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Flying Helicopters Over Mountains at Night . . .

guidance systems tested in 1965 phase of study

ABSTRACT: Under conditions simulating fireline operations, 117 helicopter flights were made at night over mountain areas in southern California. The trials indicated that such flights, carrying passengers and cargo, can be made safely if (a) the night operation is well planned, (b) the helicopter is in excellent condition, (c) adequate lighting and guidance equipment are provided and used; and (d) the pilot and crew are well trained.

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Last summer, people living on ranchess and in small communities in the San Jacinto Mountains of southern California were sometimes awakened by the sound of a helicopter flying over during the night. By the time summer was over they had grown used to the sound of night flights.

The reason for the sleepless nights--for both the residents and a small group of researchers--was to find out if light helicopters could be used safely at night in forest fire control operations. After 117 flights, we concluded that if we had skilled people, good equipment, and careful planning, night flying could be done safely.

As versatile as they are, helicopters used for forestry work are usually restricted to daylight operationss None of the light-utility helicopters often used is adequately instrumented to fly under conditions of restricted visibility. There are important reasons, however, why helicopter operations should be continued after dark:

- s Fire control tactics are likely tos be more effective at night becauses of reduced fire intensity and rates of spread.s
- Cooler temperatures, lower density altitudes, and air stability conditions are usually more favorable for helicopter operations.
- Helicopters will not compete for air space at night with fixed-wing air tankers, smokejumpers, and cargo planes (Johnston 1965).

The need for night helicopter operations is urgent, but there are several seriously limiting factors:

- Pilot orientation: without adequate instruments or visual references points on the ground, the pilot has little idea of his location, speed, altitude, or even the attitude of his aircraft (Flynn 1961; Milne 1962).
- Flight hazards: high trees, snags, ridge tops, and such man-made obstructions as powerlines and antennas are serious hazards unless the pilot can be alerted to their presence or has a safe route to follow (fig. 1).
- Landing areas: provision must be made to define or illuminate regular and emergency landing areas. Approach and departure patterns as well as any existing hazards must be clearly marked.s

NIGHT TRIALS

To determine if helicopter operations could be carried out safely at night, we conducted a test on the North Mountain Experimental Forest and at the Keenwild

Figure 1.--Typical hazards encountered by a helicopter. Unless lighted, trees would be difficult to see at night.

Station of the San Bernardino National Forest, in southern California. The areas selected were ideal because they represent elevations, terrain, and vegetation cover typical of many forested areas of the West.

In this first phase of the study, our objectives were:

1. To test the hypothesis that light helicopters can carry passengers and freight safely and efficiently at night or under conditions of limited visibility.

2. To determine the most effective guidance system--light, electronic, or both--for each type of operation.

3. To prepare initial guidelines for pilot and ground crew instruction and training in the use of selected equipment.

A Hiller 12-E Helicopter[1] belonging to Shasta Helicopters was used in this test. A Bell Helicopter has been used in earlier tests of night flying in Montana. By using a Hiller aircraft, we would then be able to compare both models of small helicopters that are now being used in forestry work (U.S. Forest Service 1965).

The pilot, Clyde Van Bebber, had extensive experience flying helicopters over mountains in the West. And he was trained in flying military helicopters at night.

In preparation for the actual tests, we took several preliminary steps. Several daytime flights were made, the optimum methods for safely conducting the mission were selected, and various kinds of guidance devices and their placement pattern were tested during these flights. Then in the actual tests, we made night-time trials over the same course. Each night flight was analyzed by the study team, and changes in the guidance system were made as necessary. Follow-up flights were made to test the effectiveness of the changes.

[1]Trade names and commercial enterprises or products are mentioned solely for necessary information. No endorsement by the U.S. Department of Agriculture is implied.

All methods were closely coordinated with helicopter guidance studies previously conducted by the U.S. Forest Service's Equipment Development and Testing Center at Missoula, Montana. Every effort was made to complement or supplement those studies--duplicating only when specific additional data were needed.

LIGHTING SYSTEM

Initial investigation of available electronic systems showed that none was immediately adaptable to our needs. Consequently emphasis was placed on developing a portable lighting system. We relied heavily upon both the system developed at Missoula and the equipment supplied by lighting system manufacturers. We evaluated five kinds of light systems.

PILOT'S CONTROLLABLE SEARCHLIGHT

From experience gained in the Missoula tests we installed a Bell 204-B type controllable searchlight on the helicopter. Mounted under the nose of the helicopter this accessory light can be controlled remotely by a thumb button on the cyclic stick (fig. 2). This in-flight adjustable feature eliminated the necessity of maneuvering the helicopter to pick up targets. With a few hours of practice the pilot became skilled in using the light, which proved especially valuable for avoiding obstructions, for landing at unlighted emergency spots, and for penetrating the darkness after the aircraft takes off from the lighted pad.

