1974
USDA FOREST SERVICE GENERAL TECHNICAL REPORT PNW-20

HELICOPTERS FOR LOGGING

CHARACTERISTICS, OPERATION, AND SAFETY CONSIDERATIONS

P.M. STEVENS
EDWARD H. CLARKE

PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE
PORTLAND, OREGON

CONTENTS

ABSTRACT

This report presents a general overview of factors relevant to the productive and safe use of helicopters for timber harvesting, with emphasis on candidate helicopters and their characteristics.

KEYWORDS: Helicopter logging, skidding methods (aircraft), logging economics.

AUTHORS

Mr. Stevens is Director, Civil Programs Division, The Aerospace Corporation, El Segundo, California. His participation on this report was authorized under U. S. Forest Service grant number FS-PNW-9.

Mr. Clarke is Research Forester with the Pacific Northwest Forest and Range Experiment Station.

This report presents a general overview of factors relevant to the productive and safe use of helicopters for timber harvesting. The characteristics of helicopters suitable for logging are discussed to serve as a guide for present or future users, as well as a tool for forestry personnel involved in administering helicopter timber sale operations. The report may also be useful to helicopter manufacturers interested in the application of rotorcraft to the timber harvesting role.

HISTORY OF HELICOPTER LOGGING

The first successful helicopter flew some **35** years ago. After World War 11, helicopters began to make their mark in commercial aviation, including several forestry operations *(1, 9, 10, 11)*. Interest in the possibility of moving logs by helicopter grew rapidly.

The first reported testing was in Scotland in **1956** (8) with a small Bell **47G** helicopter having a net load capability of only **600** pounds. The tests were made without incident but at a cost six times the economic rate. Experimental flights were made in eastern Canada in **1957** and in Russia in **1959.** Other tests were conducted in **1963** in Norway, using two U. **S.** helicopters and one from Russia. Additional testing was done in western Canada and the United States during the early **1960's** *(6)*. These initial attempts generally were not considered economically successful primarily due to the limited load-carrying capabilities of the aircraft tested.

Because of the relatively low lift capability, consideration was given to dragging the load instead of lifting it free of the ground to permit transporting heavier loads. Such trials were conducted in **1962** with an **S-58** helicopter near the Sikorsky plant in Connecticut (3). Loads equivalent to one and one-half to two times the free lift capacity were so transported on level ground at slow speeds, but the operation was potentially too dangerous to explore further.

As lifting capabilities were increased with the advent of twin turbine engines, the possibility of logging with helicopters regained interest. Serious efforts were initiated again in the early **1970's** by both Canadian (2) and U. S. *(7)* operators. Moreover, the renewed interest was accelerated by the environmental concern to reduce the road network to service a harvest area, as well as to increase the wood supply from those marginal areas that cannot be yarded with conventional systems.

The first Forest Service timber sale offered specifically for helicopter logging was sold in April **1971** on the Plumas National Forest in California. It involved **8.7** million board feet from a partial-cut operation on **520** acres of steep, rocky terrain. A portion of a skyline timber sale which had been made a few months earlier on the Plumas National Forest was modified to permit logging with an **S-61A** helicopter. Since this beginning early in **1971,** the Forest Service has designated several timber sale areas for helicopter yarding in California, Oregon, Washington, Alaska, Montana, and Idaho. Through November **1973,** the Forest Service has made several timber sales in the designated areas--a total volume of approximately **525** million board feet. Thus far, operators of those sales have employed the Sikorsky models **64, 61,** and **58** and the Boeing-Vertol **107-11** to accomplish a variety of prescribed silvicultural treatments--clearcutting, selective cutting, thinning, overstory removal, and salvaging burned and insect-infested areas.

All of these commercial operations were designed to harvest timber from sites not suitable for conventional logging systems. The helicopters used were modified to better tailor them for the logging task. The economic pressure to produce precluded systematic research evaluations aimed at improving the particular system. Operators have used the trial-and-error approach to reduce cost and increase production. Improvements are continually being made, but the unit cost of production remains relatively very expensive.

CURRENT OPERATIONAL PROCEDURE

Because of the relatively high production rate of the twin turbine engine helicopters being used for timber harvesting, efficiency can be maintained only by carefully integrating the complete operation of felling, bucking, yarding, loading, and hauling. The complement of personnel required to support the total helicopter system typically is greater than for other systems, and some of the tasks require a higher skill level as well. A typical crew for the largest rotorcraft includes four pilots and up to four maintenance personnel for the helicopter, a chaser, skidder operator, and log loader operator at the landing, and two sets each of one spotter, two choker setters, and one hooker in the area being logged. There also is usually one person supervising the entire operation. In addition, there are several timber fallers and the required trucks and drivers for hauling.

