distribution of national fleets by class of helicopter over the 15-year study period in 2015 while Figure 5 shows the distribution of fatal accidents by class of helicopter in seven countries (Ireland is excluded due to its very small fleet). In four countries (Australia, Ireland, New Zealand and South Africa) piston helicopters account for half of the combined fleet but they account for two-thirds of all fatal accidents. Among the other four countries piston-powered helicopters account for just 26 percent of the combined fleet and one-third of fatal accidents.

Table 1  
Distribution in Percent of Active National Fleets, by Helicopter Class, 2015

Class	Ireland	France	So Af	UK	Canada	NZ	Australia	USA	8-Country Total
Piston*	40.6	36.5	58.4	38.4	24.8	45.1	58.2	31.3	36.1
1-E Turbine	19.8	39.0	34.4	25.7	60.2	46.4	27.7	51.3	47.7
2-E Turbine	39.6	24.5	7.2	35.9	15.0	8.5	14.1	17.4	16.2
Turbine Sub-Tot*	59.4	63.5	41.6	61.6	75.2	54.9	41.8	68.7	63.9
Total Fleet Size*	32	853	969	1,076	2,303	844	1,862	9,851	17,990

Piston fleets and total turbine fleets are from FlightGlobal. Turbine fleets from Flight Global then were split between single- and twin-engine turbines based on data from Rotorspot.

Due to limitations on data for flight hours, we were able to estimate long-term fatal accident rates for just four of the eight countries (Australia, New Zealand, Canada and the U.S.). Those four countries indicate that a country's fatal accident rate increases as the share of piston helicopters in the fleet increases. In Australia and New Zealand, where piston-powered helicopters account for half of the fleet, the combined 15-year fatal accident rate was about 1.15 fatal accidents per 100,000 flight hours

compared to a rate of about 0.84 in Canada and the U.S., where piston-powered helicopters account for just a quarter of the fleet. Consequently, to gain an accurate sense of how any single country's fatal accident rate compares to other countries, rates need to be weighted by fleet composition.

## **Night VFR**

Despite the substantial improvement in fatal accident rates and absolute numbers, we found many of the fatal accidents that continue to occur involve truly basic factors. For example, flying under visual flight rules (VFR) at night or flying VFR in instrument meteorological conditions (IMC – weather) obviously increase risk and mostly for the same reason: visual flight assumes we can rely on vision to fly safely but we simply cannot see properly when flying in darkness or in weather. IMC, of course, can introduce multiple issues, but the capacity to see properly is certainly one of them.

We recognize that pilots can fly VFR safely at night, and many pilots do so regularly throughout the world. Nevertheless risk increases at night, and it increases a lot. Overall, U.S. data suggests that the fatal accident rate for helicopters is 72 percent higher than in day VFR. However, even at 72 percent higher, this aggregated rate understates the added risk of flying at night because daytime and nighttime flying involve very different mixes of fleets, missions, etc. When we compare like-aircraft to like-aircraft, the increased risk associated with night VFR becomes clearer.

For piston-powered helicopters, the fatal accident rate is 3 times greater for night VFR compared to day VFR (2.9 versus 1.0 per 100,000 hours). Piston-powered helicopters account for just over 29 percent of night-VFR fatal accidents in the U.S. for the 15-year study period, though they account for just 11.7 percent of all night hours compared to 27 percent of daytime hours. For turbine helicopters, which account for over 88 percent of all night hours, night rates are “only” 66 percent higher, but that, too, is a substantial increase. This somewhat lower disparity for turbine helicopters likely reflects a greater share of professional pilots operating turbines at night compared to piston-powered helicopters, a greater share of helicopters that are VFR-capable, more pilots who are IFR-capable, plus differences in average pilot experience or training, the presence of standard operating procedures, etc.

Overall, 20 percent of fatal accidents in our dataset involved VFR at night, but with some differences among countries. The highest percentage was in the U.S., where 24.7 percent of fatal accidents occurred under night VFR. Night flying in Australia and the U.K. accounted for 19 and 18 percent, respectively, and 14 percent in Canada. Night flying accounted for a more modest share of fatal accidents in South Africa and France, with 12.5 and 11.4 percent, respectively. In contrast, of New Zealand's 36 fatal accidents in our dataset, just two (5.6 percent) involved VFR at night compared to 94 of 380 fatal accidents in the U.S. If pro-rated by total fleet size, per FlightGlobal data, no other country in our dataset challenges U.S. accident numbers involving night VFR.

The difference starts with national regulatory philosophy. For example, as in many countries, pilots in New Zealand must be authorized to fly VFR at night and must operate IFR-capable aircraft when doing so. Neither is required in the U.S., where the numbers are highest, though the U.S. requires a small

number of flight hours at night to earn a private license. In addition, many flight missions in New Zealand and elsewhere, such as emergency medical services, require two pilots and operate in twin-engine turbine helicopters, or as in South Africa, landing at accident sites is prohibited at night.

