



# Epidemiology and Prevention of Helicopter External Load Accidents

Jan C. Manwaring, George A. Conway, and Larry C. Garrett

From 1980 through 1995, there were 230 helicopter external load accidents resulting in 57 fatalities and 74 serious nonfatal injuries in the United States investigated by the National Transportation Safety Board (NTSB). Helicopter external load operations, such as helicopter logging, place unique demands on the aircraft helicopters and the pilots who fly them. A descriptive analysis of NTSB "accident briefs" indicates that mechanical failure, pilot error, and maintenance errors were cited as the most common probable causes of the accidents. Recent experience in Alaska has shown that by adhering to existing regulations and manufacturer recommendations, and by implementing improved training and frequent maintenance, helicopter external load operations are safer with fewer accidents, crashes, and injuries. Published by the National Safety Council and Elsevier Science Ltd

**Keywords:** Helicopter external load operations, helicopter fatalities, helicopter nonfatal injuries

## INTRODUCTION

For several reasons, the helicopter represents a commercially viable option for helicopter log-

ging operations and for lifting and transporting other heavy objects. Many heavy lift sites are located in rugged terrain or on steep slopes that make them inaccessible, economically impractical, or environmentally restricted for conven-

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tional crane, cable rigging, and surface transportation. This has resulted in an increased use of helicopter external load operations (Georgia Forestry Commission, 1986; Proctor, 1994; Stehle, 1990).

Helicopter external load operations, both lift-load and long-line, have gained wide acceptance for use in logging, construction, seismic, fire-fighting, and for other lift and transport purposes (Herlihy, 1996). However, numerous accidents resulting in serious injury and death are associated with these operations. According to accident investigation data from the National Transportation Safety Board (NTSB), there were 230 helicopter external load accidents reported to and investigated by the NTSB during the 16-year period from 1980 through 1995. These incidents resulted in 57 fatalities and 74 serious non-fatal injuries (NTSB, 1997). The NTSB accident data reported the most common probable causes and other contributing factors. Accident rates for each probable cause could not be determined because exposure (denominator) data were not available.

Compared to fixed-wing aircraft (airplanes), rotary wing aircraft (helicopters) have a higher accident rate and helicopter pilots are in a higher-risk group for fatal injuries. Helicopters are at an increased risk for crashing when compared to fixed-wing aircraft, and helicopter pilots have been cited as a high-risk group for fatal occupational injuries (Conroy et al., 1992). According to NTSB data for 1990–94, the accident rate for all helicopters was 10.4 accidents per 100,000 flight hours, while the accident rate for all fixed-wing aircraft was 8.2 accidents per 100,000 flight hours (Bradley, 1997). There are many reasons for these higher accident rates. This analysis focused on helicopter logging external load accidents in Alaska. The findings, the action taken, and the decreased external load accident rate are applicable wherever these operations occur.

## BACKGROUND

Most phases of helicopter external load operations are conducted while in a hover or at very low airspeeds. This places the aircraft and the pilot in a high-risk flight regime for long periods of time. Rotary wing aerodynamics are fundamentally different from fixed-wing aircraft. Fixed-wing aircraft, as the name implies, rely

on the airflow over the fixed wing surface for lift. They glide and have fewer movable control surfaces and dynamic components that must be coordinated and adjusted to maintain flight. Rotary wing aircraft rely on a movable, rotating wing for lift. High dynamic loading is placed on the components to maintain flight. The rotor begins to fly in the traditional sense after forward flight produces translational lift, and rotary wing flight occurs.

In the event of a power failure or other type of emergency in a hover, the aircraft does not glide. The ability to successfully recover by “autorotation” involves unloading the rotor, thereby reducing the angle of attack on the blade. This permits the rotor speed to increase. The pilot then increases the angle of attack on the rotor in order to land successfully. The ability to land safely is a function of pilot reaction time, hover height, and rotor response time. The area beneath the aircraft (“landing zone”) may or may not permit a safe landing despite a successful recovery (see Figure 1).

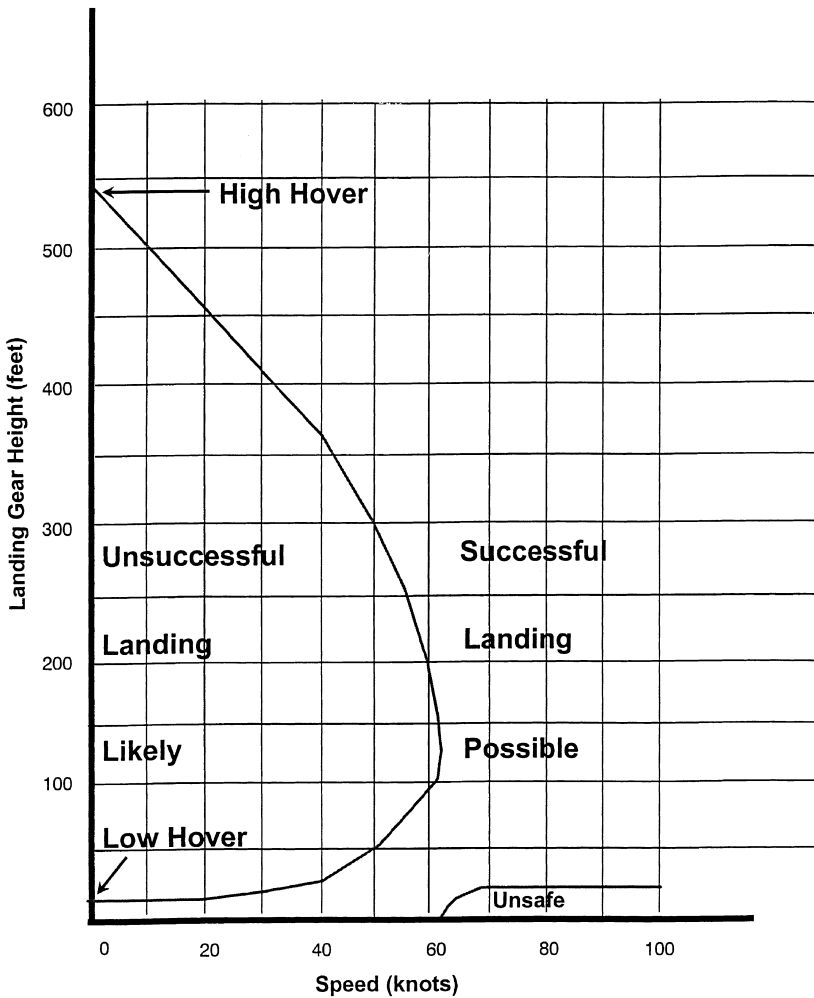
The ability to successfully recover during rotary wing flight depends on the pilot’s reaction time, rotor recovery time, altitude, airspeed, and aircraft weight. During flight, the helicopter has a very limited gliding distance due to its low airspeed, which provides some additional time in order to execute autorotation procedures, reduce aircraft weight, select a safe landing site, and prepare for landing (see Figure 1).