Log buckers, in addition to bucking logs to lengths and grade desired by the processing mill, must also be concerned with producing a log whose weight does not exceed the net lift capacity of the helicopter. They are furnished charts, circular slide rules, nomographs, or other aids which relate average species density and log dimensions to pounds, and cutters must be qualified to use them. The spotters, too, employ these aids to select and code mark the logs that will comprise a single load. The coding is later used by the hooker in assembling the preset chokers for the next load.

Each yarding cycle is much faster than those for other logging systems--from 1.5 to 3 minutes. The cycle consists of flying out from the landing to the hooker at a pickup point, hovering while he attaches the choker(s) to the hook on the end of the tagline, flying the load back to the landing, and hovering while the load is electrically released from the hook. This cycle is repeated, alternating usually between the two hookers. At the landing, chokers are removed, additional limbing is done when required, and the logs are decked or loaded onto trucks.

Light fuel loads are carried to accommodate larger net loads, requiring refueling stops every 30 to 45 minutes. Maintenance inspections are conducted three or four times daily, and flight crews are alternated to avoid fatigue (4 to 5 hours flying time per day is maximum). At frequent intervals, a supply of chokers is flown from the landing back to the woods to be reused. There is radio communication between the pilots and ground crew.

HELICOPTERS FOR LOGGING

There are over 20 U.S. firms that have built or are building helicopters. Over the last decade, these organizations have structured approximately 100 different configurations ranging from gross weights as small as 650 pounds to as large as **118,000** pounds for the planned development of the heavy-lift helicopter.

The list of several **U.S.** helicopters with a payload[1/] capacity of 1,000 pounds or more is shown in table **1.** Except for the Sikorsky **S-64** series, they were planned for passenger or internal cargo transport in either a commercial or military role. The **S-64** evolved strictly as a "skycrane" and was tailored to military use in lifting **and** transporting large exterior cargoes.

Most helicopters use piston or gas turbine engines to drive the rotor through appropriate shafts and gear trains. Of the helicopters in table **1,** only the Hughes experimental XH-17 differs in this regard. It involves the "pressure jet" concept where hot gases generated in the engines are ducted through the rotor blades to provide rotation. This concept has been studied **for** about 20 years.

Most of the helicopters in table **1** are too limited in lift capability to serve the principal role in a West Coast logging operation. Many could, however, serve in an auxiliary role of transporting work crews, their gear, etc., or possibly for thinning in small-sized timber.

With at least a 5,000-pound lift capability as a minimum requirement for lifting and moving large logs, substantiated by previous studies and trials (*3*), a list of helicopters suitable for logging is shown in table 2. The commercially available and Federal Aviation Administration **(FAA)** certified aircraft currently used for West Coast logging are the 107-II, **S-58T,** S-61, and S-64E (figs. **1-4).** Those aircraft indicated for only military application lack FAA commercial certification. **A** costly, time-consuming effort is required to obtain such certification.

BASIC CHARACTERISTICS

The basic characteristics of the commercially available helicopters are given in table **3.** Payload capability is perhaps the performance characteristic of greatest economic importance in timber harvesting. The "as delivered" empty weight for each aircraft may be reduced, thus increasing the payload capability, by removing all equipment not necessary to the harvesting role and not required for safety (e.g., passenger seats, trim, shelves, cupboards, nonessential electrical or electronic subassemblies, nonstructural panels).

The 107-11 and **S-61** are in the same general payload range (7,000-8,500 pounds). The S-58T has the least payload capability (5,000 pounds), and the **S-64E** and **S-64F** have the greatest capabilities (20,000-25,000 pounds). These payloads are for sea level operations at standard temperature conditions. The weight that can be lifted decreases with increasing altitudes, temperatures, or both. Table **4** shows this effect on load capability for two temperature and five altitude conditions.

From the safety standpoint, two other characteristics are important: disk loading and pilot visibility.

1/ As used in this report, payload = gross weight - (empty weight plus an allowance for *two* pilots, 30-minute supply of fuel, and the tagline and hook assembly).

