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Arthur H. Jukkala
The University of Montana

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AN INVESTIGATION OF THE USE OF HELICOPTERS
AT NIGHT FOR FOREST FIRE CONTROL

By

ARTHUR H. JUKKALA

B.S. University of Montana, 1957

Presented in partial fulfillment of the requirements for the degree of

Master of Science

UNIVERSITY OF MONTANA

1966

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Chairman, Board of Examiners

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Dean, Graduate School

MAY 2 1966
Date
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CHAPTER I

INTRODUCTION

The Problem

During the past decade, helicopters have proven to be extremely valuable tools in forest fire suppression work. Every year they become more valuable as improvements in performance and design are made and as new accessories are developed to increase their versatility.

Helicopters are currently used by the United States Department of Agriculture, Forest Service, and other fire protection agencies to ferry men and equipment to fires, drop chemical fire retardants; drop paracargo; dispense fire hose, telephone wire and guide string; serve as air ambulances, and to perform a number of other important tasks (16).

Presently, helicopters are available for use on fires about 30 percent of the day during the months of June, July, August and September due to darkness. Fire control planners of the U. S. Forest Service feel there is a great need to extend helicopter operations to a 24-hour basis. Some reasons for this need are:

1. The U. S. Forest Service is putting greater emphasis on night control of fires. Therefore, the capability of transporting men and supplies into unroaded areas at night is needed.

2. With more emphasis on night fire suppression, the need for night injury evacuation capability will be more acute.
Night use will help relieve the heavy pressure on day use and free the helicopter for special tasks. Jobs such as retardant dropping, telephone wire dispensing and others, for which the helicopter is a great asset, often get lower priority than cargo and personnel ferry.

Daytime air space congestion becomes a problem on large fires where large fleets of air tankers, cargo and smoke-jumper aircraft and helicopters are operating simultaneously. Of these aircraft, the helicopter appears to have the greatest potential capability for operating at night when needed to reduce the congestion.

For these and possibly other reasons, the U. S. Forest Service decided to investigate the practicability of using helicopters at night in mountainous terrain for support in control of fires. It was recognized that unlimited or unrestricted night flying, such as retardant dropping or scouting, would be impractical, but carefully controlled operations might permit point to point ferry of cargo and personnel.

The job of conducting this investigation was assigned to the U. S. Forest Service Equipment Development Center in Missoula, Montana. The author was assigned the project leadership and received permission to use the study as a thesis problem for a Master of Science Degree in Forestry.

Objectives

The objectives of the study were:

1. Study the major problems affecting the use of small
helicopters\textsuperscript{1} at night in mountainous terrain for fire control purposes.

2. Determine if these problems can be solved or minimized by the use of special equipment or procedures.

3. Determine if night flights have operational potential. If they do, define equipment needs, operating procedures and limitations for such flying.

4. Determine what additional studies, if any, are needed.

Scope

The scope of this study was restricted to investigating the practicability of using small Bell 47G-3, 47G-3B or 47G-3B-1 series helicopters at night in mountainous terrain for support in the control of forest fires.

\textsuperscript{1}The term small helicopter is used frequently in this paper and it refers to helicopters having a maximum gross weight of 3000 pounds or less.
CHAPTER II

REVIEW OF LITERATURE AND ANALYSIS OF PROBLEMS

Investigation of Existing Systems

A search of published literature uncovered only one article concerning previous work involving the use of small helicopters at night. In this article, Green (9) described his experiences in spraying crops at night using a Bell 47D-1 helicopter. He states that lighting of the helicopter is very important, especially for eliminating the problem of vertigo. He uses ten lights on the helicopter for illuminating the ground and maintains a well-lit cockpit. A radio is used to maintain communications with herbicide refueling trucks and truck lights or bonfires serve as beacons to guide the pilot to the refueling point.

Letters were written to the Bell Helicopter Company and Hiller Aircraft Company inquiring about existing operational night flying systems. A reply from the Hiller Aircraft Company (10) revealed they had done no work to extend the capabilities of small helicopters for flying in darkness or poor visibility conditions. The author stated that he had flown helicopters in the mountains at night, but considered it hazardous without visual ground reference, such as lights.

The Bell Helicopter Company reply (12) stated that they were developing a Remote Area Instrument Landing System (RAILS) for the United States Army. This system was primarily designed for larger
helicopters such as the Bell UH-1. The writer also described development work in progress on a low light-level television display that would allow the pilot to identify people, trees and vehicles at approximately 1000 yards. This equipment was expected to be available in three years.

Two U. S. Forest Service representatives, Smith and Myler, attended a helicopter night flying exercise at the U. S. Army Pathfinder School, Fort Benning, Georgia. Smith's report (15) states that the Pathfinders use a portable radio beacon to guide the pilots, flying on instruments, to the landing site. Mostly heavy H-34 helicopters were used. Battery powered sportsmen's lanterns, aircraft directing flashlights and a "Justrite" portable glide path indicator were used to assist the pilot in landing.

Another U. S. Forest Service employee, Blake, visited Detachment 1 of the U. S. Air Force Western Air Rescue Center at Glasgow Air Force Base, Montana. Blake (4) reported that Detachment 1 uses Kaman helicopters for rescue work. They also use the helicopters to suppress flames of burning aircraft. The helicopters are equipped with sufficient instruments for instrument flying rules (IFR) flying. Two pilots are used, one to fly and the other to monitor instruments.

