

Effective Injury Prevention Using Surveillance Data: Helicopter Logging, Alaska, 1992-1995

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Abstract: Background and Purpose: To reduce the fatality rate in helicopter sling-load logging in Alaska. These operations—on rugged terrain, due to environmental restrictions and economics—are an emerging technology application worldwide. During 1992 and 1993, crashes during these operations in Alaska resulted in multiple fatalities. **Methods:** During 1992, comprehensive surveillance for these events was established, combining electronic media and interagency notification with active investigation to identify preventable risk factors. These data were applied in mid-1993 by an interagency working group, which included representatives of the Alaska Department of Health and Social Services, Alaska Department of Labor, Federal Aviation Administration, National Transportation Safety Board, U.S. Coast Guard, Occupational Safety and Health Administration, U.S. Forest Service, and National Institute for Occupational Safety and Health. In response to surveillance data, consensus safety recommendations were developed. Working closely with industry, immediate improvements were made in worker training, work/rest cycles, and oversight. Surveillance results are being used to evaluate the effectiveness of interventions. On March 1-2, 1995, an international workshop was convened in Ketchikan, Alaska, to involve industry and government agencies in planning for durable prevention in this industry. **Results:** In Alaska between January 1, 1992, and June 30, 1993, there were 6 helicopter crashes, with 9 fatal (4 in pilots) and 10 severe nonfatal injuries, out of only 25 helicopters flying in helicopter logging operations. Alaska logging helicopters thus had the extraordinarily high annual crash rate of 16% and a catastrophic pilot fatality rate of 5,000/100,000/year. Investigation revealed that all crashes involved improper operational and/or maintenance practices. Since these recommendations were implemented in July 1993, there have been no additional helicopter logging fatalities in Alaska through 1995. The 1995 meeting resulted in further recommendations, including more vigorous oversight; development of rigorous voluntary industry standards for equipment, maintenance, and training; exclusive use of multi-engine rotocraft; and more vigorous controls on alcohol and drug use in this industry.

Keywords: Alaska; Injury prevention; Helicopter logging; Occupational injury/mortality; Injury surveillance

BACKGROUND

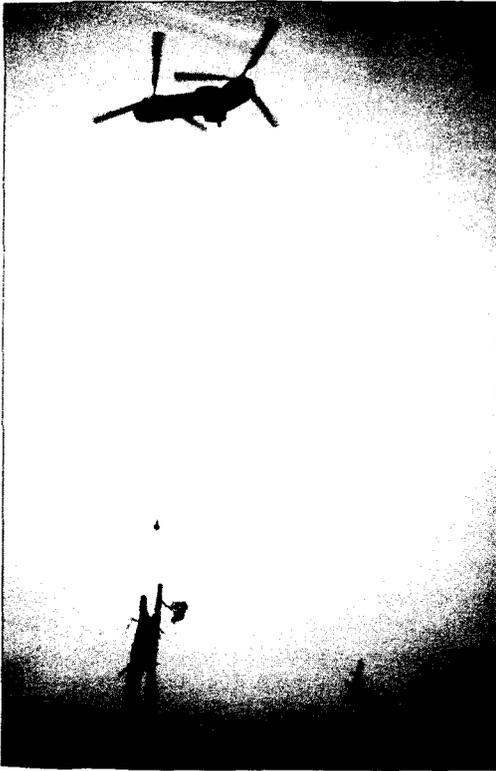
Helicopters are used by logging companies in the Southeastern Alaska panhandle to harvest timber in areas that otherwise are inaccessible and/or unfeasible for conventional logging because of rugged terrain, steep mountain slopes, environmental restrictions, or high cost. The National Transportation and Safety Board (NTSB) investigated six helicopter crashes related to transport of logs by cable (i.e., long-

line logging*) that occurred in Southeastern Alaska during the period January 1992 to June 1993 and resulted in 9 fatalities and 10 nonfatal injuries. This report presents case investigations of these incidents.

METHODS

Statewide occupational injury surveillance in Alaska through a federal-state collaboration was established in mid-1991, with 1992 being

* A typical long-line logging helicopter carries an approximately 200-foot load cable (i.e., long-line), which is attached by a hook to the underside of the helicopter. A second hook is fixed to the free end of the cable, where a choker cable (an apparatus designed to cinch or 'choke' around suspended logs) is connected to one to four logs per load.