Table 1.--*U.S. helicopters with 1,000 pounds or more payload*1/

Company	Model	Approximate gross weight	Approximate payload
		------Pounds------	
Bell	47G series	2,900	1,100
	UH series	9,500	4,000
	206A	3,300	1,500
	205A	9,500	4,600
	Twin 212	10,500	4,000
Boeing-Vertol	107-11	19,000	8,000
	CH-46	20,000	8,000
	CH-47 (Chinooks)	28,000-46,000	10,000-24,000
	BO-105	5,000	1,500
	347 (experimental)	43,009	24,000
	HLH	118,000	45,000
Doman	D-10C	5,500	2,500
Fairchild Hiller	FH-1100	2,700	1,100
Filper Research	Beta 400	2,500	1,100
Gates Learjet	Twin Jet	6,000	2,700
Gyrodyne	QH-50 series	2,300	1,000
Hughes	500 series	2,500	1,000
	XH-17 (experimental)	50,000	25,000
Kaman	UH series	13,600	5,400
	HH 43 series	6,000	3,900
	K-700	8,400	4,500
	Sea Lite	8,800	4,500
Lockheed	XH-51 series (experimental)	4,000	1,000
	286 (experimental)	4,700	1,500
	AH-56A Cheyenne	17,000	8,000
Piasecki	16H series (experimental)	8,000	4,000
Sikorsky	S-58T	13,000	5,000
	S-61 series	19,000	8,500
	S-62 (HH 52A)	7,900	3,000
	S-64E (CH 54A)	42,000	20,000
	S-64F (CH 54B)	47,000	25,000
Vought	Alouette II	3,600	1,100
	Alouette III	4,600	1,800
	SA 315B Lama	4,800	2,200
	SA 330 Puma	14,000	5,000

1/ Payload = gross weight - (empty weight plus allowance for two pilots, 30-minute fuel supply, and tagline and hook assembly).

Table 2.--*U.S. helicopters with 5,000 pounds or more payload*

Company	Model	Remarks
Boeing-Vertol	107-11 1/	Commercially available
	CH-46, 47	Military application only
	347	Experimental, one of a kind
	HLH	In research and development
Hughes	XH-17	Experimental, one of a kind
Kaman	UH series	Military application only
Lockheed	AH-56A	Military application only
Sikorsky	S-58T 1/	Commercially available
	S-61 series 1/	Commercially available
	S-64E 1/	Commercially available
	S-64F	Military application only; FAA certified for commercial use
Vought	SA 330 Puma	Military application only

1/ Currently FAA certified and being used in logging.

Disk loading (DL).-- Disk loading is the maximum thrust divided by the area of the circle swept by the rotor ($DL = T/\pi r^2$) and is a measure of the downwash air that is created below the vehicle. At hover heights of approximately one rotor diameter, a helicopter with a DL of 10 pounds per square foot creates downwash air that results in a horizontal air velocity on the ground of around 52 miles per hour. This moving air presents severe hazards to the ground crew (see section on safety considerations), both at the landing and at the log hookup areas and during both dry and dusty or cold and wet conditions.

The calculated DL's associated with the various helicopters and the resulting horizontal airstream velocities at ground level (proportional to the $\sqrt{DL}$) are as follows:

Model	DL (*Pounds per square foot*)	Horizontal air velocity 2/ (*Miles per hour*)
107-11 (19,000)	**4.8**	**36**
107-11 (22,000)	**5.6**	**39**
S-58T	**5.2**	**37**
S-61N	**6.3**	**41**
S-61L	**7.0**	**43**
S-64E	**10.3**	**53**
S-64F	**11.5**	**56**

Means for reducing downwash at ground level, short of increasing rotor diameter or reducing thrust, are limited to hover height above ground. This

2/ **Hover height = one rotor diameter.**

Figure 1.--Boeing 107-11 helicopter.

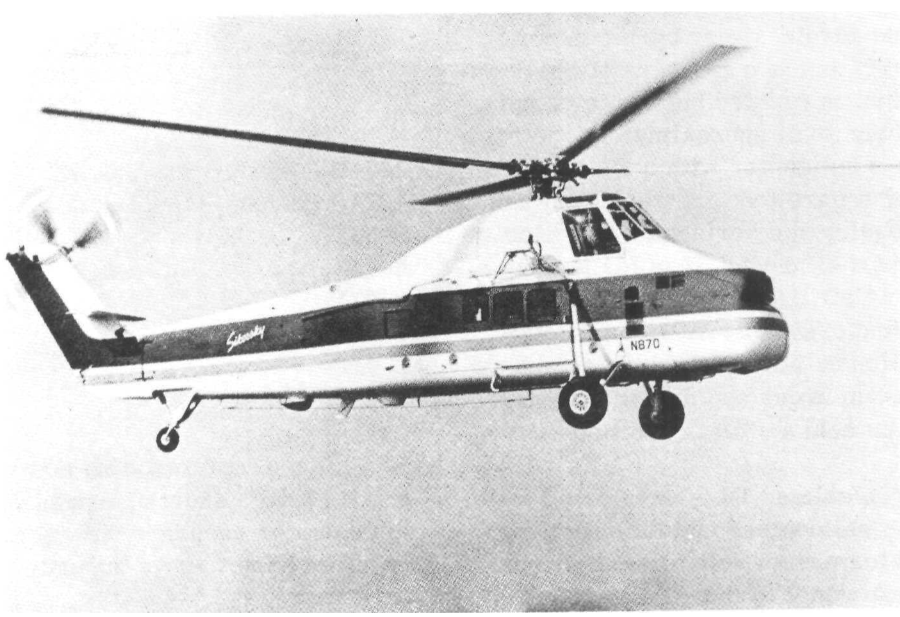

Figure 2.--Sikorsky S-58T helicopter.