The greater number of moving parts necessary to keep the helicopter flying, the stress on the dynamic components, and the hydraulic systems requires more maintenance per flight hour than fixed-wing aircraft. A small airplane requires only an engine, propeller, and wires to move the control surfaces to maintain flight.

## Helicopter Operating Environment

Because of their capability to operate in remote and unusual terrain, helicopter operations are often conducted under extreme and demanding circumstances that place high demands on the aircraft, pilots, and maintenance and other personnel that support those operations. These operations rely exclusively on the pilots’ skill to continually mentally recalculate all the factors during each phase of a flight. The high volume of these operations and absence of environmental aids such as air conditioning, hour after hour, place excessive demands on man and machine,

FIGURE 1. Height-velocity curve for single-engine helicopter autorotation regions (adapted from R.W. Prouty, *Helicopter Aerodynamics*, Phillips Publishing, Inc., Potomac, MD, 1985, p. 80).



greatly increasing the likelihood for human error and machine failure (USC Institute of Safety and Systems Management, 1992).

Perhaps no other external load operation better illustrates these inherently complex and demanding circumstances than helicopter logging, or "heli-logging." A typical logging helicopter carries an approximately 200-foot-long cable, or long-line, which is attached by a hook to the belly of the helicopter. A second hook is attached to the free end of the long-line, where a choker cable (a cable apparatus designed to cinch, or "choke," around suspended logs) is connected to haul one or several logs per load

(a typical load may weigh from 6,000 to 10,000 pounds). The load is released by the pilot with an electronic control that opens the second hook. A helicopter used in logging operations may complete 250 to 320 load/lift cycles, or "turns," each day; each turn takes one to three minutes to complete. These highly repetitive lift/transport/drop turns are frequently conducted at or beyond maximum aircraft capacity in remote areas where rugged forest terrain, extremely steep mountain slopes, and adverse weather conditions prevail.

Under these conditions, and when combined with inadequate equipment maintenance, heli-

copter flight components and equipment have been known to fail with tragic regularity (CDC, 1994; TSB, 1991). One pilot with 20 years experience (and over 18,000 flight hours) in helicopter logging stated his concerns about heli-logging with single-engine helicopters and the need for redundant systems: "Imagine accelerating your automobile engine from idle to full throttle 320 times a day, six days a week, 52 weeks a year. Engines do quit, clutches fail, inputs fail, fuel pumps stop pumping, accessory drive shafts break, power plants do stop running, and most always at times when the pilot least expects it to happen. However, if he is flying a helicopter with two engines, things are a whole lot easier to handle. . . . These helicopters have (in addition to two engines), two servo systems, two electrical systems, two fuel systems, and two pilots!" (Lindamood, 1996).

Pilot in-flight decision-making and task saturation are critical to the safety of helicopter external load operations. The experienced heli-logging pilot quoted above also stated, "The small engine aircraft [helicopters] usually have only one pilot, who flies all day long. He must divide his attention between the engine temps, pressures, power gauges, warning lights, fuel quantity, and weight cell, as well as watching his load to keep it clear of obstacles and ground personnel and his rotor blades out of the trees. While concentrating on all this, he very often lifts off too much weight and over-grosses the aircraft before he realizes it" (Lindamood, 1996). Under such complex operations, it is not uncommon for a helicopter long-line to suddenly snag on a tree, log, stump, or forest debris, which can lead to a disastrous outcome (NTSB, 1997). Helicopter pilots have also been known to conduct external load operations with insufficient fuel on board, either unintentionally or intentionally (NTSB, 1997). The main reasons are as follows: Task saturation can result in pilot inattention to a low fuel gauge. Exacerbating the problem is the fact that pilots often lift increasingly heavier loads as fuel is consumed (Herlihy, 1996). Doing so increases mental processing, resulting in a greater potential for inattention to an already low fuel gauge (Skjenna, 1986). NTSB data and an NTSB recommendation to the Federal Aviation Administration (FAA) indicate "fuel starvation" as the most common type of probable cause related to crew error in helicopter external load accidents (NTSB, 1997).

Heli-logging, as well as other helicopter external load operations (which are regulated under the Code of Federal Regulations, Part 133 [FAA, 1992]) include nonregulated flight crew duty periods. At times they exceed 10 hours per day for 10 consecutive days, and fly much of the time under conditions that are unfavorable for successful autorotation of single engine helicopters in the event of engine failure or loss of power. This practice may lead to pilot fatigue of sufficient magnitude to be hazardous. Decreases in aircrew function due to fatigue from overlong and repeat missions were well described during the Desert Shield Operation (Bisson, Lyons, & Hatsel, 1993).