A second significant difference in the number of night VFR accidents in the U.S. is the prevalence of EMS-related helicopters among those accidents. Of 134 night VFR accidents among the eight countries, 45 (33.5 percent) are related to EMS. This includes flying to and from accident sites and hospitals, plus one training flight and one test flight. Of those 45 night accidents involving VFR at night, the U.S. accounted for 41. All 41 were single-pilot flights while most countries require two pilots at night or at all times. They also typically operate twin-engine helicopters and may impose other restrictions on night operations, as in South Africa where the Health Ministry prohibits night landings by EMS helicopters at accident sites.

Several types of interventions might reduce the overall number of night VFR accidents in all flight missions. Outreach may be the easiest and also the most difficult of these interventions. It could be easy because the message is simple: avoid or at least minimize exposure to VFR at night unless you have proper training and experience. However, if this were simple, the issue would have been resolved in aviation decades ago. The difficulties include at least two basic challenges. First, reaching private pilots and small operators in a meaningful way is difficult. Journal articles and outreach efforts help, as do efforts by manufacturers but the message must be communicated widely and repeatedly to be effective. Second, the message that VFR at night involves a three-fold increase in risk must be stated clearly but somehow without sounding like a parental message reminding our children to be careful. Again, this is far more difficult than it sounds. Otherwise the problem would have been solved decades ago.

Establishing good standard operating procedures (SOPs), adhering to them and training to them would be more promising, along with good risk management programs and data monitoring or non-punitive safety reporting program both could go a long way. However, as a practical matter, these approaches may be more feasible for operators that enjoy some degree of critical mass and who in fact have people who know how to interpret the data. Reaching private pilots and small commercial operators is more difficult. They can be reached, but perhaps not as easily.

A third option involves a dreaded word in some circles: regulation. Depending on national experiences with night VFR accident rates and depending on their current regulatory requirements, regulators could consider at least the following: require a night VFR rating; limit night VFR to IFR-capable helicopters and/or to IFR-qualified pilots; and perhaps require two-pilot crews for certain commercial activities at night. All these options likely would be opposed by many operators who would be newly affected, but they need to be considered where they do not already exist.

## **VFR into IMC**

At nearly 20 percent of our accident set, the high proportion of accidents that occur at night may be the most startling fact in our review of the accident data. Even when driving an automobile, we recognize

that the entire visual scene outside the vehicle is suppressed, while the inside is muted, all of which slows our detection of and response to our surroundings. If we were to add weather to this equation, drivers immediately recognize the added difficulty of driving at night in fog, rain or heavy storms. Now add the dimension of altitude and the inability to simply pull off the road, and even the non-aviation world can begin to sense the increased challenges.

VFR into IMC continues to influence just over 16 percent of fatal accidents. The data on VFR at night and VFR into IMC include some double-counting, since nearly 8 percent of cases involve both factors. Yet a meaningful comparison of fatal helicopter accident rates while flying in IMC versus VMC is impossible. Though 14 percent of fatal helicopter accidents in the U.S. and 16.2 percent of the fatal helicopter accidents in the eight countries occurred while flying VFR in IMC, pilots report zero VFR hours in IMC, even in anonymous surveys. The result is that 14 to 16 percent of fatal accidents apparently occur when nobody is flying. How does that work?

Figure 7 shows the share of fatal accidents, by country, that involve VFR in IMC and VFR at night. The figure indicates that VFR into IMC is a more significant issue in some countries than in others, with the UK at the top of the list (31 percent), followed by France (25 percent) and Canada (20 percent), with the U.S. near the norm. However, the mix of accident categories involving VFR into IMC is consistent among the eight countries. Predictably, loss of control (LOC) and controlled flight into terrain (CFIT) or into obstacles account more than 90 percent of cases.

VFR into IMC involves both a lack of pre-flight planning and risk. A lack of pre-flight planning or proper risk assessment in turn can reflect self-imposed pressure to perform a mission, or continuing to press ahead even as a pilot recognizes that weather is deteriorating. This perhaps is most common with EMS missions, but it also is present in other flight activities, such as some air taxi operations or other commercial activities, and it helps to explain more than a few accidents in private or personal flying. However, at the extreme, flying VFR into IMC can be the product of a simple failure to obtain weather.

Perhaps a more common issue is inadvertent VFR into IMC despite proper pre-flight planning, obtaining weather reports, etc. This reflects the absence of an enroute weather system. Only ground level sites report weather but the weather at 500 or 1,000 feet is not reported. An "enhancement" that reports clouds or low visibility directly in front of the helicopter could help to avoid these events.

The risk of inadvertent VFR into IMC is especially difficult at night, when the helicopter pilot must watch for clouds while flying in inherently low-visibility conditions, i.e., darkness. If the single pilot in this scenario also lacks recent or any instrument experience, and is operating with minimum instrument panel, that pilot can quickly get into trouble. Other common manifestations involve inadequate fuel planning, flying with known maintenance issues, weight and balance, inadequate fuel supply, and conscious risk-taking, including inappropriate "no-go" decisions in weather or with known mechanical problems. Complicating all these issues is the near absence of navigational aids at lower altitudes, where helicopters earn their keep.

Technology obviously can contribute. We might start with the development of an on-board device that detects low visibility or clouds. Similarly, the development of a low-level IFR system could prove to be a major enhancement. To these we can add greater access to current weather information and ensuring that helicopters have enough instrumentation to enable a 180-turn when VFR pilots find themselves inadvertently in IMC.