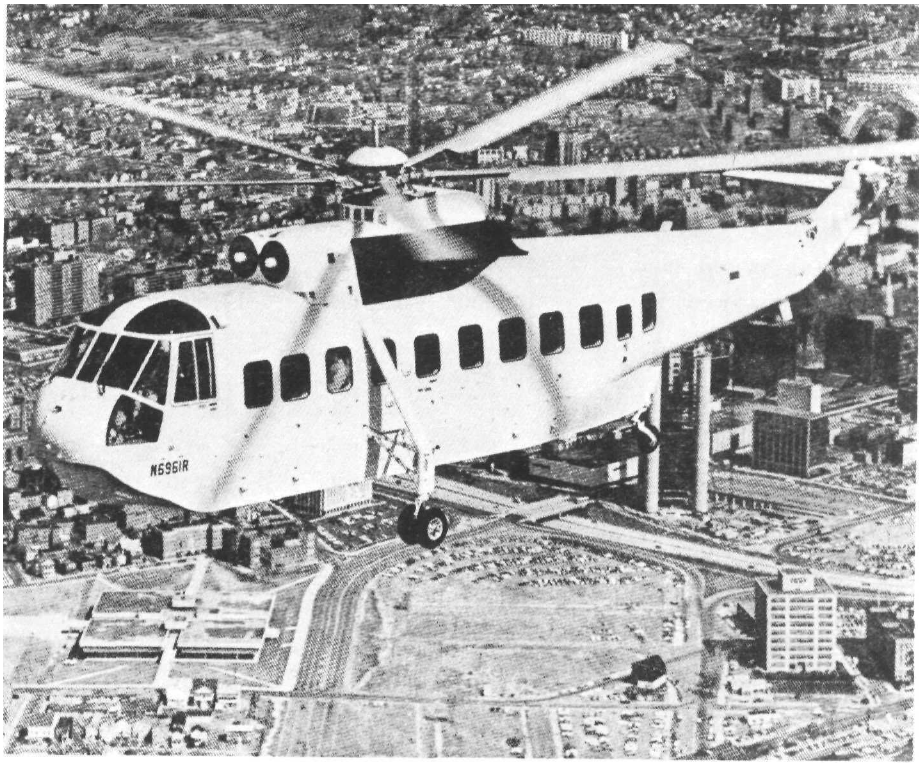

Figure 3.--Sikorsky** S-61L **helicopter.

Figure 4.--Sikorsky S-64E helicopter.

Table 3.--*Basic characteristics of commercially available and FAA-certified helicopters*

	107-11	S-58T	S-61N and L	S-64E	S-64F
Performance:					
Maximum speed (miles per hour)	167	150	150	127	115
Service ceiling (feet)	10,000	15,000	12,500	10,000	16,000
Fuel consumption (gallons per hour)	180	110	150	550	550
Engines					
Number	2	2	2	2	2
Maximum horsepower	1,350	800	1,250	4,500	4,800
Weights (pounds):					
Gross weight	19,000	13,000	19,000	42,000	47,000
Approximate payload	8,000	5,000	8,500	20,000	25,000
Dimensions (nearest foot):					
Fuselage length	45	39	61	70	70
Fuselage width	7	6	7	22	22
Overall length (with rotors)	83	51	73	89	89
Overall height	17	16	18	25	25
Main rotor diameter	1/ 50	56	62	72	72
Tail rotor diameter	--	10	10	16	16
Tread	13	12	14	20	20
Wheelbase	25	28	24	24	24

1/ Two main rotors, each 50 feet in diameter.

requires increased tagline lengths, which lead to other problems associated with the ability of the pilot to position the hook or load accurately.

Pilot visibility.--Except for the S-64, these helicopters were not designed to carry large external loads and thus are configured in such a fashion that, when logging, the pilot must lean out the side window (usually covered with a plastic "bubble") to fly the hook to within reach of the hooker. This adds to his already taxing duties. The S-64 models have an aft-facing pilot station; however, this has not been used in logging operations yet

Table 4.--*Helicopter hover lift capability*

(In pounds)