Ground crews supporting helicopter external load operations are frequently exposed to a number of potential hazards. For example, objects have fallen from external loads, striking and killing workers below (NTSB, 1997). Others have been killed by walking or falling into a moving tail rotor (Crowley & Geyer, 1993). Loggers and construction workers must be especially cautious of rotor downwash (the downward movement of air at high velocity caused by the helicopter's rotors), which may knock down tree limbs and send construction debris flying in all directions. Another hazard, unique to external loads, is the high static electric shock potential of the steel long-line and hook, which must be allowed to touch the ground to discharge the static electric energy before being handled.

## METHOD

NTSB Accident Briefs of CFR Part 133 helicopter external load operations in the United States, 1980–1995, were reviewed, and 65 data elements were entered into a computer database and analyzed for descriptive information about the accidents. Denominator data (such as the total number of external load flight hours or the total number of lift cycles) was not available to determine the rate information necessary for a more in-depth analysis.

The NTSB and FAA define an aircraft "accident" as an event resulting in personal injury or substantial aircraft damage. There were 230 reported accidents. A "crash" is an accident subset that involves the impact of the helicopter body or its parts, resulting in personal injury or substantial aircraft damage. The terms are not

**Table 1.** Helicopter External Load Fatalities and Serious Nonfatal Injuries in US, 1980–95, by Work Crew (*n* = 131)

Crew	Incidents (per 230 accidents)	Rate
Flight crew	44 Fatalities	19% Fatality rate
	55 Serious nonfatal injuries	24% Serious injury rate
Work crew (flight crew plus worker passengers and ground crew)	57 Fatalities	25% Fatality rate
	74 Serious nonfatal injuries	32% Serious injury rate

Source: NTSB Accident Briefs 1980–95.

interchangeable. Of the 230 reported accidents, 97% (222) were classified as crashes. The other 8 events involved the external load. For example, in one accident, a cedar block fell from an external load, fatally injuring a ground crewman (NTSB, 1997).

For purposes of this study, NTSB accident data from 1980 through 1995 provided a sufficient database, and are available on the Internet and in diskette and paper format. NTSB data are collected on private and commercial accidents. Publicly owned and military helicopter external load accident data are not included in the report.

## RESULTS

There were 230 external load accidents, resulting in a total of 57 work crew fatalities (25%

accident fatality rate), 44 flight crew fatalities (19% accident fatality rate), 74 serious nonfatal injuries to work crew (32% accident injury rate), and 55 serious nonfatal injuries to flight crew (24% accident injury rate) during the study period (Table 1 and Figure 2). The work crew distribution of fatal and serious nonfatal injuries combined were as follows: flight crew with 99 (76%), worker passengers with 24 (18%), and ground crew with 8 (6%) (Figure 3). Of the 230 accidents, there were 44 (19%) resulting in one or more fatalities, 51 (22%) resulting in one or more serious injuries, and 135 (59%) resulting in one or more minor or no injuries (Figure 4). This information indicates an excessively high rate of fatal and serious injury when helicopters crash while conducting external load operations. Although helicopters have the capability of autorotation for emergency landings, because of

FIGURE 2. Helicopter external load fatalities and serious non-fatal injuries in US, 1980–95, by work crew (*n* = 131) (Source: NTSB Accident Briefs 1980–1995).

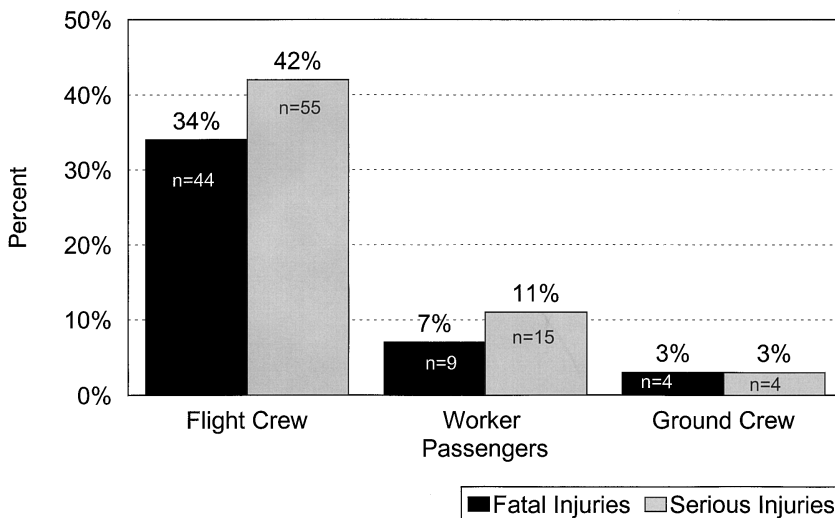


FIGURE 3. Helicopter external load fatalities and serious non-fatal injuries in US, 1980–95, by work crew ( $n = 131$ ) (Source: NTSB Accident Briefs 1980–1995).



the location of most external load operations, being able to find an accessible and suitable emergency landing site is difficult. The average age of the pilot in command for 217 accidents (age data was not available for 13 pilots) was 40 (Figure 5). This information indicates a relatively older workforce age among helicopter external load pilots than the national average workforce age of 35 (US Department of Labor, 1996).

The largest number of accidents ( $n = 25$ ) oc-

curred in 1982, and a mean of 14.4 accidents per year was observed over the 16-year period of 1980–95 (Figure 6). The majority of all external load accidents occurred during warmer weather, which may reflect the seasonal nature of these operations (Figure 7).

Of the 230 accidents, 65 (28%) occurred during heli-logging operations, and represent the largest portion of all external load accidents by type of operation. This was followed by 48 (21%) with an unspecified type of operation, 42

FIGURE 4. Helicopter external load accidents in US, 1980–95, by outcome of accident ( $n = 230$ ) (Source: NTSB Accident Briefs 1980–1995).