The pilots of Detachment 1 stated vertigo was a problem in flying the twin-rotor Kamans at night. Presumably it is caused by reflections off the two main rotor blades. To maintain good night vision, the pilots wear goggles with red lens when they fly near aircraft fires.

A beacon light mounted on a sandbag is used to mark reference
points or crash sites. Reportedly, the light can be dropped from a hovering helicopter and it will land upright.

Analysis of Problems

Information obtained in personal interviews and discussions with helicopter pilots was relied upon quite heavily in analyzing problems and formulating test plans.

Fred Gerlach, Assistant Professor of Forestry at the University of Montana, and a summer-time helicopter pilot, and Robert Schellinger, pilot for the Johnson Flying Service of Missoula, were the principal pilots interviewed. Both had prior experience in flying at night. Most of Fred Gerlach's night flying experiences took place in Alaska where he was an Army pilot. Bob Schellinger sprayed crops at night. Both pilots, like many others doing contract flying for the U. S. Forest Service, had emergency night flying experiences during their many summers of flying on fires.

Much of the information discussed in this section on analysis of problems was based on information furnished by Gerlach, Schellinger and others. Both of these pilots later participated in actual night flying tests.

Visibility and vision. Visibility or the lack of it is the crux of the night flying problem. If the pilot could see obstacles and hazards there would be no problem. The lack of visibility or ground reference can be compensated for in various ways:

1. Fully instrument the helicopter for zero-zero or no visibility condition flying (2), (3).
2. Use a combination of external lighting on the helicopter and visual ground reference beacons (9).

3. Use a combination of visual ground reference beacons or radio beacons, together with aircraft navigational instruments.

It was assumed in this analysis that one or a combination of the latter two methods would be the most practical for U.S. Forest Service use. Since both the latter two methods rely upon some degree of visual ground reference, it was important to recognize and consider some of the environmental factors which could influence ground reference. A few are: (1) phase of the moon, (2) fog, (3) smoke, (4) cloud cover, (5) precipitation, (6) topography, and (7) vegetative cover.

Fog, smoke, precipitation and heavy cloud cover can all be expected to reduce ground reference and probably would have to be avoided. Terrain and ground cover are indirect factors affecting visibility and their influence can be expected to reduce or enhance visibility depending upon the circumstances involved. These features are discussed in more detail in the section on terrain and ground cover. Moonlight could be expected to have a great influence on visual ground reference.

Light from fire flames, plus aircraft and ground reference lights, could also be expected to affect pilots’ visibility. Blake (4) reported some of the problems experienced by Air Force pilots flying helicopters at night around fires.

Flynn (8) states that flickering lights can cause unconsciousness.
Flashes occurring at a rate of 12 to 30 per second are particularly liable to cause trouble. In regard to helicopters, he recommends avoiding watching the flash of the rotor blades. If the pilot becomes suddenly aware of flicker unconsciousness, he suggests blocking out the light with the hands, but not to close the eyes.

Continued review of literature after tests were already in progress revealed that Navy pilots had night vision problems in making visual approach carrier landings. Kennedy and Berhage (11) studied pilots’ attitudes on dark adaptation for night flying. They found that the greatest value to an aviator of being adapted to the dark was during pre-flight operations. After being airborne, the aviator’s major visual problem lies in reflection of the instrument lights which reduce visibility and can affect dark adaptation.

**Terrain and ground cover.** Narrow canyons were expected to cause problems due to limited maneuvering space and darker environment. The darker environment results from canyon walls blocking out available light. Entrapment of smoke and fog in canyons by temperature inversions is another problem associated with canyons.

Steep, rocky or heavily timbered terrain could be expected to pose problems in locating flight routes and emergency landing areas. This situation is true for daytime operations as well, but the advantage of being able to see obstacles minimizes some of the hazard.

Certain types of ground cover such as light-colored soil or rock and cured grass could be expected to enhance ground reference, while dark green vegetation would reduce it.
Terrain and ground cover would greatly influence the planning and marking of flight routes and dictate the type of equipment needed to accomplish the job.

**Pilot.** Discussions with pilots showed they differed considerably in their views on night flying. Many felt it was unsafe and were unwilling to do test flying. Others felt night flying had possibilities and were very willing to cooperate in tests.

It was concluded that it would be extremely important to have highly qualified, interested pilots do any needed test flying. Prior experience in night flying, either in helicopters or fixed-wing aircraft, would also be essential.

**Helicopter.** The type of helicopter and how it is equipped are major factors in the practicality and safety of such operations.

The Bell Helicopter Company has developed a micro-wave Remote Area Instrument Landing System, termed RAILS, that will give the helicopter a zero-zero flight capability. According to a company brochure (2), "This system is an integrated instrument flight system specifically designed for solution of the problems peculiar to the operation of V/STOL (vertical/short take-off and landing) type aircraft in unprepared remote areas. The system provides the capability for velocity programming along space stabilized flight paths during cross-country flight and in terminal areas including programmed approaches and touchdowns on selected landing spots. It also provides the information required for landing path terrain avoidance."