Helicopter model	Approximate payload capabilities[1]									
	Sea level		2,000 feet		4,000 feet		6,000 feet		8,000 feet	
	59°F	86°F	59°F	86°F	59°F	86°F	59°F	86"F	59°F	86°F
107-11 (19,000 pounds)	8,200	8,200	8,200	7,700	8,200	6,400	7,100	5,100	5,900	3,950
107-11 (22,000 pounds)	11,200	9,100	9,000	7,700	8,500	6,400	7,100	5,100	5,900	3,950
S-58T	5,050	5,050	5,050	5,025	5,050	4,050	4,050	3,050	3,050	2,050
S-61N	9,000	9,000	9,000	7,800	8,500	6,300	7,000	4,800	5,500	3,300
S-61L	8,700	8,550	8,700	6,900	7,700	5,600	6,250	4,300	4,850	3,300
S-64E	20,750	20,750	20,450	19,500	18,650	18,000	16,850	16,550	15,150	13,750
S-64F	25,050	25,050	25,050	24,750	24,650	22,950	21,650	19,850	19,650	16,650

NOTE: 59°F = 15°C, 86°F = 30°C.

[1] Ground effect and wind effect not included.

because the aft-facing pilot cannot see much more than 50 feet directly below his station. *Also,* time is lost when pilots shift aircraft control.

AVAILABILITY

A summary of the status of helicopters that are now or could be used follows.

Boeing-Vertol 107-II.--Initially manufactured in United States; Kawasaki Heavy Industries, Japan, now producing aircraft (about one per month). The FAA certified previous U. S. ships for external load up to 8,000 pounds; one ship recently certified for 11,500 pounds.

Sikorsky S-58T.--Sikorsky modifies s-58 hulls with two turbine engines to make S-58T or provides kits for operator to do own conversion.

Sikorsky S-61 series.--Built in United States. FAA certified for external load up to 8,500 pounds. FAA certification in process for external load up to 11,500 pounds. Used ships also available.

Sikorsky S-64E.--Being built on order. FAA certified for external load up to 20,000 pounds.

Sikorsky S-64F.--Being built for military use. FAA certified for external load up to 25,000 pounds. Capability exists to upgrade (not yet FAA certified) to 30,000-pound payload. Delivery time approximately 16 to 18 months.

All of these aircraft are currently supported in maintenance and spares, upon request, by the manufacturers.

ECONOMIC ASPECTS

In relation to other systems for harvesting timber, the helicopter suffers from a high initial cost and a high operating cost including a high fuel consumption (up to 20 or more gallons of fuel per thousand board feet yarded). Thus, there is a need for carefully weighing the system's advantages and disadvantages for each operation (*4*). The predicted long-term energy crisis may escalate costs faster than cost-reducing procedures can evolve.

No helicopter has ever been designed solely for logging. This could be done only with a huge investment in research and development. Suggestions that bigger helicopters might improve logging efficiency may or may not be valid. Designing a larger helicopter represents a considerably more difficult problem than merely scaling up a smaller one. Aerodynamic forces increase as the square of the size of the aircraft, but the structural weight increases as the cube of the size. A point is reached when increasing size no longer increases payload capability, unless with each step of increasing size one makes that additional breakthrough in efficiency to mitigate the cube-square law. The growth of the helicopter during recent years has been relatively slow compared with that of the airplane, The breakthrough in the development of the jet turbine engine, for example, greatly benefited the airplane through greater speed and, thus, greater productivity. On the other hand, there was less benefit from the turbine engine in the helicopter because of a definite limit to its top speed.

Some of the helicopters now being used for logging in the Pacific Northwest were purchased new, but many were purchased secondhand at prices far less than those of new machines. Current replacement parts are new and, in time, only new helicopters will likely be available to replace wornout machines. New machines of the models now used for logging, with spare parts, cost a great deal more--between $250,000 and $2,800,000.

FIXED COSTS

Fixed costs include depreciation, interest, insurance, and salaries of key aircraft personnel.

Depreciation.--Depreciation is usually based on government tax limitations. Operator's accounting practices vary in both time and assumed residual value (e.g., 5, 7, or 10 years with residual values of 25 percent, 15 percent, or 0 percent of new cost).

Interest.--These rates have fluctuated over the years, depending on loan risk, but have increased appreciably since about 1970.

Insurance.--Insurance is comprised of both hull and liability coverage. Hull insurance is generally a negotiated rate and has ranged as high as 16 percent of the aircraft's estimated value. The aircraft value in the first year is the investment price and in succeeding years is logically reduced in proportion to the depreciated value. This might vary somewhat on the operator's assessment of actual value needed to be insured in relation to risk or replacement costs in any given year.

Liability insurance, too, varies with operation risk. It does not vary greatly with the value of the aircraft and generally is low compared with hull insurance ($5,000 is a common annual premium for such coverage).

Personnel.--The required aircraft personnel vary with the expected annual utilization, number of aircraft in operator's fleet, etc. The fatiguing nature of the logging task generally dictates 4- to 5-hour shifts for both a salaried pilot and copilot. Generally it should be assumed that a minimum of four pilots (average $20,000 per year) and four mechanics (average $15,000 per year) are required to support a helicopter logging operation.