Helicopter long-line logging in Southeast Alaska.

the first full year of comprehensive population-based occupational fatality surveillance for Alaska. Sources of information included preliminary and final investigative reports from the NTSB, death certificates, medical examiners' reports, Alaska State Troopers' reports, and emergency medical service records.

RESULTS

Incident 1. On February 23, 1992, a helicopter crashed while transporting nine loggers. The copilot and five loggers died; five others were seriously injured. The

NTSB investigation revealed that a long-line attached to the underside of the helicopter became tangled in the tail rotor during a landing approach, causing an in-flight separation of the tail section.¹ Passenger flights with long-line and external attachments are illegal² and violate industry safety standards.

Incident 2. On March 6, 1992, a helicopter crashed while preparing to pick up a load of logs with a long-line. The pilot and copilot were seriously injured. According to the pilot and copilot, the engine failed, and the pilot immediately released the external log load and attempted autorotation.**

Incident 3. On November 10, 1992, a helicopter crashed while attempting to land at a logging site, sustaining substantial damage. The solo pilot was not injured. NTSB investigation revealed that the helicopter's long-line had snagged on a tree stump during the landing and that the company had no documented training program.¹

Incident 4. On February 19, 1993, a helicopter crashed from a 200-foot hover after transporting two logs to a log-drop area. The pilot and copilot were killed. NTSB investigation revealed in-flight metal fatigue of a flight-control piston rod.

Helicopter long-line accident at Dora Bay, Alaska.



**Autorotation allows a helicopter to make an unpowered descent by maximizing on the windmilling effect and orientation of the main rotor. Forward airspeed and altitude can be converted to rotor (centrifugal) energy to reduce the rate of descent. Successful autorotation depends on helicopter airspeed and altitude when the maneuver is attempted.³ Most helicopters conduct long-line logging operations with minimal or no forward airspeed at less than 400 feet above ground level. Optimal conditions for emergency autorotation require an altitude of at least 500 feet above ground level and airspeed of more than 60 knots per hour.

Incident 5. On May 2, 1993, a helicopter crashed during an attempted emergency landing after using a long-line to lift a log 1,200 feet above ground level followed by rapid descent to a 75-foot hover. The pilot died, and a logger on the ground was injured. NTSB investigation revealed an in-flight separation of the tail rotor and tail rotor gear box from the helicopter. The company had been using a flight procedure that would have heavily loaded the helicopter drive train.¹

Incident 6. On May 8, 1993, a helicopter crashed after attempting to lift a log from a logging site with a long-line. The pilot and copilot sustained minor injuries, but the aircraft was substantially damaged. NTSB investigation found that the engine failed because machine nuts had come loose from the engine or its housing and became caught in the engine. The helicopter crashed when the pilot attempted autorotation.

INVESTIGATIVE FINDINGS

During the time these incidents occurred, an estimated 25 helicopters in Alaska were capable of conducting long-line logging operations; approximately 20 were single-engine models from one manufacturer.⁴ Approximately 50 helicopter pilots were employed in long-line logging operations in Southeastern Alaska.⁵ Using these denominators, the events in this report are equivalent to an annual crash rate of 16% (6 crashes per 25 helicopters per 18 months), 0.24 deaths per long-line helicopter in service per year (9 deaths per 25 helicopters per 18 months), and an annual fatality rate for

long-line logging helicopter pilots of approximately 5,000 deaths per 100,000 pilots (4 pilot deaths in 50 pilots during 18 months).***

In comparison, during 1980-1989, the U.S. fatality rate for all industries was 7.0 per 100,000 workers per year; Alaska had the highest overall occupational fatality rate of any state (34.8 per 100,000 per year) for the same period.⁶

According to NTSB investigations to determine probable cause, all six crashes involved "... improper operational and/or maintenance practices" that reflected a lack of inspections of long-line helicopter logging operations.¹ In incidents 4, 5, and 6, investigative evidence also indicated that log loads routinely exceeded weight and balance limits for the aircraft. Following increased inspections, no additional logging-related helicopter crashes were reported through June 30, 1994.

All of these severe incidents occurred among helicopters operated by two companies using single-engine aircraft (see Table 1).

To enable a more thoughtful approach to this analysis, proven and putative risk factors for these events have been arranged in a time-

Table 1. Helicopter logging incidents, Alaska, 1992-1993.