The use of a system such as RAILS, or a similar one developed
by the Bendix Corporation (3) would permit flying in zero-zero or no visibility conditions. Unfortunately, these systems were designed for medium-size helicopters in the 8500-pound gross weight class such as the Bell 204-B and are too heavy and bulky for use in small helicopters. Although costs of this equipment were not obtained, it is reasonable to assume that it would be expensive. Most of the helicopters contracted by the Forest Service are of the small variety so further investigation of these systems was discontinued.

Since it appeared impractical to fully instrument a small helicopter for zero-zero flying, it was concluded that some form of visual night flying would be the most practical approach. Therefore, the remainder of this analysis on equipment needs and flying procedures is based on this premise.

For visual flying, Gerlach and others recommended installing attitude and directional gyro instruments for a backup system in the event the pilot momentarily lost visual ground reference. It was also felt that an external light or lighting system for illuminating the ground from the helicopter would be essential, as indicated by Green (9).

Requirements for this external lighting were not too well defined. A light that would allow the pilot to distinguish terrain features from a distance of 1000 feet would be desirable. Two pilots suggested the use of a controllable searchlight such as found on the military H-21 and commercial Bell 204B helicopters.

It was recognized that a radio for communicating with landing sites was an essential item of equipment for the helicopter.
Most pilots interviewed agreed that they would want to carry lighter loads at night for a greater margin of safety. Therefore, it might not be practical to use all small helicopters at night, but only the higher performance models having a useful load capacity in excess of 1000 pounds at sea level (6). It appeared that loads might be carried best in slings so they could be released in case of emergencies. A single-point release cargo hook would be safer and more positive than older model two-point assemblies commonly in use, and the former type should be required.

Landing areas. Study indicated that requirements for landing areas, referred to as helispots in this report, would have to exceed the standards established by the U. S. Forest Service (16). It was felt that landing pads should have a minimum clearing of 100-foot diameter for night work. The helispot would have to be occupied by at least one man highly experienced in helicopter operations and safety. He would have a radio and a kit of special lighting equipment to mark the helispot.

It was assumed that some of the requirements for visual flight rules (VFR) airport lighting described by Robinson and McKelvey (14) would apply. In regard to VFR airport lighting they state, "To locate the field and to get aligned with the safe landing area is an operation that at night depends on visual aids regardless of the nature of the surface." They list runway lighting and beacon systems as the two fundamental "building blocks" for airport lighting.

According to their report, the runway edge lights perform the basic function of defining the runway outline, and for maximum
effectiveness should be omni-directional. Omni-directional pertains to a lighting fixture where the intensity is substantially independent of the azimuth from which the light is viewed. Adequate spacing for runway lights is given as 200 feet. Recommended intensity is 25 to 100 candles for VFR conditions.

The basic function of airport beacons is the location and identification of airports. The beacon should be visible from at least 15 miles. A beacon having a peak intensity of 25,000 to 50,000 candles (at elevations between 1° and 8°) given off in a "white" flash is termed adequate for VFR airports.

Use of a lighted wind indicator is also recommended in their report.

**Flying procedures.** It was assumed that all night flying would have to be done under strict control over planned routes marked by ground beacons. The pilot involved in the night flying would have to fly and plan flight routes during the daylight to select the best routes, emergency landing sites and obtain necessary terrain elevation data, distances, headings, etc. He would inform ground crews on beacon locations and assist in placing them with the helicopter where possible.

**Weather.** In general, weather conditions appear to be more favorable for night flying than daytime flying. The air is generally more stable and less bumpy at night due to less convective activity (7). Stable air contributes to easier and safer flying.

Temperatures are lower at night. According to one source (7),
night temperatures may be as much as 60°F cooler than daytime highs in high mountain valleys. The average daily range in August is 21°F. in Chicago and 43°F. at Elko, Nevada. Helicopters perform better at lower temperatures because the air is denser (18), (17). Therefore, the lower night temperatures favor night flying.

Winds are usually less gusty and variable at night due to less turbulence (7). However, according to Barrows (1), peak wind velocities in the mountains are frequently reached at night. Haze, mist and fog are apt to be problems in night flying. These conditions frequently occur as the air cools and relative humidity increases to 70 percent and higher (13).

Temperature inversions are also more likely to occur during the early morning hours when there is less air mixing from winds and convective activity (13). When inversions occur, smoke, fog or mist are likely to be trapped in valleys and canyons, making flying into or out of these areas during this period impossible or unsafe.
CHAPTER III

TESTS

Test Objective

The test objective was to determine if the problems of flying small helicopters at night could be solved or minimized through the use of special equipment, techniques and procedures, as indicated by the analysis of problems and review of literature.

Test Plan

The general test plan was to start with simple night flying exercises and progress to more difficult ones as procedure and equipment needs were satisfied. Providing flights remained safe, the test flight program would continue until realistic field conditions were reached.

The pilot and author were responsible for determining unsafe conditions.

Test Procedures

Each test was planned around certain objectives. Prior to the tests, objectives were listed on special test data forms (Appendix C). Space was allowed for comments which were filled in after the tests were completed. Other data pertinent to the tests were also recorded.

The pilot and ground crew members were briefed prior to each test on the objectives and requirements for the test. Debriefing sessions were sometimes held immediately after the tests but most
frequently comments were obtained from the pilot the following day.