In applying the above fixed costs to a particular logging operation, the cost per hour is, of course, dependent on the annual utilization of the helicopter. The effect of increasing the hours of utilization on the prorated fixed costs is negatively logarithmic.

In summary, the prorated fixed costs are strongly dependent on the initial price of the helicopter and the yearly hours of utilization. The two largest contributors to fixed costs are depreciation and hull insurance. Depreciation may be generally constant over the depreciated period, whereas hull insurance would be expected to decline each succeeding year to reflect the depreciated value.

OPERATING COSTS

Operating costs comprise maintenance, overhaul, fuel, and lubricants. Maintenance and overhaul costs include replacement parts, repairable items, and regularly scheduled overhaul of major components--engines, rotor heads, gear boxes, etc. These major operating costs vary with the size of the helicopter and the time-before-overhaul periods (TBO) that are established by the manufacturer for the main components. TBO's vary with operating history on a particular aircraft. For example, if a fleet of a certain type of helicopter is operated for years with no engine troubles, the TBO for the engines would be extended, thereby reducing the hourly operating costs. Manufacturers provide updated TBO schedules and cost factors for all aircraft that they continue to support in commercial operations.

Operating costs are generally proportional to size (or initial investment).

PRODUCTIVITY

Factors that affect unit cost of timber production approximate those that prevail for other systems of logging. Such production costs for a helicopter are generally much greater than those experienced for other systems. This dictates the need for careful layout and design of each operation, as well as rigorous attention to the details of logistics for accommodating the higher rate of production.

As with other logging systems, the most significant factors of helicopter productivity are average cycle time, average load factor, and hours of utilization.

Cycle time.--The components of each turn cycle are travel out, hookup, travel in, and unhook. Typical cycle times range from 1.5 to 3 minutes, depending on distance traveled to and from the pickup point. Most of today's operators prefer yarding distances up to 0.75 mile, but distances of 1.25 miles have been achieved. Similarly, elevation differences between the pickup point and the landing will affect the in-and-out travel time. Operators prefer to fly the load uphill to avoid excessive rotor and airframe vibrations during loaded downhill travel. Elevation differences of not over 1,000 feet over a half-mile distance are preferred.

The hookup component approaches 50 percent of the time for each cycle on most operations. The steepness of the slope and the amount of underbrush impede the movement of the hooker between the logs selected for the turn, as well as movement to a safe location before lift-off. Both impediments increase hover time during hookup as does the number of pieces in the load. Brush and understory vegetation also make it more difficult for the pilot to spot the hooker waiting to attach the next load. Whether the timber stand is to be clearcut or partially cut has an effect on the hookup component. If partially cut, a much longer length tagline is required to allow the helicopter to hover safely above the standing trees. The longer line, also required in very steep country, takes more time to position over the hookup point.

The size of the landing and its position relative to prevailing winds are factors affecting the unhook component of the cycle time. A small and congested landing, in addition to being unsafe, requires hovering to delicately place the load. On the other hand, a larger, properly located landing allows a straight-in approach with the load without time-consuming maneuvers.

Any unforeseen delays affect average cycle time. A too heavy load which must be aborted is very costly in both time and dollars. If it is a multiple log load, the pilot must hover while the hooker moves in to remove one log from the hook; if a single-log load, it must be either rebucked or split.

Load factor. --With any system of logging, a high average load size is more desirable--the higher the average, the lower the unit cost of production. It is very difficult to attain a high average load factor with any logging system. Currently, helicopter operators are averaging load factors between 50 and 60 percent on most operations. Considerable effort is being made by operators to improve this situation through improved log weight estimation.

The state of the art of estimating the weight of logs (5) and trees has advanced slowly because both density and moisture content of roundwood vary greatly--for example, within trees, between trees of the same species, and between locations and seasons. Greatly improved weight estimation might mainly reduce the frequency of aborts rather than significantly increase the average load factor. The full benefit of a precise weight estimation technique cannot be captured because of the random mix of log sizes available at a given pickup point within the radius of the choker lengths. Moreover, some weight must be compromised to accommodate a mill's order file or log lengths in multiples of product lengths, e.g., 8 feet for softwood plywood blocks. Because the weight of roundwood is so variable and because helicopters have a zero tolerance to overload, a significant increase in average load factor may shorten the fatigue life of the helicopter and increase the frequency of aborts--both of which have an adverse effect on logging cost. Any success in improving load factors will benefit all logging systems.

Because the lift capacity of a helicopter varies with altitude and temperature, two stands of equal mix of size and quality, but at greatly different elevations, would need to be bucked differently to attain the same average load factor. The effects of altitude and temperature on performance, which will affect cost, were shown in table 4. Most operators attempt to take advantage of these effects to improve load factor. There are opportunities in stands to bunch small, scattered logs into a single load, but operators rarely bunch more than once before returning to the landing. It is unsafe to bunch among standing trees in a partial-cut situation.