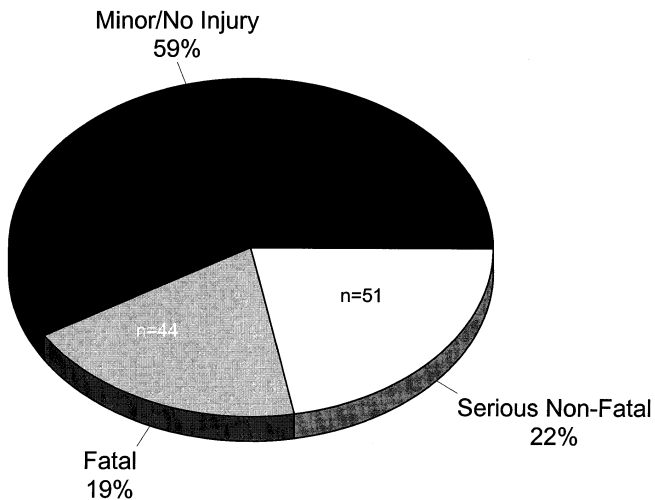
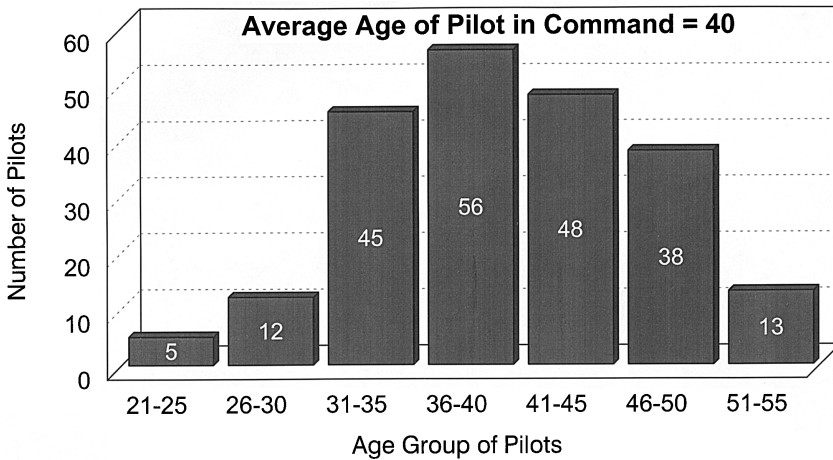


FIGURE 5. Helicopter external load accidents in US, 1980–95, by age of pilot in command ( $n = 217$ ; of the 230 accidents, age not available for 13 pilots) (Source: NTSB Accident Briefs 1980–1995).



(18%) for construction, and 29 (13%) for miscellaneous cargo (Figure 8). As mentioned earlier, the 230 accidents resulted in 131 fatal and serious nonfatal injuries. The distribution of these fatal and serious injuries was 56 (43%) for heli-logging, 24 (18%) for construction, 15 (11%) for miscellaneous cargo, and 27 (21%) for all other operations (fire control, agriculture, seismic, Christmas tree, and power line operations; Figure 9). This data clearly indicates that

in the event of an external load helicopter accident, heli-logging represents the operation of greatest risk for fatal and serious nonfatal injuries.

California leads the United States in the number of all external load accidents with 38 (17%); followed by Oregon with 29 (13%); Washington with 28 (12%); Alaska with 27 (12%); Utah with 12 (5%); and Wyoming with 11 (5%) (see Figure 10). For heli-logging accidents, Alaska

FIGURE 6. Helicopter external load accidents in US, 1980–95, by year ( $n = 230$ ) (Source: NTSB Accident Briefs 1980–1995).

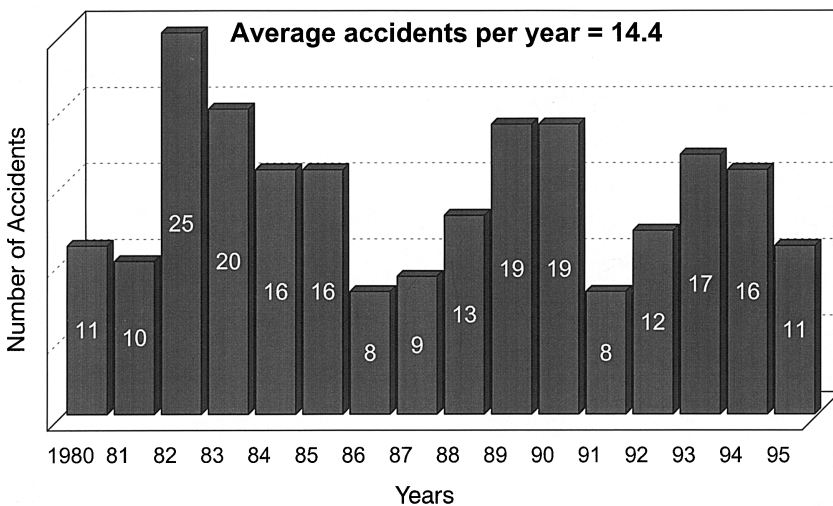
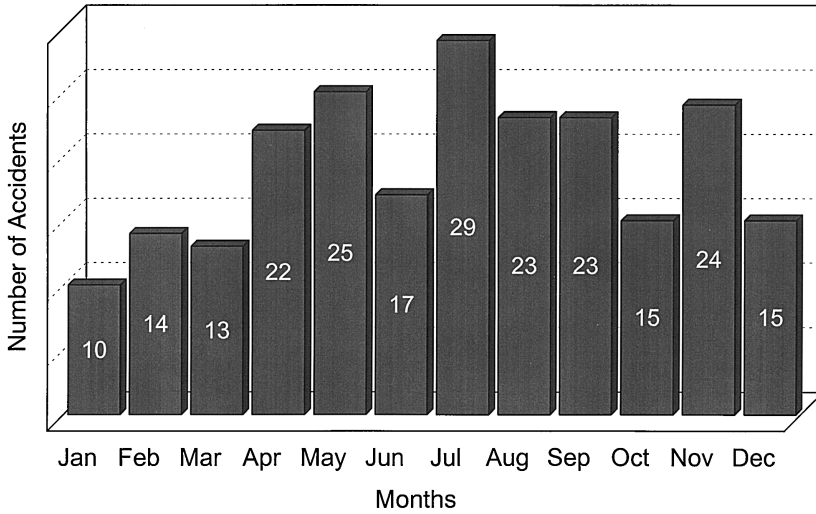