Tests—Series I

During April 1961, tests were conducted on six nights. For purposes of reporting, they are classed as Series I tests.

Equipment for these tests was obtained on the basis of anticipated requirements determined by the analysis of problems and review of literature. Cost and weight were important considerations in equipment selections.

Helispot marking equipment. The flashing, omni-directional light in Figure 1 was selected for evaluation as a helispot boundary and pad marking light. Amber lights were used for boundary identification and blue or green for identifying the center of the pad. Tests proved the lights to be satisfactory for both purposes. However, the flashes of the lights are unsynchronized with one another and were somewhat distracting. Also, weather proofing may eventually be necessary.

Best results in marking helispot boundaries were obtained with the lights placed about one chain (66 feet) apart. The lights can be used in a number of ways. In some situations they were used to mark the entire perimeter of the helispot as in Figure 5. In other situations they were used to mark the perimeter of the landing pad area or to serve as takeoff and approach reference lights some distance away from the pad, as in Figure 6.

The sportsman's lantern shown in Figure 2 has a spot-type beam and was selected for illuminating obstacles such as lone snags and
Figure 1. Boundary and pad marking lights.

Figure 2. Obstacle marking light.
trees surrounding helispots. A fiberboard hood was made to provide additional confinement of the beam, if the light had to be placed far from the obstacle.

These lights worked very well for illuminating obstacles. They also were found useful for illuminating the helicopter rotors while the helicopter remained on the landing pad. Helicopter rotors are always a safety hazard and even more so at night when they are hard to see.

Additional items tested for use at helispots were: scotchlite reflective paper and aluminum-coated paper for wind direction indicator panels, standard U. S. Forest Service belt weather kit for collecting weather data and portable radios. The radios and belt weather kit were found to be essential for this type of work. The wind direction indicator panels were unsatisfactory. In these tests, the pilot was informed by radio of wind conditions at the helispot. However, a wind direction indicator system would be desirable in event of a radio communications failure.

**Route marking equipment.** Routes were marked using two helispot boundary marking lights taped together. Two lights provided more illumination plus somewhat of a fail-safe system in the event one of the lights burned out. The light component has an undetermined life. The batteries provide about 8 hours of continuous service.

Route lights were placed in position from the ground in all tests but systems for placing them from the helicopter were also tested. Methods tried included: small parachutes, a large dart, sandbags, and a controlled descent device. The controlled descent device was essentially
a holder for a spool of monofilament fishing line with a brake to slow up and stop the free-spinning spool. The small parachute and controlled descent device showed the most promise.

A small strobe light was also evaluated for a route marking beacon (Figure 3). The strobe light designated ACR-4 by the manufacturer has a peak output of 2 million lumens per flash at 40 flashes per minute. Tests indicated that fewer high-intensity lights such as these strobe lights were more suitable for marking routes than numerous weaker ones. The less intense, inexpensive lights appear to have greater application for dropping into inaccessible areas by parachute or other means. Since they are inexpensive and the batteries will go dead in about 8 hours, they need not be recovered.

Tests also suggested a need for lights with solar switches to mark routes for several nights' use and the need for special colored lights for marking emergency landing spots along or adjacent to flight routes.

Helicopter. A Bell model 47G-3 helicopter, owned by the Johnson Flying Service, was used for the Series I tests. The helicopter was fitted with a retractable landing light from a C-46 aircraft, as shown in Figure 4, and a standard U. S. Forest Service radio for air-ground communications.

A small electric motor on the light allowed the pilot to change its position through a 90-degree arc in the vertical plane. The light had no movement horizontally. In tests, control of the light beam in the horizontal plane was accomplished by yawing or crabbing the helicopter.
Figure 3. Strobe route beacon.
Figure 4. Controllable searchlight extended.
Tests indicated that in emergency situations the searchlight could be used from about 1000 feet above the terrain to follow roads, rivers and ridges. It could also be used to make landings without the benefit of helispot boundary and obstacle lights. However, the latter lights would be essential for operational use. They serve as a backup system in event the controllable searchlight malfunctioned. Landings were intentionally made in the black, with the searchlight turned off, to prepare the pilot for such an emergency. Landings can be made in this manner, but are much more difficult and marginal.

The light actually malfunctioned twice, which resulted in the cancellation of parts of two tests. The malfunctions, together with the lack of control of the light in a horizontal plane, indicated the need for a better system.

The searchlight and navigation lights caused considerable glare and reflection on the cabin bubble. It was found that a clean cabin bubble was essential. Tests with navigation lights turned off greatly reduced bubble glare. However, this practice would be prohibitive in most areas where other air traffic exists. Also, it is difficult for ground crew members to monitor flight progress.

Items such as mirrors used for cargo hauling, snow pads, and other accessories attached to the front portion of the skids can cause bubble glare and should be removed or covered.

Test areas. Three areas were used for the Series I tests. A semi-open field south of the U. S. Forest Service Aerial Fire Depot and west of the Missoula County Airport was used for initial tests.
The second area involved only one helispot (Figure 5). The area is south of Missoula in Section 3 of T12N, R20W, and immediately adjacent to the National Guard Rifle Range. Takeoffs and landings were made at the one helispot. The Missoula County Airport served as the base heliport.