Hours of utilization.--Logging helicopters at the present time probably average less than 1,000 hours of operating time per year. Some other commercial applications are achieving utilization rates of 1,600 hours or more. Weather conditions such as fog, high wind, and accumulated snow interfere with logging operations and contribute to this problem of relatively low utilization. Most helicopter logging operators have developed other uses for their ships such as construction, fire fighting, and other forestry operations to attain cost reductions through higher utilization.

In summary, the most favorable combination for keeping unit production costs as low as possible is one of minimizing cycle time and maximizing load and utilization.

SAFETY CONSIDERATIONS

No attempt is made to determine what safety aspects of helicopter logging can or cannot be enforced by Federal or State agencies under existing acts or regulations (e. g., P. L. 91-596, "Occupational Safety and Health Act of 1970," FAA Regulations, State Workman's Compensation Groups, Forest Service Regulations, etc.). The aim here is to illustrate the safety issues, hopefully to serve as a guide for current or future helicopter operators and forestry personnel in timber sale layout or sale administration.

Planning for a safe operation must begin with the layout of the timbered area for which helicopter logging is to be required. Special attention must be directed to providing a safe flight path and sufficiently large landings that are properly oriented with prevailing winds. As a minimum, forestry personnel should be familiar with the concept of helicopter logging and concerned with safety. Supervisors of helicopter logging operations should have a continuing program of training ground crew personnel on safe practices in general and on specific aspects of safety on the current logging operation in particular. The crew should be provided with suitable protective gear for existing conditions, and they should be urged to use it.

Since a larger number of personnel is required to support a helicopter logging operation than other logging systems, the odds are greater for accidents, and thus, there is more need for diligence. Many improved safety practices have evolved with this relatively new concept of logging, but more effort is needed as evidenced by the following serious accidents to men and machines that have occurred during the past 2 years:

- Two logging helicopters crashed and were totally demolished; in one instance both the pilot and copilot were killed.

- One hooker was killed when struck by the log being lifted. Another required hospitalization--apparently struck by the log or by a falling limb dislodged by the downwash.

- Two helicopters sustained rotor damage due to running into standing trees.

- One helicopter sustained fuselage damage from "snap-back" of the tagline due to excessive maneuver during load release.

There have been numerous other less-than-satisfactory practices observed or reported that, if continued, have the potential of resulting in serious injury or worse. There are certain general recommendations that will make for safer working conditions surrounding each job.

FALLERS, BUCKERS, AND LOAD MARKERS

These personnel should operate well ahead and clear of any helicopter logging activity.

CHOKER SETTERS AND PILOTS

In addition to working as far ahead of logging as possible, there should be safe, predefined techniques by the pilots for periodically delivering supplies of chokers from the landing. These bundles of chokers can weigh several hundred pounds, and an unexpected gust of wind at the time of drop could result in an accident. Consideration might be given to placing the chokers on the ground rather than dropping them.

HOOKERS

The hookup man has one of the most dangerous jobs in the system. He must work directly below the helicopter and cope with the several problems this presents--downwash, static charge on the tagline hook, and the gyration of the load at the point of lift-off.

Downwash.--The air velocities at ground level can vary from about 35 miles per hour to more than 50 miles per hour. In a partial cut, this moving air could break off branches, dislodge cones, or even topple small, partially uprooted trees. During operation over dry or powdery soil (as in a burned area), there will be considerable flying dust and debris. During cold weather operation, this downwash produces chilling conditions. Protective devices and garments are available to reduce these safety hazards, and they should be provided and used.

Static charge.--Under certain operating conditions, the helicopter rotors cause a static charge to build up on the tagline hook. This charge may be small or a real "knee-buckler." There are a few preventive actions that may be taken and, although they may be time consuming, uncomfortable, or cumbersome, their use should be encouraged until improved techniques are devised.

1. The pilot can set the hook on the ground to discharge it.
2. In dry weather, the hooker can wear insulated lineman-type gloves.
3. In wet conditions, current will bypass lineman's gloves and still shock the hooker. A glove with a metallic palm and a conductive wire from the palm to the ground may solve shock problem.
4. The hooker can use a light, insulated, metal rod to touch the hook and ground simultaneously to discharge the hook.

Gyration of load.--On single log turns, the log will pivot before lift-off on the end away from the choker, and the hooker merely has to be slightly uphill and clear to be safe. When multiple-log turns are lifted, the logs will roll, twist, and swing together, and the hooker needs to be farther uphill to be clear of any gyrations. In all cases, the pilot should be aware of the hooker's location before lift-off, either visually or by radio, and the hooker should wear distinctively colored markings or garments.