Once the light was installed, the only alteration required was to depress the up-stop limit switch to prevent reflections from the main rotor tip. Although the spotlight is helpful in checking obstruction clearance, it was unnecessary for following a known route. Cost of the equipment installed was about $400.

LANDING AREA LIGHTS

Lights must be seen and identified from a relatively long distance. And they should define the exact touchdown spot and indicate the best direction of approach. The study indicated that two kinds of lights were required: a fairly high intensity amber flashing or rotating beacon, and smaller steady amber pad marker lights (figs. 3,4).

First, we used a high intensity strobe light and a rectangle or triangle of flashing amber landing pad lights. The large strobe--when on continuously--was so bright that it blinded both air and ground crews when they were within 100 feet of it. But beyond that distance, it was quickly discernible at ranges exceeding 5 miles--even under hazy conditions. Intermittent activation and extinguishment of the large strobe on the pilot's radio command was satisfactory for enroute references. But because it still blinded the ground crew at the heliport, it was totally unsatisfactory for illuminating the area.

Next, we tried a much smaller flashing strobe beacon. To a limited degree we had the same problem with a small, continuously operating beacon at the landing area. When placed above a pole-mounted reflector, this small light was not objectionable to the ground crews. A Nelson 12-volt amber flashing type appeared to be the most effective tested. It has a normal bulb life of about 1,500 hours.

Changes were made in the original attempts at marking landing areas. Rectangular and triangular patterns were tried but eliminated in favor of a lighted "T" for combined heliport and wind indicator. Steady amber lenses gave an excellent landing reference. Straddling the trunk of the aligned "T" ensured adequate clearance for all rotors. Even the visibility restriction resulting from the Hiller 12-E and Bell-J central control console was acceptable for safe use of this lighting system. The small 6-volt amber steady lights were excellent. Their normal life is 12 hours, between battery changes.

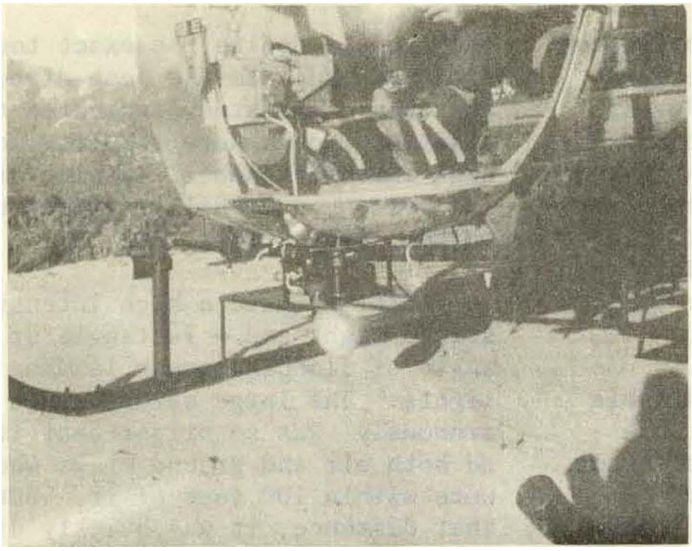

Figure 2.--Bell 204B type controllable searchlight mounted under the helicopter's cockpit.

Figure 3.--Flashing beacon type heliport light.

Figure 4.--Small steady pad marker lights.

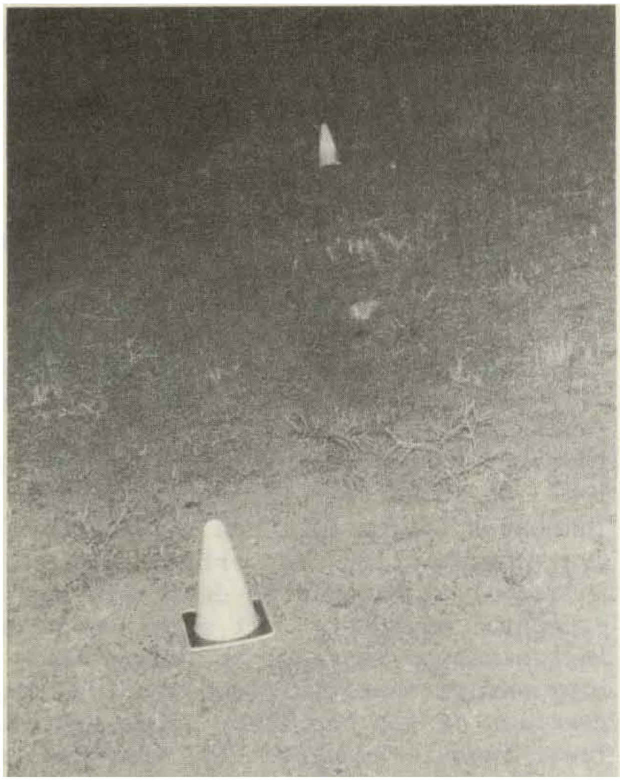

Figure 5.--Red plastic highway marker cones were used to illuminate emergency landing spots.