Training on how to escape IMC also has a place here, though with the caveat that one-off training efforts have little to no effect. To be effective, such training must be repeated and, where appropriate, reflect an operator's SOPs and risk assessment criteria. Pilots acknowledge that dependable IFR skills are perishable, which makes currency of experience important. Finally, regulators also could help via more surveillance of operators' SOPs, or assistance in the development of SOPs and risk assessment programs.

Reducing these accidents must rely on establishing, adhering to and training to good SOPs and risk assessment programs, with particular emphasis on currency of experience, pre-flight planning and go/no-go decision making. More broadly based SMS programs and non-punitive or confidential reporting programs also need to be part of the effort. Again, though, this approach faces challenges trying to reach private pilots and small operators. Even small operators of course can benefit from such programs but they may lack the necessary management capacity.

## **LOC & CFIT**

By far the most common and the most lethal fatal accidents are loss-of-control (LOC) and controlled flight into terrain (CFIT), which may or may not include wire strikes, depending on definition (not included here). LOC and CFIT are strongly influenced by several common factors, such as VFR at night and VFR into IMC, and they both should be affected by several common interventions. Consequently, possible interventions will be discussed jointly.

**LOC Accidents:** Regardless of how one defines loss-of-control (LOC) accidents, they easily constitute the largest single category of fatal accidents, as noted by all the industry-government working groups. By our count, LOC accounted for 316 fatal accidents in our dataset (47 percent). Of the 316 accidents, 72 involved night VFR (23 percent) and 52 (16.6 percent) involved VFR into IMC. These numbers include 26 accidents that checked both boxes: VFR at night into IMC. Four other fatal LOC accidents involved IFR flight in IMC, three of which were at night.

The 31 percent of LOC accidents that involved VFR at night or VFR in IMC, or both, suggest weaknesses in pre-flight planning, go/no-go decisions, and perhaps a failure to recognize just how dramatically risk increases when flying VFR in those conditions. Those failures also involve more than pilots; they also involve management and dispatch practices in various types of organizations.

Yet, two-thirds of all fatal LOC accidents involve neither IMC nor VFR at night. LOC is more complex than those two factors because it captures such a variety of factors and flight missions. The variety of missions is significant here. Many missions invite LOC accidents due to frequent and abrupt maneuvers

from low altitude and perhaps from relatively slow speeds, as in surveillance flights, herding, law enforcement, aerial application, and more. Of the 316 LOC accidents, EMS accounted for 31 while instruction-training accounted for 40 (of 62 instructional flights in our dataset).

LOC also captures a high concentration of fatal accidents involving heavy lift and other work (44 of a total 70). Many of these events involved the inherent challenges to any pilot during these operations, including long-line operations, with ground support playing a role. In addition to LOC, the remaining common factor in heavy-lift and work accidents is the prevalence of system and component failures, particularly maintenance that was not performed plus several in-flight breakups due to structural fatigue. The nature of the operations also can invite extra risk from foregoing prudent cabin safety practices. For example, doors often are removed on the pilot's side to ensure the ability to monitor long lines and the like, and shoulder harnesses often are not used in order to give pilots upper-body flexibility to perform the same monitoring. The result is that pilots can be exposed to needlessly severe injuries.

Other accidents involving system-component failures include the full range of maintenance issues, from issues related to production or premature failure and various maintenance errors. Again, though the more frequent issues is a simple failure to obtain proper maintenance. In short, maintenance organizations and managers also can benefit from adopting internal reporting programs and by developing and enforcing good standard operating procedures.

The fleet mix in LOC accidents also may be telling. Of the 316 helicopters involved, 138 (44 percent) were light piston-powered helicopters. This compares to just 25 percent of flight hours attributable to reciprocating helicopters. Part of this disproportionate share of accidents reflects the common use of these helicopters for instruction; 33 of the 138 reciprocating helicopters involved in LOC were on instructional flights. In contrast, just 7 of 178 turbine helicopters involved were operating instructional or training flights. Nevertheless, low rotor RPM continues to be an issue among these accidents, as do mast-bumping and carburetor icing.

NTSB has noted multiple times in accident reports that low rotor RPM often is the result of a simple failure to maintain power. Similarly, Australia's ATSB and the UK's AAIB both have noted in several accident reports that the issue remains too common, especially in light piston helicopters.

Piloting skill and knowledge, or at least pilot performance on accident flights, is perhaps the most obvious issue in all LOC accidents, including a failure to respond properly to manageable problems or failure to execute a proper autorotation when a successful autorotation was possible. In some cases, poorly designed infrastructure, e.g., the heliport appears to have been a factor leading to a pilot's loss of control. By our count, up to 47 of the 316 fatal accidents (7 percent), not all of which were scored as LOC, may have been averted by earlier entry into autorotation or if the autorotation were executed properly. This excludes cases in which successful autorotations were not feasible due to absence of safe landing areas or due to insufficient altitude when the need to autorotate developed.