Date	No. killed	No. injured	Type of helicopter	Logging company
2/23/92	6 (co-pilot and 5 loggers)	5 (pilot and 4 loggers)	Manufacturer A, type A single-engine	Company A
3/6/92	0	2 (pilot and co-pilot)	Manufacturer A, type A single-engine	Company A
11/10/92	0	0	Manufacturer A, type B single-engine	Company A
2/19/93	2 (pilot and co-pilot)	0	Manufacturer A, type A single-engine	Company B
5/2/93	1 (solo pilot)	1 (ground crew logger)	Manufacturer A, type C single-engine	Company B
5/8/93	0	2 (pilot and co-pilot)	Manufacturer A, type A single-engine	Company B

*** These rates refer to the period of intense collaborative investigation (January 1992-June 1993) and may not represent incidence over a longer period of time; however, they accurately reflect the high risk of helicopter long-line logging during this period.

phase (Haddon's) matrix (see Table 2). These events are often the result of the interaction of many different factors.

In response to these incidents, the Alaska Interagency Working Group on the Prevention of Occupational Injuries**** met in a special session on July 8, 1993, to discuss approaches for reducing the number of such crashes and ameliorating the outcome of crash injuries. Based on these and other findings, the working group made the following recommendations:⁷

- All helicopter logging pilots and ground crews should receive specific training in long-line operations. Companies should follow all manufacturers' recommendations for more frequent helicopter maintenance (because of intensity of use) and for limits on maximum allowable loads.
- Companies should establish and observe appropriate limits on helicopter-crew flight time and duty periods.
- Companies should consider using multi-engine rotor craft.
- Specific industry-wide operating standards and procedures should be developed.

- Companies should provide training in on-site emergency medical care for helicopter logging crews at all work locations.
- State, regional, and local agencies involved in emergency medical services education should make low-cost emergency medical training available to persons likely to work in a helicopter logging environment.
- All flights over water should include appropriate survival equipment for all crew and passengers, who should wear personal flotation devices at all times during flights over water.

The implementation of the Interagency Working Group's recommendations had immediate and lasting results: from July of 1993 through April of 1996, there have been no additional crashes, severe injuries, or fatalities during helicopter logging operations in Alaska (see Figure 1).

DISCUSSION

The incidents in this report demonstrate that long-line helicopter logging is a technology application with an unusually high risk for occupational fatalities. General aviation regulations

restrict the number of hours pilots can fly during given time periods; however, long-line helicopter logging involves carrying loads outside the rotor craft, and there are no legal limitations on crew flight hours. Although flight-crew work schedules and daily flight hours vary greatly by logging company, flight-crew duty periods can exceed 10 hours per day for 10 consecutive days.

Helicopter logging operations often place heavy demands on helicopter machinery and

Table 2. Features of Alaska helicopter logging injury events (after Haddon).

	Host/human	Agent/vehicle	Environment
Pre-event/pre-injury	Pilot training, experience, fatigue, stress, Rx, illegal drugs, alcohol Ground crew training, experience	Helicopter design lift, durability Maintenance and repairs Engines and controls Ergonomics Unstable work platform Surplus/improvised equipment	Terrain Weather Landing zones Oversight FAA (CFR pt 133) industry
Event/injury	Pilot reaction to emergency situation (i.e., autorotation), task overload Ground Crew reacting, avoiding	Helicopter autorotation performance: deformation on impact; fires and explosions	Terrain Weather
Post-event	Types of injury, severity		Little assistance available EMS not available

****Representatives from the Alaska Department of Health and Social Services, Alaska Department of Labor, Federal Aviation Administration, CDC's National Institute for Occupational Safety and Health, NTSB, Occupational Safety and Health Administration, U.S. Coast Guard, and the U.S. Forest Service.

associated equipment. The highly repetitive lift/transport/drop cycles are frequently conducted at or beyond maximum aircraft capacity in remote areas, where rugged terrain, extremely steep mountain slopes (as great as 70°), and adverse weather conditions prevail. Complex operations under such circumstances may increase the likelihood of both human error and machine failure.⁸ In addition, conditions are unfavorable for successful autorotation during most helicopter long-line logging operations.