To mark and illuminate emergency landing areas, we tested three different types of lights. These consisted of our regular 6-volt amber landing pad lights, Nelson 12-volt amber lights,and amber and red translucent plastic highway construction marker cones that were placed over the light source. Both the amber and the red cones over steady lights appeared to be the most effective (fig. 5).

To provide parallax needed for depth preception and to prevent confusion with regular landing pads, the lights or cones were set up in an equilateral triangular pattern with 20 feet between corners.

OBSTRUCTION MARKER LIGHTS

Obstacles, such as trees, poles, or high brush near the landing area, form a serious hazard to the helicopter. To mark obstacles in the tests, we illuminated the top of each potential hazard from the ground by shining a hooded spotlight on it. This system, developed by Missoula Equipment Development and Testing Center, gave the flight crews a fairly good reference of canopy or barriers outlines when approaching from one direction. When approached from the opposite direction the light produced only faint silhouttes that suddenly became blinding when direct rays were encountered. Considerable delay also resulted when landing directions had to be changed owing to wind shifts because the lights had to be re-oriented. Standard flashing red lights and reflectors were recommended for pointing out intervening ridges, rock outcrops, the tops of tall snags, or other invisible hazards. Two types of lights proved effective: (a) 12-volt Burgess lantern, flood type, which illuminates more of the obstacles, such as tops of trees, poles, etc., but is not bright enough for good definition; and (b) 6-volt Ever-ready lantern spot type, which illuminates less of obstacle, but what is shown is much more clearly defined.

ROUTE LIGHTS

Early in the study, we found that if night flying was to be done safely, the helicopter would have to follow carefully predetermined routes rather than fly randomly around the countryside. The use of small strobes (ACR Model 40) to mark a line-of-sight route was generally satisfactory. They were considered superior to steady white lights because the pilot could easily and quickly identify them. Although the single strobe light when mounted well above screening vegetation or topography did not permit accurate range estimates, it did clearly define the path the helicopter was to follow. The units tested had a flash rate of 60 per minute; perhaps a higher flash rate (80 to 120 flashes) might be more effective. The ARC strobe light weighs 12 oz. and is only 6 inches long, but produces a flash easily visible for 12 miles under normal night time conditions. Some of the units were taped to short steel rods so that they could be mounted above the ground where needed.

MISCELLANEOUS LIGHTS

The angle-of-approach light systems tested were generally unsatisfactory. The pilot found no difficulty in making a good approach even without the aid of such equipment. However, the helicopter manager could materially help the pilot by using red plastic extension flashlights for arm signals.

A distinct passenger approach and departure lane should be lighted. We used a hooded neon light (Nelson Manhole) for this purpose. The light was placed in a position that would not affect the pilot's vision. It may be set up in which ever is the safe passenger approach and departure lane from the helicopter; that is, on either side or in front. And it can serve to illuminate marshalling areas for arriving and departing passengers and as a light for a night field office.

Helicopter managers and other personnel engaged in the control of the opertion should assist the pilot during landing by constantly observing the tail rotor clearance until final touch down. They should warn vehicle drivers and others in the area to turn off nonessential lights when helicopters are approaching and departing. This warning also applies to ground personnel using head lamps.

INSTRUMENTATION

The normal Hiller 12-E panel of instruments was supplemented by an attitude indicator and a standard rate-of-climb indicator (Dep. of the Air Force 1962). These instruments were considered only as "back-up" in case visual reference to ground objects was momentarily lost. (Care was taken that this did not occur. Flights were cancelled at the earliest indication of ground fog.)

The trials indicated that some supplemental equipment was desirable. The attitude indicator proved to be a valuable aid. It should be the non-spillable, electrically operated gyro type. Installation requires careful alignment of panel to allow full travel of the adjustable vernier. Cost including the inverter ranges from $75 to $250 installed. We found that the rate-of-climb indicator lagged too much and caused over-compensation. A vertical speed indicator also would be desirable supplemental equipment. It should provide instantaneous read-out to reduce serious errors resulting from the lead-lag reaction of the capillary bleed system. These inertia actuated IVSI instruments cost about $500. Also desirable is a lightweight radar altimeter. It should have scales showing 5-foot changes in the 50 - 1,500-foot range. It costs about $500.