The third test area was located west of Missoula in T13N, R21W. Helispot #1 and #2 were located in Sections 12 and 2, respectively. (Refer to Figures 6 through 8.)

All test areas were carefully selected for maximum safety, with lights in the Missoula valley providing supplementary ground reference.

Weather. The weather was good for all tests except the fifth. On that night, wind direction at helispot #2 of the Deep Creek test area was variable with gusts up to 20 m.p.h. For this reason, no landings were attempted at helispot #2 during this test.

On the night of the fourth test (April 14, 1964), the sky was completely overcast (10-tenths cloud cover) with altostratus clouds. This air was stable, and the horizon distinguishable. Surprisingly, the completely overcast sky caused no particular problem in flying that night.

Pilot. Bob Schellinger of the Johnson Flying Service was the pilot for all the Series I tests. Schellinger’s total flying experience of over 3000 hours, coupled with previous night spraying experience, proved invaluable in the tests and strengthened the theory that highly qualified, experienced pilots would be needed for night flying assignments.
Figure 5. Rifle Range test area.
Figure 6. Deep Creek test area.
Figure 7. Deep Creek Helispot #1.

Figure 8. Deep Creek Helispot #2.
Discussion of results. These tests indicated that under very favorable weather and topographic conditions, a limited degree of night flying capability could be achieved with the use of a small amount of special equipment. Additional tests would be needed to determine and define the extent of this capability.

Tests—Series II

This series involved only one test in August, 1964. More were planned, but an accident involving the test helicopter destroyed the controllable searchlight and curtailed further testing. The accident occurred in a daylight flight unrelated to these tests.

The weather for this test was considered to be very good. Light winds and low temperatures prevailed. Bob Schellinger piloted the helicopter.

Test area. The primary difference between Series I and II was the test area. The Ninemile area (Figure 9) used in the Series II tests was selected because: (1) it offered possibilities for longer flights between helispots having greater differences in elevations; (2) there is less ground reference provided by cultural features, yet it is close to Missoula, and (3) the large valley provided many safe emergency landing possibilities.

Helispot marking equipment. The landing sites were marked with boundary and obstacle lights similar to patterns described in the Series I tests, with only slight variations dictated by the physical features of each spot.
Figure 9. Ninemile test area.
An angle-of-approach light (Figure 10) designed for military light aircraft and helicopter use was evaluated in these tests. The unit projects three beams of colored light to guide the pilot vertically for a landing. Two additional lights provide horizontal guidance. The unit was unsatisfactory because the colors could not be differentiated from a sufficient distance. The pilot was virtually committed to land by the time the colors were visible. Additional work on angle-of-approach aids was recommended.

In this series, test flights revealed a need for a high-intensity beacon at the helispot for positive identification when long flights are made. The small strobe beacons shown in Figure 3 were evaluated but their intensity was not adequate for this purpose. Under good conditions, the small strobe lights can be seen from three to four miles, but this was not considered adequate for this purpose.

**Route marking equipment.** Several harbor navigation beacons with solar switches (Figure 11) were purchased for route marking beacons. They were placed adjacent to helispot #1 for evaluation but were not placed along the flight routes.

The harbor beacons have a neon bulb which produces a relatively low-intensity flash in comparison to the small strobe lights. Although they cannot be seen from much further than two miles, they are expected to be useful for marking routes for operations lasting several nights.

Beacons were not placed along flight routes in these tests because the lights of helispot #1 and #2 were visible from each other and numerous ranches line the road along the center of the valley.
Figure 10. Angle-of-approach light.

Figure 11. Harbor navigation beacon.
between helispot #1 and #3. It was felt that the lights from the ranches would provide adequate reference. However, tests proved that flashing beacons should have been used because the ranch lights provided no distance reference. Consequently, the pilot had difficulty in locating helispot #3 in the flight from helispot #2. (Refer to Figure 9.)

**Helicopter.** The same helicopter used in Series I tests was used, but in place of the C-46 landing light, a fully controllable searchlight (Grimes, Model G625C-L, Type MA-3) had been installed. Designed for helicopter use, the light rotates 360 degrees in the horizontal plane and 120 degrees vertically. Control switches were mounted in a special cyclic stick grip. No comparative tests were made, but the intensity of this light appeared to be less than the C-46 landing light. However, greater controllability and faster movement response greatly offset any loss in intensity. The light is a little smaller but essentially the same in appearance and mounted identically as the light shown in Figure 4.

**Discussion of results.** On the only flight between helispots #2 and #3, the pilot commented he had "poor feel" of the helicopter. Periodic checks of the airspeed indicator showed fluctuations from 0-60 m.p.h., but the pilot could not readily feel this difference.

The lack of sensation of movement was assumed to be partially due to two factors: (1) high altitude above the terrain (about 3000 feet), and (2) lack of adequate distance reference on the ground.

Another problem encountered during the same flight was a
"boxed-in" feeling as helispot #3 was approached. The following factors appeared to contribute to this feeling:

1. Increasing darkness in the direction of travel due to narrowing of the valley (see Figure 9).
2. Diminishing horizon reference as valley narrowed and landing letdown was made.
3. Inadequate ground reference lighting. The helispot lights were not bright enough to provide positive identification over lights of adjacent ranches.