ALL OF THE WOODS PERSONNEL

If these people hike into the cutting area, either a predefined, marked trail should be used that is not under the intended flight path of the helicopter when it is transporting a load, or logging should not be started until crews are in position. Pilots often have to drop a load because of engine malfunction, and other times a log has slipped out of the choker during the flight to the landing.

If any of the crew is flown into or out of the cutting area, suitable heliports for safe landing, take-off, and unloading or loading of people should be provided.

CHASERS

Workmen at the landing should be alert to the helicopter flight path during log delivery to remain clear of released logs, including the probable path of heli-copter and log if an engine should fail. These personnel also are subject to both downwash and possible static charge on the hook when they attach bundled chokers for return to the cutting area.

LOG LOADERS

Generally they are protected from downwash by a cab but should be alert for incoming logs and expected helicopter and log flight path if engines should fail and the load is hastily dropped.

MAINTENANCE MEN

Good judgment and established safety procedures for working around an operating helicopter on maintenance or refueling tasks should be observed.

PILOTS

Certain qualifications are imposed on the pilots by the **FAA** and insurance companies to certify their capabilities. Regarding safety in logging, there are five areas of concern that pilots must be especially alert to.

Hangups. --Hangups can occur if the turn is too heavy, if unremoved limbs on logs are embedded in the ground or tangled with surrounding timber, or if an unloaded tagline should become fouled with some obstruction. For these situations, the pilot must have a backup release system to imme-diately discharge log or tagline. The present system is two electric release hooks (one at end of tagline and one near ship) backed up by a mechanical disconnect which the pilot can operate to effect positive release.

Engine failure. --Only twin-turbine engine ships should be used for logging be-cause they can fly safely, unloaded, with only one engine operating. If an engine fails while a load is being carried, the load would likely have to be hastily jettisoned--thus the need for fixed flight patterns so ground crews can avoid this danger.

Rotor clearance. --Landing areas, servicing heliports, and cutting areas generally have adjacent standing timber which presents possible areas of contact with the rotors of a harvesting aircraft. Extreme care should be exercised by the pilots to maintain adequate clearance.

Cable "snap-back." --Excessive maneu-vering while releasing a load can result in "snap-back" of the tagline which could damage the helicopter fuselage or foul the rotor.

Fatigue. --The helicopter pilot must lean out his side window and look down and under aircraft to position hook, lift logs, and fly load to landing--mostly in a hover mode. This is an extremely exacting duty. Exper-ience has shown that on a continuing basis, about **4** to **5** hours per day is the tolerance limit and this should not be exceeded.

FOREMAN, AUXILIARY PERSONNEL, AND SPECTATORS

All other persons should be made aware of flight paths and be required to stay clear of all activity during harvesting operations. Experience has shown that the general public will be attracted in large numbers to observe this impressive method of logging. Where possible, signed viewpoint areas should be estab-lished in safe locations for spectators.

LITERATURE CITED

1. Agar, Carl
   1958. When can we log by air? For. Prod. J. VIII(9): 17A-19A, illus.

2. Alder, Diane
   1971. Copter logs steep slopes in continuing B. C. test. For. Ind. 98(10): 51, illus.

3. Binkley, Virgil W.
   1964. Research objectives and developments on the concept of vertical logging with helicopters. Auburn For. Forum Proc. 1963: 11-22.

4. Burke, Doyle
   1973. Helicopter logging: advantages and disadvantages must we weighed. J. For. 71(9): 574-576, illus.

5. Mann, Charles N., and Hilton H. Lysons
   1972. A method of estimating log weights. USDA For. Serv. Res. Pap. PNW-138, 75 p., illus. Pac. Northwest For. & Range Exp. Stn., Portland, Oreg.

6. O'Leary, John
   1964. Aerial logging research. For. Prod. J. XIV (10): 447-450, illus.

7. Pease, David A.
   1971. Helicopter undergoes private test in logging. For. Ind. 98(3): 34-37, illus.

8. Shaw, R. G.
   1959. Helicopters in British forests. For. Prod. J. IX(2): 30A-31A, illus.

9. Sikorsky, I. I., and H. R. Kwiatkowski
   1958. Present and probable future developments of helicopters. For. Prod. J. VIII(9): 9A-11A, illus.

10. Sloan, Lloyd
    1958. Helicopters in logging operations. For. Prod. J. VIII(9): 15A-17A, illus.

11. Townsend, J. G.
    1958. Helicopters for forest operations. For. Prod. J. VIII(9): 20A-22A, illus.

☆ U. S. GOVERNMENT PRINTING OFFICE: 1974—697-456 /34 REGION 10

The FOREST SERVICE of the U. S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives — as directed by Congress -- to provide increasingly greater service to a growing Nation.