**CFIT Accidents:** We identified 118 fatal CFIT accidents in the 15-year data set, or 17.5 percent of our dataset. This includes high or flat terrain, water, and obstacles but excludes wire strikes. Of those 118 fatal accidents, a large majority occurred while flying VFR in IMC or VFR at night, or both. Just two of the 118 involved IFR operations (both in IMC, one day and one night) and one involved a GPS flight in day IMC. Of the 118 accidents, 53 involved VFR in IMC (45 percent), while 45 (38 percent) involved VFR at night. However, rather than adding to 98, they in fact add to “only” 74, as 24 of the accidents involved both VFR at night in IMC. At least 39 of the 74 pilots were IFR-rated in helicopters.

These high percentages illustrate the increased risk when flying VFR at night or VFR in weather. When a flight combines the two factors, the increase in risk is essentially infinite. The remaining 43 CFIT accidents that occurred in day VFR and day VMC were affected by a variety of factors, including impact with obstructions during low-level flight operations in confined spaces, and various work operations.

**Wire Strikes:** Independently of CFIT accidents, we also identified 81 fatal wire strikes, or 12 percent of the fatal accidents in the dataset. These accidents are concentrated in three countries. In South Africa, 20 percent of all fatal helicopter accidents involve wires strikes, with Australia close behind at 19 percent, followed by the US at 14 percent. In contrast, wire strikes account for just 5 percent of fatal accidents in New Zealand and Canada, while the UK had no fatal wire strikes in the 15-year data set.

Just over half of these accidents involved missions that inherently require low-level flight, including agricultural operations, mustering/herding, observation/surveillance, search and rescue and some lift operations. Private or personal flights accounted for 22 of the 81 (27 percent), followed by training/instruction as a distant third-most common mission.

Night VFR was less of an issue in wire strikes than in many accident categories. Night VFR accounted for just seven of the 81 accidents, or 8.6 percent compared to 21.5 percent of all other accident categories. Significantly, though, of the seven night VFR wire strikes, just one involved a mission that inherently requires low-level flying (police action).

Common issues in wire strikes included inadequate pre-flight preparation was a common issue, as was a failure to follow planned routes. In-flight decision making also is a significant factor in wire strikes during private flying and training. Some of these accidents include ostentatious but, almost by definition, the involve flying at very low altitudes.

Technology could help to reduce these accidents. Wire strike prevention systems (e.g., wire cutters) might be the most obvious tool, but other tools would include more use of radio altimeters, alerts based on pre-set altitudes, GPS mapping or other detailed mapping of obstructions.

**Behavioral Issues:** In addition to all the above issues, some accidents involve serious behavioral issues. For example, of the 672 accidents in our dataset, 20 reports identified pilots who were impaired by alcohol, medications or illicit drugs, or some combination. At 3 percent of our accidents, this is a small but not a trivial share, and several more cases likely occurred but were not or could not be documented.

In several of the 20 cases, employers could have or should have detected problems. The two most obvious examples involved alcohol. In one case, a pilot's blood alcohol content (BAC) was reported at 0.153 percent. Performance of course deteriorates with just a single drink, but we begin to meet common definitions of "drunk" by 0.08 percent. At 0.153 percent, this pilot would have been visibly drunk. A second example involved a pilot who crashed after losing control at 0900 in the morning and was found to have a BAC of 0.08 percent – at 0900. He had reported for duty earlier that morning after drinking wine "late into the night ... with colleagues" on the operator's premises then was paired with a co-pilot who was not qualified on the aircraft. In either case, a random alcohol testing regime likely could have identified problems with both pilots well before the accidents, or a comment from a co-worker could have prevented the accidents. However, preventive action is more difficult with private pilots flying their own aircraft.

We also identified 28 other fatal accidents in which behavior often was egregiously irresponsible or at least invited a reaction of "what was he thinking?" Several of them involved buzzing and ostentatious display, including the classic "watch this." A few more such cases may have occurred but with no survivors to describe the events. Some of the pilots involved in these examples, like the two alcohol examples noted above, very likely would have been flagged by their commercial operators if those operators had data monitoring or other internal reporting programs.

Other examples include various categories of commercial operators knowingly using helicopters that were not airworthy, knowingly using a pilot who was not properly licensed, etc. Finally, the 28 include several extreme cases of pressing to get home or to complete a mission. In short, up to 8 percent of fatal accidents involved impairment from alcohol or drugs, or irresponsible behavior. This may be a modest share, but it is not trivial.

### **Do Investigations Make a Difference?**

The theme of this year's ISASI seminar asks whether investigations really make a difference. The short answer is yes. Accident and incident investigations document facts and allow us to analyze what happened, how and why. The process has informed the aviation community for nearly 100 years about interventions that could improve safety. In today's data-rich world, investigations have been the primary source for identifying what factors we track and analyze from operational data. Investigations also continue to be the primary source of documentation for current efforts to improve helicopter safety, such as the effort by the US Helicopter Safety Team. However, two investigative tools could help the investigative process to improve our understanding and analysis of helicopter accidents.

First, as the investigation community has recommended for years, digital flight data recorders (FDRs) need to become commonplace in helicopters, at least in commercial operations. FDRs would produce data with which to document exactly what happened in most cases. Voice recorders also would help, even in single-pilot operations, by capturing on-bound sounds, but flight recorders are more urgent. This is always a controversial suggestion, primarily due to cost, but they would substantially reduce findings such as "lost power for unknown reasons" or "lost rotor RPM for unknown reasons."