These tests served to point out additional problems in night flying, particularly when greater distances and valleys or canyons are involved. The need for more tests was apparent.

Tests--Series III

The third series of testing was undertaken during the summer and fall of 1965.

Pilot. Fred Gerlach served as pilot for these tests. Bob Schellinger was unavailable due to another flying assignment.

Bob Clark, a U. S. Forest Service fixed-wing and helicopter pilot, participated as an observer in most of the Series III tests.

Test area. Several evenings were spent familiarizing the new pilot and observer with the equipment and procedures used in earlier tests. The helispot adjacent to the U. S. Forest Service Aerial Fire Depot, Deep Creek helispot #1 (Figure 6) and Ninemile helispots #1 and #2 (Figure 9) were used progressively for these flights.
Weather. Weather conditions were ideal for most of the tests. By chance, much of the flying in this series of tests was done under clear skies with excellent moonlight. Under these situations, without a reduction in visibility by smoke, night flying appears to be no great problem.

In one test, winds on the ridge at helispot #2, Ninemile test area, were about 15 m.p.h. Until further experience is gained, this appears to be the maximum allowable for night flying.

Helispot and marking equipment. During Series I and II tests, helispot and route marking equipment needs were established. As a result, the helispot marking kits (Figure 12) were assembled.

A high-intensity strobe beacon, obtained as the result of findings of the Series II test, was included as part of the kit. The manufacturer of these lights (Model Sky Lite BX 7214-1), the Gas Equipment and Engineering Company, states peak output is 2000 to 2400 candle-power seconds. The flash rate is about 40 per minute.

With the use of this beacon, it was felt that the small flashing boundary lights should be converted to steady, continuous beams since the flashing was somewhat distracting. Comparative tests verified this hypothesis and all boundary lights were converted.

The high-intensity helispot beacon could be seen readily from about six miles. Because of its brilliant flashes, ground crew members had to switch it off when the helicopter got within about one-quarter of a mile from the helispot so the pilot would not be blinded. The flashes were also somewhat distracting to the ground crew, so it was only switched on while the helicopter was flying. The beacon provided
Figure 12. Helispot marking kit.
the positive helispot identification needed.

A new method of indicating wind direction for the pilot was devised and tried. White translucent plastic golf club protector tubes were taped to flashlights. The end opposite the flashlight was plugged, resulting in a wand or tube of light. Two wands were placed in the shape of a "V" with the apex pointing into the wind. The "V" could be seen from about 1000 feet above the helispot.

No new route marking systems were evaluated in these tests.

**Helicopter.** Pilot orientation flights were made with a Bell 47G-3B-1, using a controllable searchlight and a radio as the only special items of equipment. After a number of flights, both the new pilot and observer recommended installing attitude and directional gyros (A.G., and D.G.) in the helicopter for a backup system in case visual ground reference was momentarily lost. Both felt that these two instruments would greatly improve the overall safety of night flying.

Electric instruments had to be ordered because of the difficulty of connecting vacuum instruments to the engine manifold. It was difficult to find an electric directional gyro, but once the instruments were obtained, no problems were encountered in installing them.

**Figure 13** shows the instruments mounted on the left side of the instrument console. This location was selected because the pilot could read the instruments adequately and the console provided the best mount.
An inverter to convert the aircraft voltage from 28 volt to 110 volt AC to operate the instruments was also needed. This was installed inside the cabin underneath the pilot's legs, as shown in Figure 14. This location was used for simplicity of installation for tests and may or may not be the best ultimate location.

Aircraft flares for use in making emergency landings were also installed on the helicopter. The idea was suggested by a Johnson Flying Service pilot, and followed up because emergency landings had been an important consideration since the onset of this project and no absolute solution to the problem had been reached.

Until this time one procedure for making emergency landings appeared workable. Routes would be planned over terrain which included the best emergency landing areas. Special color lights would be placed in emergency landing spots along the route. In the event of an emergency, the pilot would head for the nearest spot and use the controllable searchlight to make the landing. This procedure was not considered to be the best solution because it offered little assistance to the pilot out of range of a marked area. The searchlight might be used but it would be of little value in selecting the best landing site.

Since aircraft flares were designed to provide fixed-wing pilots with illumination to select emergency crash landing sites, it was decided that they might be useful for night helicopter flying and should be evaluated.

Flares appearing to be the most suitable were 1-1/2 minute parachute flares, designated MKI MODI, manufactured by the Harvell Kilgore Corporation. According to the manufacturer, the flares will
Figure 13. Special navigation instruments.
Figure 14. Inverter installation.
illuminate a circle having a radius of three-fourths to one mile when fired from 2000 feet. They will burn for 700 feet or 1-1/2 minutes before going out. The flares will likely start a fire if fired below 700 feet. However, since the crash of a helicopter would also probably start a fire, this was considered irrelevant.

Calculations by Missoula Equipment Development Center engineers showed that the effects of firing thrust on the helicopter would be negligible if the flares were mounted close to the aircraft's lateral center of gravity (C.G.). A rack holding three flares was mounted on the right side cargo tray for tests. Figure 15 shows the flare rack with two flares fired. Refer to Figure 13 for cabin location of flare firing switches.