Helicopters are very complex machines with an inherent requirement for constant vigilance and input from the pilot during flight and extraordinary maintenance requirements between flights. In contrast to conventional fixed-wing aircraft, helicopters can take off and land vertically, but are not self-trimming (i.e., able to maintain stable or level flight when control surfaces are in a neutral position) and cannot successfully

move or hover without constant input to the controls by the pilot. The aerodynamics of these machines are fundamentally unforgiving, as they do not glide, and when the engine stops, free fall commences immediately and can only be arrested by successfully restarting the engine or by autorotation maneuvers. Autorotation allows a helicopter to make an unpowered descent by

maximizing on the windmilling effect and orientation of the main rotor. Forward airspeed and altitude can be converted to rotor energy to reduce the rate of descent. However, successful autorotation depends on helicopter airspeed and altitude when the maneuver is attempted (see Figure 2).⁸

Figure 1. Crashes, fatalities, and nonfatal injuries in Alaska helicopter logging operations, 1990-1995.

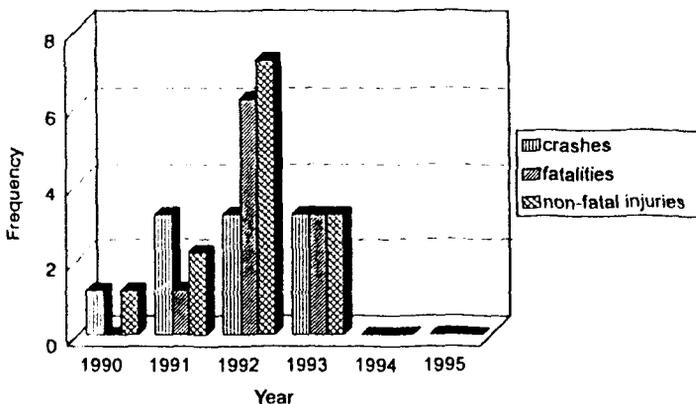


Table 3. Alaska helicopter logging injury: recommended countermeasures (from Alaska Interagency Working Group for the Prevention of Occupational Injuries, July 1993).

	Host/human	Agent/vehicle	Environment
Pre-event/pre-injury	increased training for pilots and ground crew Improved work/rest cycles	Maintenance per manufacturer's recommendations Impact (g)-resistant seats NTSB-to prohibit surplus equipment	Improved interagency communication, Increased FAA oversight
Event/injury	Practical training in autorotation		Emergency (backup) landing zones
Post-event			

Most helicopter logging operations are conducted at an altitude of less than 500 feet while at a hover or very slow airspeed, beneath the height-velocity curve for single-engine helicopters, as illustrated. Figure 2 also displays the location of the six previously mentioned crashes, all dangerously inside this curve.

Regardless of where helicopter logging operations are conducted, the jurisdictional responsibility for inspection rests with the Federal Aviation Administration (FAA) office nearest the main or registered corporate office for the helicopter company (in all of the cases in this report, these offices were in the contiguous ["Lower 48"] United States). This necessitates travel of great distances to conduct helicopter

logging inspections, and remote operations may escape or evade inspection for long periods. NTSB has recommended that operational and maintenance oversight responsibilities for remote sites be assigned to the nearest FAA office.

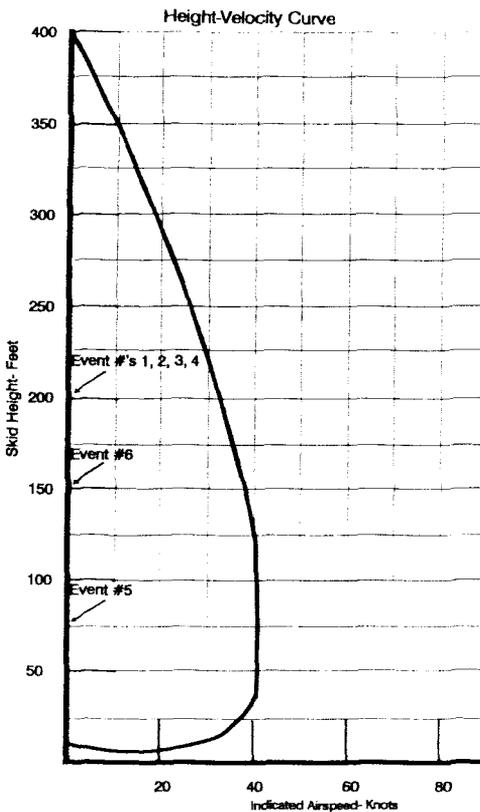
When these preventive interventions are superimposed on the risk time-phase matrix for these events (see Table 3), it becomes clear that the emphasis chosen by the Working Group was on pre-event factors.