The cabin heater and the defroster in the helicopter should be in operating condition at all times in case weather conditions cause sudden condensation on the cockpit bubble. A clear, clean bubble is vitally important during night flying to reduce light image scatter effects.

HUMAN FACTORS

We found that pilots must be familiar with the problems they may meet and what they can do to recognize and avoid them. Ground personnel should know what steps they can take to assist the pilot as much as possible. To find out what could be done to aid the pilot and avoid problems, we made a search of flight and associated medical literature.

When night flying becomes established, practice (including auto-rotation) on a continuing basis will be necessary to maintain pilot proficiency. Pilot Van Bebber had previous night flying experience in medium-size military helicopters, but did not have experience or practice when this study was begun. His night flying techniques improved with each test series.

It is apparently a universal trait to undershoot power off approaches to points of light. This tendency was also true in Van Bebber's first 12 auto-rotation landings, the last being a 360° full auto-rotation from about 800 feet above the ground back to a lighted landing "T." The result was a perfect landing that could not be improved upon--even in a daylight maneuver.

Limitations on individual pilot flight time were not included in this study, but it would certainly be necessary to establish the maximum number of hours any one pilot can fly in a night operation. The need for having qualified relief pilots under actual operations also must be recognized since a pilot cannot be expected to fly day and night or portions thereof without adequate relief.

TRANSPORTATION

PASSENGERS

During the tests 57 passengers were flown in their first night helicopter experience. However, we seldom ever carried more than one passenger at a time, mainly to improve the performance of the aircraft by reducing weight and as a safety factor. In the event of engine failure the ship would be lighter for auto-rotation descent and landings. This factor should be considered in future operations. And, it is obvious that some fire control personnel will refuse to fly at night.

Judging from experiences in these trials, the casual passengers will have difficulty observing tip path plane of main and tail rotors at night. And they may be in doubt as to which direction to approach or leave the aircraft. Because of darkness, passengers also have trouble with their gear, such as, harnesses, helmets, fasteners, microphone, and other personal equipment. Well trained helicopter managers and familiarity with the necessary equipment will eliminate most of this problem.

CARGO

Hauling freight by helicopter at night is essentially the same as during daylight operations. Air freight loaded on cargo racks should be loaded in relation to center of gravity range, and should be tied securely. Transportation by helicopters of externally carried air freight should be done by sling load technique if at all possible--regardless of whether it is night or day. Ground-to-air signals for take-off and touchdown with sling loads can be accomplished by ground crewman either by lighted arm signals (red flashlight wands) or by radio communications. During our tests we flew six sling loads, with a total weight of 600 pounds.

SAFETY

Compared to daylight operations, night helicopter flights are potentially more dangerous--first, to the pilot who must operate the aircraft; and second, to ground personnel who provide support for the operations. Many of the physiological phenomena that effect pilot performance, such as night vision adaptation and motion vertigo, are likely to be more of a problem under conditions of fatigue, hunger, and excessive flight time (Griffith 1922; Houssay 1955).

Not only will the helicopter manager have to enforce strict safety rules, but all fire personnel from fire boss on down must comply with these rules. A radio at each landing area manned by the helicopter manager or assistant is another important safety item. Individual pilot safety items include a pen light, a powerful flashlight, small rescue strobe, and back-up nav-com systems.

SUMMARY AND CONCLUSIONS

During the study we made 117 flights under conditions approximating fireline operations without any kind of "incident." However, all flights were carefully planned, managed, and the pilot was exceptionally skilled. This simulation phase of the study showed that light utility helicopters can fly relatively safely in the mountains at night provided:

- The night operation is well planned in advance.
- The entire mission is carefully managed by personnel thoroughly trained in their jobs.
- The helicopter and supporting accessories are adequate for the task.
- The pilot is skilled in both night and mountain flying.

This new capability of the helicopter to fly safely at night will give the fire boss the option of considering a delivery system that need not be interrupted by darkness. It will permit him to fly in reinforcement crews during the hours of darkness to critical sections of the line. And just as important, the day shift can be flown to the line in the predawn hours to relieve the night shift.

In the second phase of this study, we plan to determine the *best* light system for each task; evaluate several electronic devices, including radar altimeters and a radio navigation aid system; and test the equipment and procedures under carefully controlled conditions in actual fires.

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