Problems with glare produced by the controllable searchlight prompted the installation of a shield around the light. This can be seen in Figure 15. The shield shown is not the ultimate answer but it did reduce bubble glare. A shield attached directly to the light is recommended for future work.

In an attempt to minimize the effects of glare and diffused light caused by the searchlight, navigation lights and helispot lights, the pilot tried wearing amber lens glasses. The pilot reported that the glasses seemed to help when the controllable searchlight was on. When the light was off, he felt they probably reduced overall visibility which is true of any light filter.

Special glasses appear to be another area worthy of study. Military studies (12) indicate that red lens glasses are valuable in protecting night vision while the pilot is in a lighted area, but
Figure 15. Emergency landing flares.
they are not worn in flight.

**Auto-rotations.** Because of the concern about emergency landings and to acquaint himself with the problem, the pilot made about a dozen night auto-rotations. An auto-rotation is defined as a power off landing with rotors turning (18).

An area in the open field south of the Aerial Fire Depot was marked with boundary lights to provide a target. Auto-rotations were made from various altitudes, mostly from about 1000 feet. Full 180-degree turns were executed in the descent. Power was reapplied just prior to touchdown, which is common procedure in practicing auto-rotation landings. The controllable searchlight was used for ground illumination plus height reference. It worked well for both purposes.

The pilot noted a tendency to come in short of the target, but in all cases would have reached the target area for a safe landing in an actual emergency.

**Instrument evaluations.** Daylight and night flights were made in the Missoula valley to acquaint the pilot with the navigation instruments.

By using the attitude and directional gyros together with the standard altimeter, the pilot had no difficulty in maintaining the helicopter in directed, level, stable flight or descending for a landing on instruments. He reported no particular difficulty in monitoring the instruments periodically while flying by visual ground reference. This indicated he could make the transition to instruments if visual ground contact were momentarily lost.
After these flights, both the pilot and observer Clark were satisfied that the instruments would provide a valuable backup to visual night flying. Subsequent flights further satisfied the pilot of the instruments' value and relieved some of the apprehension of night flying.

Flare tests. The emergency landing flares were first static fired with the cargo tray mounted on the back of a pickup truck. The firing was successful so they were next fired in daylight from the helicopter about 1500 feet above the ground. In this firing, the pilot executed an auto-rotation with a left turn to avoid being blinded by the bright flare. A complete descent was made before the flare burned out. According to the manufacturer, the flare shoots out about 400 feet before the parachute deploys and begins its descent. In this test, the flare was well clear of the helicopter before it deployed and appeared to constitute no safety hazard. The thrust exerted upon the helicopter was unnoticeable.

Next, two flares were fired at night. In both cases, the incendiary material broke away from the parachute and free fell to the ground. The malfunctions were attributed to old age of the flares. Unfortunately, these tests were inconclusive and further testing was recommended for future study.

Cargo hauling experiments. These experiments were conducted at the Ninemile airstrip and were primarily concerned with sling loads. The problems in hauling sling loads at night center around the pilot's judgment of ground clearance during load hookup, takeoff, landing
approach and load release. The problems of point-to-point flying are no greater than with cargo tray loads. In fact, sling loads are safer because loads can be released in emergencies.

Loads were attached to the hovering helicopter by one man while a second with a radio guided the pilot over the load. The procedure could be further simplified by having the hook-up man fitted with a helmet with built-in radio communications. He should also wear a headlamp to provide illumination while working underneath the helicopter. Once the hook-up was completed, the radioman informed the pilot of his load clearance on takeoff. A radioman on the load-receiving helispot provided the pilot with ground clearance estimates for load touchdown.

Flashlight wands, commonly used for directing aircraft, were also obtained for sling load ferrying operations. They were not used but should be provided in helispot marking kits in case of radio communications failure.

In general, cargo hauling at night is more critical than in the daytime. In the daytime, if the pilot has difficulty maintaining adequate terrain clearance during a climb, he can meander along the terrain contours until he gains sufficient altitude. This practice is not recommended for night flying and the pilot should adhere to the marked route. Therefore, he must know in advance what altitudes he will have to be at over certain points along the route and climb to these altitudes before proceeding along the flight path. For example, in ferrying cargo from helispot #1 to #2 (Figure 9), the pilot spiralled over helispot #1 to an altitude of about 5000 feet
before proceeding to helispot #2. In normal daytime operations, a pilot probably would not do this.

It is essential that the pilot makes daylight flights with maximum loads between the spots he will use at night. He can then plan his climb patterns for night operations. Loads should be reduced by about 10-15 percent of gross for night work. This will give the pilot greater margin of safety for landings and takeoffs.

Hypothetical problems. As part of this series of tests, several hypothetical night supply problems were created. The pilot was given an opportunity to thoroughly review the situations with the helicopter and offer his comments.

Some of the most rugged terrain in the Missoula area was selected for the hypothetical situations because it was felt that terrain would be a limiting factor to night flying. However, of all the situations reviewed, none was completely rejected by the pilot as unsafe to fly at night from a terrain standpoint alone. In most situations, when asked how he would prefer to fly to a ridgetop helispot, the pilot elected to fly from another ridgetop helispot. When possible, he would plan the route to fly along ridges rather than across canyons.