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

agency Working Group for the Prevention of Occupational Injuries and the National Institute for Occupational Safety and Health (NIOSH) sponsored the first Helicopter Logging Safety Workshop in Ketchikan, Alaska, on March 1-2, 1995. The objectives of the workshop were to: describe and analyze the risks of helicopter logging; share new aerologging technology; foster safety research in aerologging 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.

The 65 workshop participants, representing 12 helicopter logging companies, 4 helicopter manufacturers, 4 industry associations, 5 federal agencies, 2 state agencies, 6 logging companies, 1 university, and a representative from the Helicopter Association of Canada, used a consensus-building group process to determine possible root causes, countermeasures, and action plans. Workshop participants drafted the following safety rec-

Figure 2. Fundamentals of fixed and rotary wing aerodynamics. (Adapted from curve illustrated in Roland and Detweiler.³)



ommendations for injury prevention in helicopter logging.⁹

Equipment

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

Maintenance

- The aerologging 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 certificated authority.

Human Factors

- The use of a qualified second pilot is recommended for aerologging.
- 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 aerologging should be prohibited, and aerologging camps should be dry.
- There should be random drug and alcohol testing, and mandatory testing in the event of a mishap.
- FAA should not be permitted to sanction by way of irrevocable certificate action those individuals entering voluntary drug and alcohol rehabilitation programs.

It was also recommended that NIOSH 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 aerologging operations.
- Flight and ground crew coordination training should be provided for all aerologging 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

- An aerologging association should be established to serve as a forum and spokesman for the aerologging industry.
- Companies should be encouraged to develop a strong safety culture within upper-level management.
- Mid-level managers should be trained in the concepts and responsibilities of developing a strong safety management culture.
- Employees should be encouraged to report safety violations without fear of reprisal or 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 job/task termination safety rules.

Oversight

- The group strongly recommended that FAA promptly enforce all known rule violations.
- Staff of all local FAA Flight Standards District Offices (FSDOs) should be trained in all pertinent aspects of aerologging operations.

Table 4. Alaska helicopter logging injury countermeasures: proposed at March 1995 workshop, Ketchikan, Alaska.

	Host/human	Agent/vehicle	Environment
Pre-event/ pre-injury	Qualified second pilot Flight/duty time limits Drug and alcohol testing Availability of drug/alcohol rehabilitation	Multi-engine only Dual drive train Improved controls Improved crash worthiness Limit to certified parts with valid FAA history	Industry SOP for maintenance, safety culture, and management Helilogging association Educate FAA, FSDO Improve communications
Event/injury	Qualified second pilot	Crash-resistant fuel tanks Controlled deformation	
Post-event		EPIRBs	Improve EMS availability CPR/first aid training for crews

- 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

- Establish a helicopter logging association and encourage membership.
- Companies should establish communication between each other when conducting aerologging operations in close proximity.
- Companies conducting aerologging in the same areas should establish joint EMS and emergency action plans.
- Companies and agencies should develop and disseminate a contractors 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 U.S. Forest Service,

state agency, and environmental group personnel concerning the necessity of more adequate helicopter emergency landing zones, and concerning the potentially hazardous combination of danger trees and rotor downwash.

These recommendations are also summarized in matrical format in Table 4.

CONCLUSIONS

Helicopter logging is an expanding industry in Alaska, the U.S., and abroad. Helicopter pi-

lots and ground crews involved in long-line logging operations face an extremely high risk for severe traumatic injuries resulting from helicopter crashes. Inadequate equipment, improper operational and/or maintenance practices, and the lack of adequate inspectional surveillance of helicopter long-line logging operations in Alaska have been frequently cited as the factors most strongly associated with the risk of crashes. The risks for fatal and serious injuries in this industry should and can be reduced by scrupulous attention to the needs of pilots, crew, and equipment. To minimize these extreme hazards, pilots and crew need more rest and better training; helicopters and equipment need more frequent and intensive maintenance; and operators must adhere not only to existing regulations, but also to manufacturer recommendations for load, lift cycle, and other appropriate applications. The Alaska experience has shown that helicopter logging can be extremely hazardous. However, careful attention to identifying and minimizing the risks and hazards can make it safer.

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