The second and easier tool to implement would be the development of an investigator's checklist designed explicitly for helicopter accidents. Investigations often are undertaken with an airplane frame of reference and more than a few issues that are unique to helicopters can be overlooked. A specifically designed checklist could focus some investigations. A checklist specifically designed to address the idiosyncrasies of helicopter operations could help to provide complete information that may otherwise not be captured in the course of an investigation.

## Recommended Interventions

We have outlined some opportunities for training and outreach, management processes and technology. Below is a more explicit listing of interventions that we recommend at least for consideration. We recognize that some face practical barriers, primarily the difficulty of influencing actual behavior, while others may face pricing barriers and/or political barriers.

### Training Recommendations

Every safety study seems to include suggestions for training. This one is no exception. We recognize the increased costs and time that more training requires, and we recognize the limitations of training, particularly one-off efforts. Nevertheless, the accident data suggests that more training can help. Below is a list of recommended targets, starting with some of the more basic targets.

**Pre-flight planning**, with particular attention to weather, fuel and known mechanical issues, requires more attention in instructional programs, recurrent training or review programs and training programs operated by larger operators. Pre-flight should be routinely assessed as part of any routine training or as part of any internal reporting or data monitoring programs.

**Risk Assessment** is a close relative to better pre-flight planning, with emphasis on weather, the substantial increase in risk when flying VFR at night, the quality of the planned landing zone, pilot pairing in two-pilot crews, etc. Like pre-flight training, risk assessment needs to be a basic element in any routine training as well as any data monitoring and internal reporting program. The ultimate target would be to influence go/no-go decisions and in-flight decision making.

**How To Exit IMC** and how to recognize signs of deteriorating weather could help to address the high share of fatal accidents that involve IMC in all categories of helicopter operations.

**Proper Autorotations**, including the early recognition of when an autorotation is prudent or required, could reduce LOC accidents, but also a significant number of accidents that occur on landing or while responding to manageable in-flight problems. We recognize that successful autorotations sometimes are not feasible due to an absence of safe landing areas or due to insufficient altitude when a problem develops, but about 7 percent of all fatal accidents included a failure to enter timely autorotations or a

failure to execute them properly. When related factors are included, such as **low rotor RPM**, mast bumping and low-G maneuvers, the modest number of 7 percent increases substantially. Note that training to these issues would be especially useful in light piston helicopters but the issues can apply to turbine helicopters as well.

**Line Orientation Flight Training (LOFT)**, the effectiveness of which is well established in the commercial airplane world, should be instituted in commercial helicopter operations, including but not limited to EMS and passenger air taxis. It should also be considered by private entities that regularly transport their own employees or contract employees. Training scenarios would be based on well documented accident accidents and should involve inadvertent entry into IMC, spatial disorientation, LOC, and CFIT.

**Require Mandatory Quarterly Instrument Training** for pilots in certain commercial operations, such as EMS and passenger-carrying air taxis, to acquire 1.5 to 3 hours in high-fidelity simulators or in actual helicopter flight with a safety pilot. This training should include basic IFR skills, such as climbs, turns, descent, unusual attitude recovery, and ILS and GPS approaches. Where special ratings or authorization is required for pilots to fly VFR at night, the training could apply to all authorized pilots, albeit with less demanding requirements for private and some small commercial operators. This type of systematic training, rather than a one-off effort, could help to reduce both LOC and CFIT accidents, but particularly LOC accidents.

**Upset Training** should be added to training programs that use high-fidelity simulators. Again, as a systematic effort, such training could help to reduce LOC accidents, many of which appear to involve spatial disorientation.

## **Process Recommendations**

The aviation safety community has long advocated the adoption of several key processes to reduce accidents throughout the system. These include at least the following.

Establish and enforce **Good Standard Operating Procedures (SOPs)** to train to those SOPs. This clearly is more feasible for larger operations and larger maintenance facilities. However, programs operated by manufacturers, safety alerts from safety organizations and efforts by various user groups can and do provide assistance to private pilots or small operators. The central objective of all these efforts is straight forward: to the degree possible, do it the same way every time.

Establish **Non-Punitive Reporting Systems** to help identify unanticipated or unrecognized issues. Again, this may appear more feasible for larger operators but in fact it is equally pertinent to small operators.

**Establish Data Monitoring Programs** to monitor aircraft health and operational consistency. Doing this right requires a staff that can interpret this data. Again, this may be more feasible for larger organizations, but various programs operated by manufacturers and some industry groups can enable private pilots and small operators to benefit from such programs.

**Improve Heliport Oversight and Enforcement** to correct and avoid improperly designed helicopter infrastructure or improper implementation of aviation standards, which can create needless risk. Examples include non-existent approach or departure paths, confined areas that require maximum performance capabilities, architecturally induced turbulence, nearby and on-site obstructions, etc. Operators may range from large hospitals and off-shore energy platforms to resort hotels or restaurants, and everything in between. This could be accomplished by more comprehensive regulatory authority or by a third-party program for heliport accreditation administered by insurers or industry organizations. Effectiveness obviously would be limited to operations to or from something that qualifies as a heliport. The objective would be to ensure that proper safety standards are incorporated and then maintained in heliport design and operations.