FIGURE 7. Helicopter external load accidents in US, 1980–1995, by month ( $n = 230$ ) (Source: NTSB Accident Briefs 1980–1995).



leads the United States with 14 (22%); followed by Washington with 11 (17%); California with 10 (15%); Oregon with 8 (12%); Idaho with 7 (11%); and South Carolina with 4 (6%). For construction-related external load accidents, California leads the United States with 10 (24%); followed by Alaska and Wyoming with 5 (12%) each; and Colorado, Minnesota, and Utah with 3 (7%) each. For miscellaneous-cargo-related external load accidents, California leads the United States with 6 (23%); followed by Oregon with 4 (14%); Alaska, Hawaii, and Washington with 3 (10%) each; and Utah with

2 (7%; Table 2). As indicated by this data, helicopter external load accidents occur predominately in the Pacific, Pacific Northwest, and Rocky Mountain states. Specifically, heli-logging accidents tend to occur predominately in the Pacific Northwest states. Accordingly, the data are consistent with the locations where most heli-logging and construction-related helicopter external load operations occur (Proctor, 1994).

Helicopter external load accidents most often occur during the hover and maneuver phases (35% and 23% respectively; see Figure 11). A

FIGURE 8. Helicopter external load accidents in US, 1980–1995, by type of operation ( $n = 230$ ; percentages rounded; \* = Unspecified—no flight purpose listed) (Source: NTSB Accident Briefs 1980–1995).

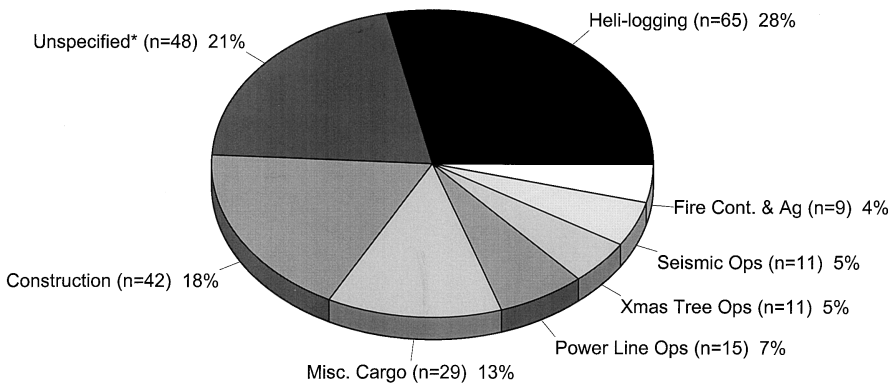
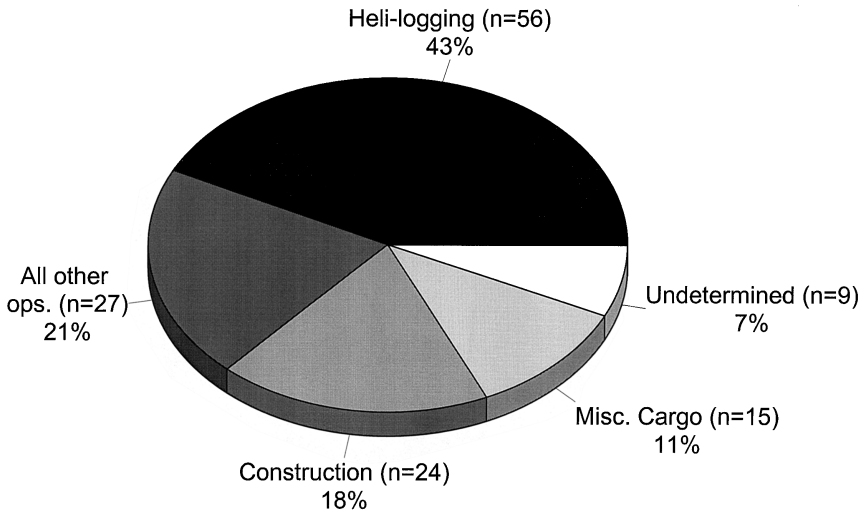


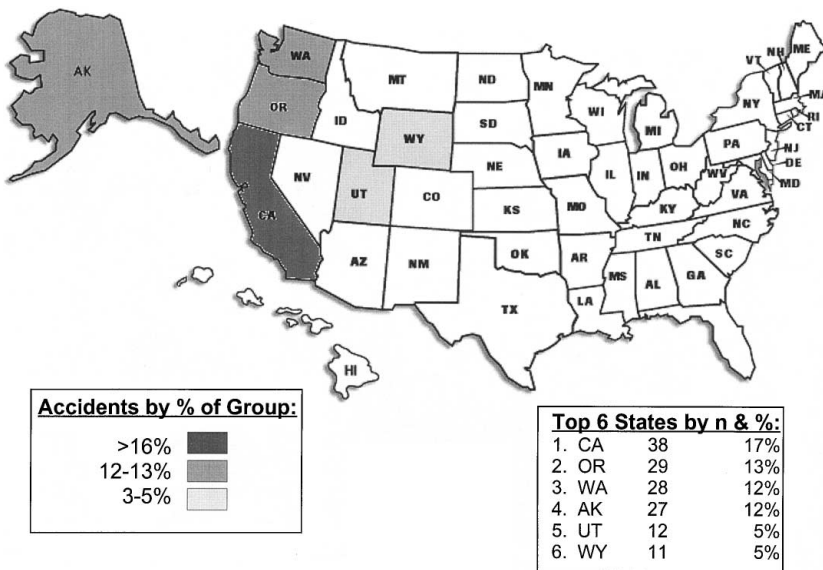
FIGURE 9. Helicopter external load facilities and serious non-fatal injuries in US, 1980–95, by type of operation (n = 131) (Source: NTSB Accident Briefs 1980–1995).



marked difference is apparent within the maneuver phase between heli-logging and all other external load accidents. For heli-logging accidents, maneuver phases account for 31%, whereas for all other external load accidents, maneuver phases account for only 19%. As pre-

viously described, most helicopter external load operations are conducted in the hover and maneuver phases of flight. This places the helicopter dangerously within the height-velocity curve where successful landing is unlikely in the event of an in-flight emergency. The problem is fur-

FIGURE 10. Helicopter external load accidents in US, 1980–95, by top six states (Source: NTSB Accident Briefs 1980–1995).