### **Recommended Technology**

More extensive use of technology could help to continue lowering helicopter accident and fatal accident rates, particularly in larger commercial fleets. Substantial gains already have been achieved with tools like FADECs, engine control units, the application of three-axis autopilots, etc. Nevertheless, a broader application of technology could substantially reduce the fatal accident rate. Most of the technologies recommended below target the factors that are dominant in our data set, particularly night flight, weather, loss of control and CFIT.

**Helicopter Terrain Avoidance Systems (HTAWS)** has been greatly improved since it became available around 2001 and now is required in EMS operations in the U.S. where it had already penetrated about 20 percent of the EMS fleet by 2014. However, it could prove equally effective in any other helicopter operations involved in the movement of passengers, especially at night, where it could assist pilots who lack external visual clues in low-visibility conditions. Cost remains a barrier. Retrofits would cost about \$35,000 per unit.

**Three-Axis Autopilots** would enable pilots to maintain a stable flight path and would thereby reduce a pilot's workload and susceptibility to spatial disorientation during low-visibility operations and during recovery maneuvers after inadvertently entering IMC. This would reduce LOC at night and during other low-visibility conditions. EMS is an obvious candidate, but the equipment would benefit other passenger operations as well. Again, cost is the primary barrier, with retrofits costing up to \$25,000 per unit.

An **On-Board Forward-Looking Device** should be developed to identify low-visibility conditions ahead or to display narrow spreads between air temperature and dew point at various altitudes. The device would include a warning to the pilot when visibility ahead is likely to deteriorate with an estimate of distance in order to inform the pilot's in-flight decision making.

**Night Vision Goggles (NVGs)** obviously target only accidents that occur in darkness, but by capturing minimal ambient light or even limited star light to provide an external image, broader use of NVG could substantially reduce the 20 percent of fatal helicopter accidents that occur at night. NVGs of course have

limits, such as minimal effectiveness in absolute darkness or in brightly lighted areas, and the visual field is mono-colored which invites a loss of depth perception. They also can feel cumbersome and, depending on the version being used, may have a limited field of view of 40 to 60 degrees. The biggest barriers to greater use are the cost of initial purchase, the cost of maintenance, and the need for initial and recurrent training. Nevertheless they can substantially increase situational awareness at night and could reduce LOC, CFIT and landing accidents.

**On-board Color-Coded Weather Displays** similar to the current computer-generated on-line HEMS weather tool provided by the Aviation Weather Center could display color-coded ceiling and visibility in the cockpit. This would help to reduce inadvertently flying into IMC and it would provide intuitive information more rapidly to pilots who may be dealing with any kind of on-board problem and it would negate the need to page through multiple weather reports or listen to multiple AWOS stations, both of which could lead to head-down situations and increased susceptibility to spatial disorientation. It also would be a valuable tool for pilots who must make quick go/no-go decisions to or from remote sites.

**Integrate Available Weather Reporting Stations** into weather information that currently is distributed by civil aviation systems. Those systems typically report weather within a 30-mile radius of an aviation weather reporting station, which leaves large areas, especially at low altitude, with no reported weather. Yet, countless other weather stations exist that can offer pertinent information if they were integrated into the standard system of weather dissemination. That information often would not be as comprehensive as official weather systems, but some information is far better than no information. This is especially important for EMS helicopter operators and some air taxis that operate in sparsely populated areas since they do not normally operate from airports where aviation weather reporting systems are available. Instead, they often are required to operate from rural and remote sites or hospitals where no aviation weather reporting stations within 30 to 60 miles.

## Summary

The helicopter community has a good safety story to tell. The fatal accident rate has improved by 60 percent since 2003 and the rate continues to improve. Nevertheless, the fatal accidents that continue to occur often involve age-old issues, such as a high rate of VFR flying at night, flying VFR into weather and inadequate pre-flight planning, including go/no-go decisions. LOC and CFIT accidents continue to account for a substantial majority of accidents and each is strongly influenced by night flying and by weather. Other common issues include pilot performance (at least in accident flights), dispatch and other issues in larger organizations, including a failure to establish, follow and to monitor good standard operating procedures.

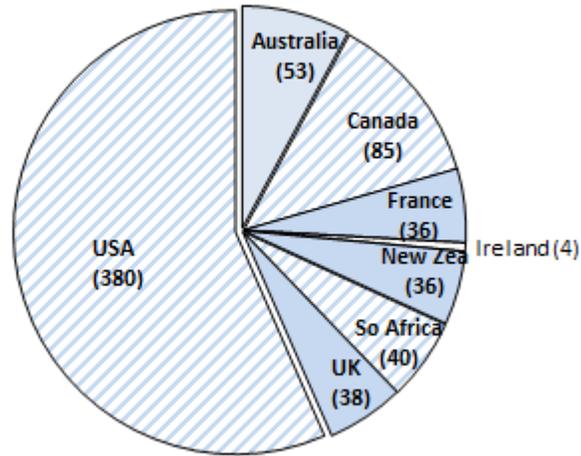
However, accident rates differ significantly by category of helicopter. Those rates are influenced by differences in basic capabilities but perhaps more by differences in who is flying the equipment, the mixture of missions in each category, differences in instrumentations, etc. Each country likely needs to adapt any concerted safety effort to reflect its own fleet mix; one size may not fit all.

Recommendations focused on the need for more thorough pre-flight planning and training as a starting point for reducing accidents in night VFR and in IMC. Training and better pre-flight are standard recommendations in any safety study, but they are difficult to do effectively. It must be repeated and sustained, and that can be costly and time consuming.

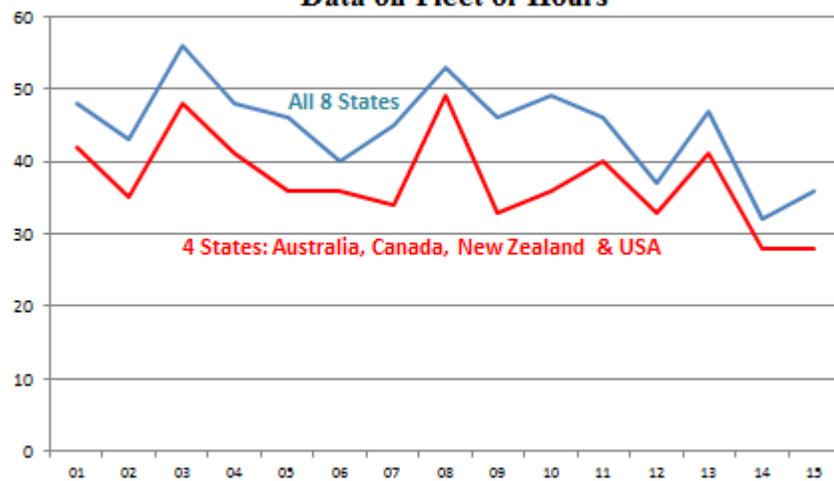
We also have recommended that more organizations adopt non-punitive reporting programs and more use of meaningful data monitoring. These approaches may be more difficult options when addressing private pilots and small organizations and, even in larger organizations, they require staffs that can understand and analyze the information. Again, this is not free.

However, we also have recommended multiple technological interventions that can further improve helicopter safety, particularly by reducing LOC and CFIT accidents. They include but are not limited to greater use of TAWS and night vision goggles, more use of on-board weather detection systems, three-axis autopilots, greater attention to helipad design and more. Cost is the most common barrier to broader application of these technologies.

**Figure 1. Fatal Helicopter Accidents in Dataset, By Country of Operator, 2001-2015, Total 672**

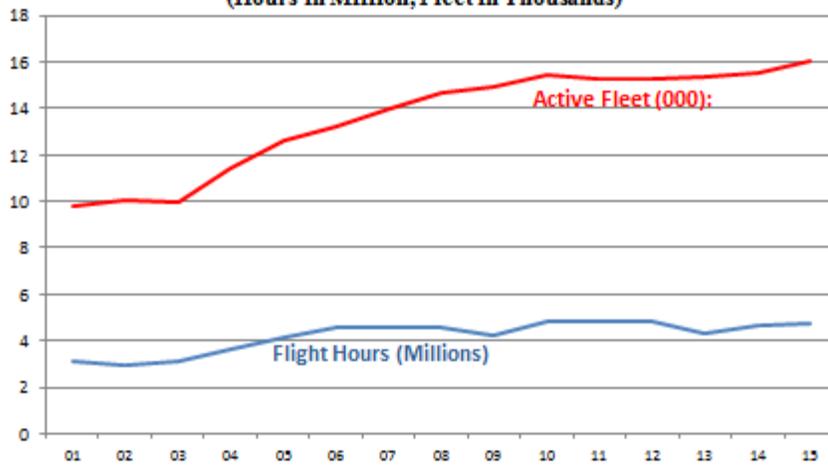


**Figure 2. Fatal Helicopter Accidents, 2001-2015, Eight States in Study & Subset of 43 States with Adequate Data on Fleet or Hours**

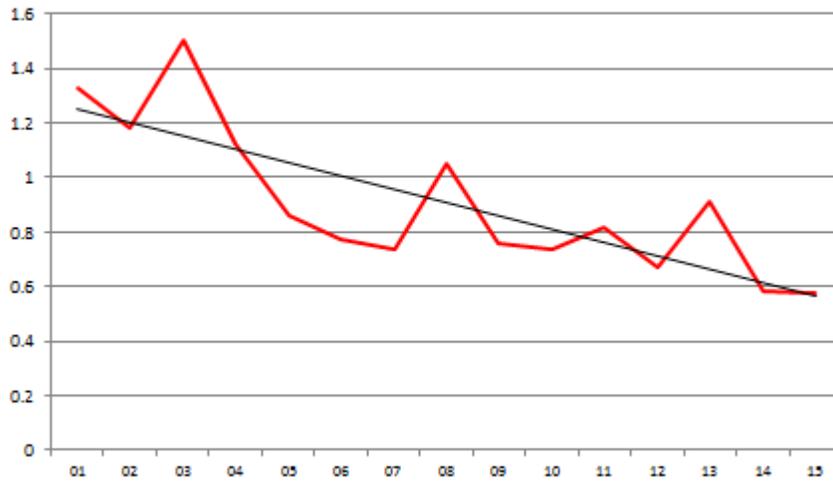


Eight states are: Australia; Canada; France; Ireland; New Zealand; South Africa; United Kingdom; United States