**Table 2.** Helicopter External Load Accidents in US, 1980–95, by Type and Top Six States

Type	Percent (sample size)
All external load types ( <i>n</i> = 230)	
CA	17 ( <i>n</i> = 38)
OR	13 ( <i>n</i> = 29)
WA	12 ( <i>n</i> = 28)
AK	12 ( <i>n</i> = 27)
UT	5 ( <i>n</i> = 12)
WY	5 ( <i>n</i> = 11)
Heli-logging ( <i>n</i> = 65)	
AK	22 ( <i>n</i> = 14)
WA	17 ( <i>n</i> = 11)
CA	15 ( <i>n</i> = 10)
OR	12 ( <i>n</i> = 8)
ID	11 ( <i>n</i> = 7)
SC	6 ( <i>n</i> = 4)
Construction related ( <i>n</i> = 42)	
CA	24 ( <i>n</i> = 10)
AK	12 ( <i>n</i> = 5)
WY	12 ( <i>n</i> = 5)
CO	7 ( <i>n</i> = 3)
MN	7 ( <i>n</i> = 3)
UT	7 ( <i>n</i> = 3)
Misc. cargo ( <i>n</i> = 29)	
CA	23 ( <i>n</i> = 6)
OR	14 ( <i>n</i> = 4)
AK	10 ( <i>n</i> = 3)
HI	10 ( <i>n</i> = 3)
WA	10 ( <i>n</i> = 3)
UT	7 ( <i>n</i> = 2)

Source: NTSB Accident Briefs 1980–95.

ther complicated with heli-logging where suitable emergency landing sites are scarce due to rough, uneven, and mountainous terrain.

External load accidents were analyzed for probable cause (see Figure 12). Among the 230 external load accidents, the NTSB indicated that flight crew or pilot error accounted for 102 (44%). Mechanical failures of all types accounted for 88 (38%). Improper or inadequate maintenance was cited as the probable cause in 23 (10%) of the accidents, and as a contributing factor in 21 (9%) additional accidents where the probable cause was listed as pilot error and maintenance error.

A considerable difference in the probable cause is noted between heli-logging and all other external load accidents (see Figure 12). Pilot error was listed as the probable cause in 29% of heli-logging accidents, compared to its being

listed as the probable cause in 50% of all other external load accidents. Mechanical failure was listed as the probable cause in 63% of heli-logging accidents, whereas it was listed as the probable cause in only 28% of all other external load accidents. Accidents due to specific mechanical failures such as engine parts, main rotor drive parts, and tail rotor drive parts were more than twice (2.25) as likely to occur as the probable cause in heli-logging than in all other external load accidents. Pilot error was cited as the primary probable cause more frequently in all other external load accidents than in heli-logging accidents (50% versus 29%). The most common source of specific pilot error in heli-logging accidents was fuel starvation (11%). Fuel starvation in all other external load accidents accounted for 9%.

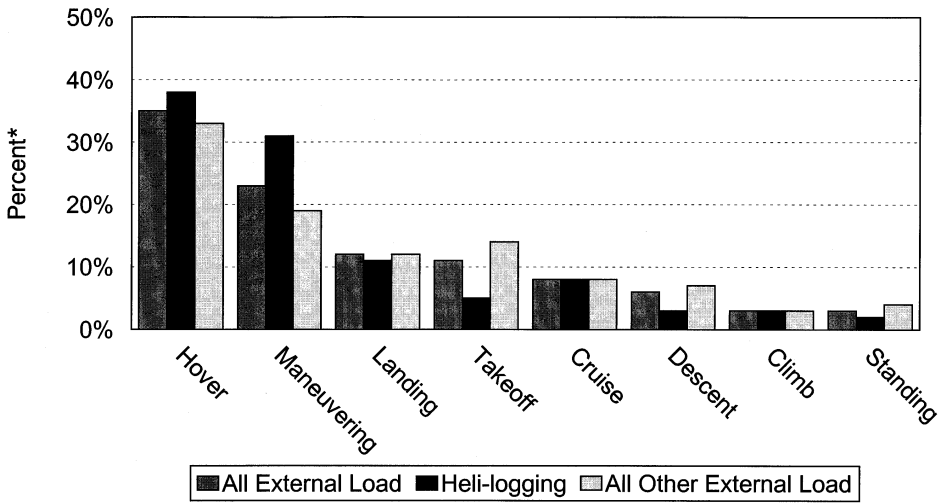
## DISCUSSION

In Alaska during 1992–93, six logging helicopter crashes occurred in an 18-month period. In response, an Interagency Working Group was formed (the Alaska Interagency Working Group for the Prevention of Occupational Injuries). The following illustrates that what started as a response to prevent logging helicopter injuries in Alaska has the potential to reduce helicopter external load injuries throughout the United States and other countries involved in similar operations (see Figure 13).