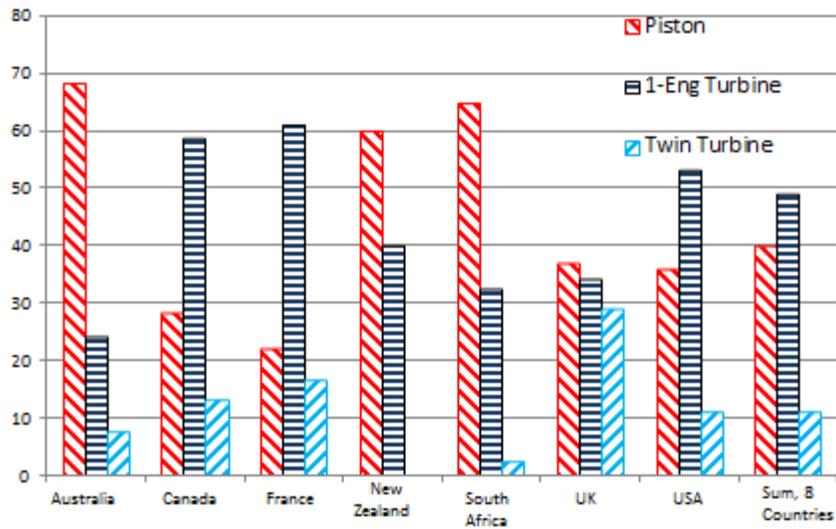
**Figure 3. Trends in Helicopter Fleet & Flight Hours, Australia, Canada, New Zealand & USA**  
(Hours in Million, Fleet in Thousands)



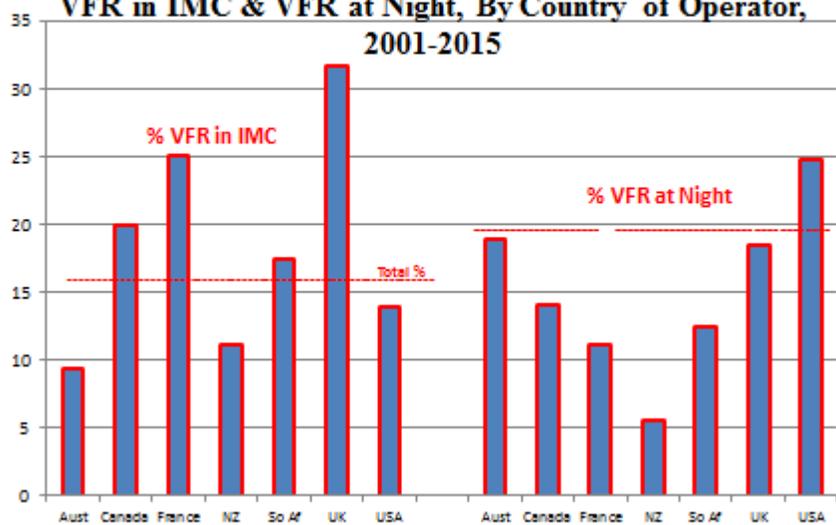
**Figure 4. Fatal Accident Rate & Trend Line: Australia, Canada, New Zealand & USA, 2001 Through 2015**



**Figure 5. Percent Distribution of Fatal Helicopter Accidents, by Country & Class of Helicopter, 2001-2015**



**Figure 6. Percent of Fatal Helicopter Accidents VFR in IMC & VFR at Night, By Country of Operator, 2001-2015**



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<sup>i</sup> Data Insight: Helicopters 2015, Flight Global, October 2015.

<sup>ii</sup> Canada published annual flight hours for helicopters through and including 2010. Thereafter, Canada's annual Statistical Summary published only total GA hours, without identifying helicopter hours. Data in Figure 2 for Canada from 2011 through 2015 was estimated based on extending three trend lines: (1) helicopter hours for 2001 through 2010 were extended through 2015; (2) helicopters' percentage of all reported GA hours for 2001-2010 was extended to 2015 and was applied to total reported GA hours for those years; and (3) total helicopter hours for 2001-2010 were compared to total reported GA hours for 2001-2010 and that share was applied to total GA hours for 2011-2015. Finally, the mean of the three results was used to estimate fleet and hours for 2011-2015.

<sup>iii</sup> The comparison of rates by helicopter class is based on 10 years of data on flight hours from the U.S. because the GA Survey distinguished between by the type of power plant and number of engines, rather than just the number of engines, with no clear distinction between reciprocating and turbine engines as is the case with data from several other countries. The quality of that U.S. data improved significantly beginning in 2004 and 2005, so a more traditional 10-year period is used here (2006-2015) rather than comparing the entire 15-year study period used elsewhere in this paper. However, the 2011 Survey was not published by FAA. As a result, data for 2011 was pro-rated based on (negative) growth rates from 2010 to 2012.