Our office convened an emergency meeting in Anchorage on July 8, 1993, to discuss approaches for reducing the number of logging helicopter crashes and ameliorating the outcome of crash injuries. The meeting was attended by representatives from the Alaska Interagency Working Group for the Prevention of Occupational Injuries (consisting of the Alaska Department of Health and Social Services, Alaska Department of Labor, FAA, NTSB, the Occupational Safety and Health Administration [OSHA], US Coast Guard, the US Forest Service, and the National Institute for Occupational Safety and Health [NIOSH]). The working group recommended countermeasures or injury prevention interventions (CDC, 1994).

During the summer of 1993, the FAA and the Alaska Department of Labor increased their inspectional oversight of flight and ground operations at helicopter logging sites. Also, during this same period of time, two of the helicopter

FIGURE 11. Helicopter external load accidents in US, 1980–95, by phase of operation ( $n = 230$ ) (Source: NTSB Accident Briefs 1980–1995).



logging companies with the most operating problems, and which each accounted for three of these serious crashes, closed down their Alaska operations. Fortunately, there are other helicopter logging companies in Alaska with outstanding safety records that had already implemented the safety recommendations made by the working group. As a result, there were no logging

helicopter crashes or injuries in Alaska from 1994 through 1995, and a single crash, resulting in one pilot fatality and one pilot serious nonfatal injury, in 1996 (see Figure 13).

Because of the previous Alaskan experience, a rising concern for helicopter logging safety nationwide, and a projected increase in heli-logging due to environmental restrictions and eco-

FIGURE 12. Helicopter external load accidents in US, 1980–95, by probable cause category ( $n = 230$ ) (Source: NTSB Accident Briefs 1980–1995).

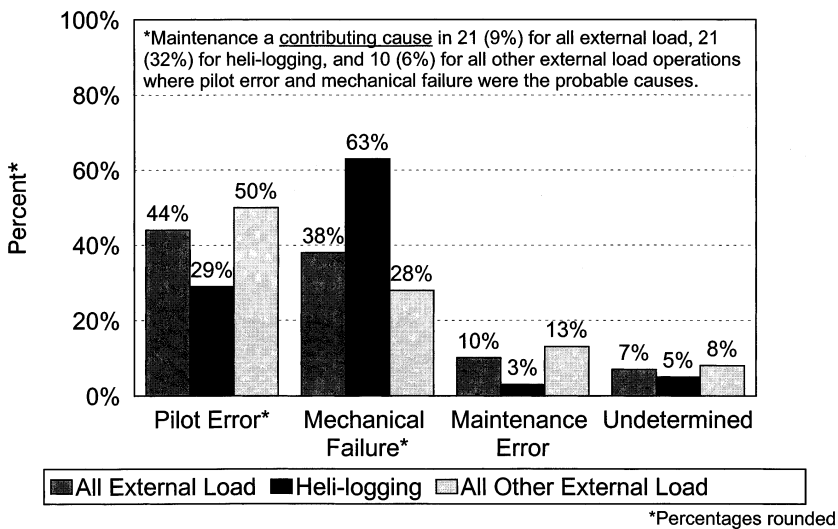
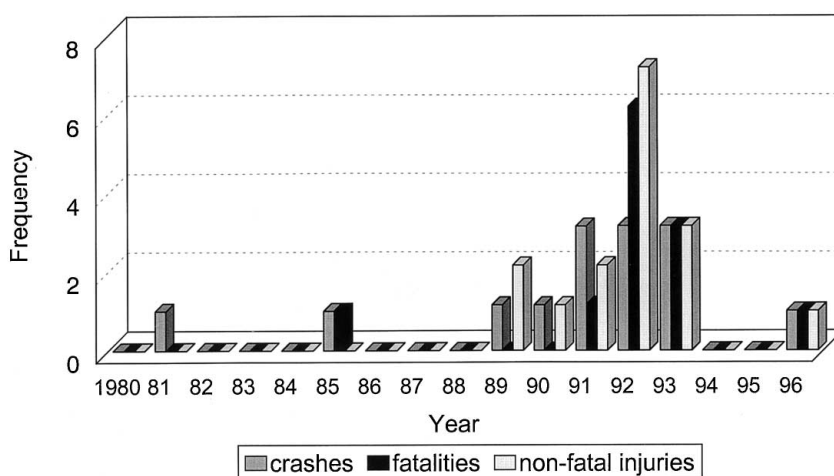


FIGURE 13. Alaska helicopter logging operations, 1980–96.



conomic factors, the Alaska Interagency Working Group for the Prevention of Occupational Injuries and NIOSH sponsored two Helicopter Logging Safety Workshops in Ketchikan, Alaska, on March 1–2, 1995, and February 28–29, 1996. The workshop objectives were to describe and analyze the risks of helicopter logging; share new helicopter logging practices and technology; foster safety research in helicopter logging operations and technology; review current regulations governing helicopter logging; consider helicopter logging safety training opportunities and options; and draft consensus safety recommendations for helicopter logging (Klatt, Hudson, & Conway, 1996). The approximately 100 workshop participants represented 12 helicopter logging companies, four helicopter manufacturers, four industry associations, five federal agencies, two state agencies, six logging companies, one university, and the Helicopter Association of Canada. Using a consensus-building group process to determine possible root causes, countermeasures, and action plans, workshop participants drafted additional safety recommendations for injury prevention in helicopter logging (Klatt et al., 1996). These are summarized in the Recommendations section.

The Helicopter Logging Safety Workshops resulted in the formation of the Helicopter Logging Committee under the auspices of the Helicopter Association International (HAI). The committee is composed of individuals from helicopter logging companies, manufacturers, insur-

ance companies, governmental agencies, and other organizations who share an interest in helicopter logging safety. According to the Helicopter Logging Committee's Terms of Reference, "The committee was formed to help promote the safe use of helicopters in all aspects of the helicopter logging industry," (HAI, 1997c). The committee is currently drafting its own "Helicopter Logging Guidelines," which address four issues: (1) general helicopter safety for forestry operations, (2) integration of ground and flight activities, (3) helicopter specific planning, and (4) a pre-accident plan (HAI, 1997b).

Other recent strategies for injury prevention in helicopter logging are being planned by helicopter manufacturers and the NTSB. Because of the disparity in mechanical failure between heli-logging (63%) and non-heli-logging (28%), helicopter manufacturers are recommending much more frequent maintenance (i.e., a much lower maintenance cycle lifetime) for helicopter parts involved in heli-logging operations (HAI, 1997a). Also, on January 9, 1997, the NTSB issued four recommendations to the FAA based on a recent external load helicopter crash in San Jose, California, that resulted in two pilot fatalities: (1) require all external load pilots to receive regular training in external load operations and to demonstrate acquired knowledge and skills; (2) require crew safety briefings during preflight preparations; (3) require that all external load helicopter flight manuals include procedures for fuel quantity and fuel reserve planning; and (4)

require periodic recalibration of fuel quantity indicating systems, and establish appropriate minimum fuel requirements for external load operators (NTSB, 1997).

## RECOMMENDATIONS

The following recommendations were developed as a result of the Helicopter Logging Safety Workshop held in Ketchikan, Alaska, in March 1995. Although the recommendations focus on preventing logging helicopter accidents, many of them can be implemented for preventing all types of external load helicopter accidents (Klatt et al., 1996).

### Equipment

- The use of multi-engine helicopters is recommended for heli-logging.
- The design, weight and balance, and operating limitations established by the manufacturer must not be exceeded.
- Heli-logging equipment and components should be certified by the FAA and overhauled in accordance with the manufacturer's documentation or manuals.

### Maintenance

- The heli-logging industry should establish standards for sound maintenance procedures.
- Adequate facilities should be available for the level of maintenance to be accomplished.
- An FAA-approved maintenance program should be established.
- Only FAA-approved parts should be used.
- All flight-critical components should have accurate historical records.
- All maintenance work should be inspected prior to sign-off by a certificated authority.

### Human Factors

- The use of a qualified second pilot is recommended for heli-logging.
- Companies should develop and publish standards for maximum flight and duty time.
- Companies should establish and enforce

standards and methods to monitor unsafe attitudes and unsafe types of competition.

- The use of drugs and alcohol in heli-logging should be prohibited, and heli-logging camps should be dry.
- There should be random drug and alcohol testing in the event of a mishap.
- The FAA should not be permitted to sanction, by way of irrevocable certification action, those individuals entering voluntary drug and alcohol rehabilitation programs.
- NIOSH should conduct or sponsor a study of cockpit environment design for improvement of comfort and safety, and chronic injury reduction.

### Training

- Helicopter model-specific and flight-specific training should be provided for heli-logging operations.
- Flight and ground crew coordination training should be provided for all heli-logging crews.
- Companies should provide maintenance training in specific helicopter models, special inspections, and documentation of maintenance operations.
- Companies should provide recurrent documented training for flight crews and mechanics.

### Management

- A heli-logging association should be established to serve as a forum and spokesman for the heli-logging industry.
- Companies should be encouraged to develop a strong safety culture within upper level management.
- Mid-level managers should be trained on the concepts and responsibilities of developing a strong safety management culture.
- Employees should be encouraged to report safety violations without fear of punishment.
- Companies should specifically designate a safety manager, with a specific job description.
- The safety manager should receive formal training on a continuous basis.
- Companies should establish an employee/management safety committee.

- All employees should participate in the management of safety.
- Company officials and employees should be made aware of the cost-benefits of an accident-free operation.
- Companies should establish task termination safety rules.

### **Oversight**

- The FAA must promptly enforce all known rule violations.
- The Staff of all local FAA Flight Standards District Offices (FSDOs) should be trained in all pertinent aspects of heli-logging operations.
- Companies should be required to give prior notification to the local FAA FSDOs concerning any proposed helicopter logging operations in their service area.

### **Interagency/Company Cooperation**

- Companies and agencies should establish a helicopter logging association and encourage membership.
- Companies should establish communication between each other when conducting heli-logging operations in close proximity.
- Companies conducting heli-logging operations in the same areas should establish joint EMS and emergency action plans.
- Companies and agencies should develop and disseminate a contractor's safety check list.
- Companies and agencies should assist each other in writing and disseminating incident and accident reports.
- Companies and agencies should develop and disseminate Standard Operations Procedures manuals.

### **Environment**

- Companies should provide improved and continual training concerning environmental hazards for all helicopter logging crews.
- Companies should establish improved communication and educate US Forest Service, state agencies, and environmental group personnel concerning the necessity of more adequate helicopter emergency landing zones, and concerning the potentially haz-

ardous combination of danger trees and rotor downwash.

## **CONCLUSIONS**

Helicopter external load operations are expanding in the United States and abroad (Georgia Forestry Commission, 1986; Proctor, 1994; and Stehle, 1990). There is a need to obtain exposure or denominator data (number of flight hours or flight cycles) within the helicopter external load industry so that injury rates can be estimated and compared to other industries. Helicopter pilots and ground crews involved in external load operations, especially helicopter logging operations, face an extremely high risk for severe traumatic injuries in the event of a crash. Inadequate equipment, improper operational and/or maintenance practices, and the lack of adequate inspectional surveillance of helicopter logging operations (to ensure equipment and operational compliance) have frequently been cited as the factors most strongly associated with the risk of crashes. The risks for fatal and serious injuries in all helicopter external load operations should and can be reduced by scrupulous attention to the needs of equipment, pilots, and crew. To minimize these hazards, external load operators (and especially helicopter logging operators) should: (1) adhere not only to existing regulations but also to manufacturer recommendations for load, lift cycle, and other appropriate applications, (2) ensure that helicopters and equipment receive more frequent and intensive maintenance, and (3) require that pilots and crew receive improved training. The Alaska experience has shown that helicopter logging can be extremely hazardous. However, it has also shown that careful attention to identifying and minimizing the risks and hazards can make all helicopter external load operations safer.

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