When necessary to fly from a valley, the pilot usually preferred to circle and climb directly over the valley helispot to gain altitude before proceeding to a higher helispot. In narrower canyons, where this was not a good practice, he preferred to find a ridgetop spot to fly from rather than fly up or down a narrow canyon.
Although none of the hypothetical situations were actually flown at night, they proved to be an extremely valuable exercise in investigating the probability of flying under various terrain conditions. From these experiments, it was concluded that under favorable weather and visibility conditions, terrain was not as much of an obstacle to night flying as originally suspected. More work of this nature is recommended with followup of actual night flights of the situations examined.

Discussion of results. Experiments for flying at night adjacent to a fire were planned. However, they were cancelled for this study due to delays in obtaining new flares, adverse weather and other scheduling problems.

Although the flare experiments described earlier were not a complete success, their potential contribution to a safe night flying operation appeared to be so promising that we were reluctant to conduct additional tests before fully evaluating them.

Two suppositions can be made about flying near fires:

1. Helispots should be located to avoid smoky conditions.
   In most cases this means locate them on ridges and upwind from the fire.

2. Radio communications will have to be utilized to the fullest for informing pilots of smoke conditions at helispots.

Light smoke may not be a great limitation to night flying.

During tests, numerous night flights were made across the Missoula valley when inversions accompanied by rather heavy smog conditions prevailed. However, it was surprisingly easy to see ground reference
lights. Actual tests on fires are needed to support this hypothesis. It appears safe to assume that heavy, dense smoke conditions will have to be avoided.

The fire flames may provide considerable ground reference and in many cases actually aid the total operation rather than hamper it.
CHAPTER IV

SUMMARY AND CONCLUSIONS

Night use of small helicopters in mountainous terrain is potentially more hazardous than daytime use. However, through the use of special equipment, procedures, careful planning and qualified personnel, it appears safe to fly at night under favorable environmental conditions. The effects of smoke were not studied, so no definite conclusions can be made about flights where smoke is a problem.

Considerable preparation is required in advance of night flights, and this capability has little value in initial attack transportation except in situations where all the essential preparations have been made in advance.

The following requirements and guidelines were indicated by the results of these experiments. Additional studies are needed for their further qualification and refinement.

Pilot

A. The pilot should have the following minimum flying experience. More experience is preferable.

<table>
<thead>
<tr>
<th>Hours of flying time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total in all aircraft</td>
</tr>
<tr>
<td>Helicopter</td>
</tr>
<tr>
<td>Total</td>
</tr>
<tr>
<td>Night (includes special training)</td>
</tr>
</tbody>
</table>
Hours of flying time (cont.)

Typical terrain

100

In weight class to be flown (light, medium and heavy)

200

Forty landings and takeoffs at typical altitude and type of helispots or heliports to be used.

These requirements are approximately double the U. S. Forest requirements (16) for helicopter pilots.

B. It is extremely important that he is interested in and willing to do night flying of this nature. He should not be compelled to do it.

C. He must be given night flying training using equipment and procedures outlined in this study. A minimum of ten hours of night flying orientation is recommended.

Helicopter

A. Newer models having greater payload capabilities are recommended. They must be in excellent mechanical condition. The Bell 47G-3B and 47G-3B-1 are suitable models. Recent unpublished studies by the U. S. Forest Service, Pacific Southwest Forest and Range Experiment Station, indicated that the Hiller 12E is also suitable for this work.

B. The helicopter must have the following special equipment:

1. Controllable searchlight. Preferably, the light should be shielded to minimize glare.

2. Radio for communications with helispots. Two-way VHF radio is also essential.
3. Attitude gyro (electric).

4. Directional gyro (electric).

5. Altimeter (if it is not a standard item).

6. Flashlight, with red lens. For reading instruments in case panel lights burn out.

The bubble should be clean. Mirrors, snow pads and other accessories should be removed or covered if they are potential causers of glare.

Table I (Appendix A) lists weights and costs of special equipment.

C. Other equipment:

1. Flares—experiments indicated that emergency landing flares would be desirable but the results were inconclusive.

2. Terrain avoidance radar—a new lightweight, low cost radar altimeter which has become available since the completion of these tests also appears to have merit for this work. Additional studies will be needed to determine its value. The unit is designated TRN-70 by Bonzer, Inc., of Shawnee, Kansas, the manufacturer.

The altimeter gives direct readings on the height of the aircraft above the terrain. It reads in 10-foot increments between heights of 200-2500 feet above the terrain. It does not indicate heights out of this range. The instrument has a 70-degree cone of influence and measures the distance to the nearest terrain.
**Helispot Selection**

The helispots must be carefully selected in conjunction with flight routes. Particular considerations must be given to wind, smoke, terrain, obstacles, road accessibility and special obstacles or hazards. Other U. S. Forest Service guidelines (16) for selecting helispot sites apply.

It is very difficult to give specific guidelines for locating helispots in regard to flight routes because many factors are involved. The **most important guideline is to locate helispots so the very best terrain can be utilized for flight routes**.

The following are general guides for flight route location.

**Situation No. 1.** Fly to a ridgetop helispot. This can usually be done best from another helispot located on the same major ridge or a spur ridge.

If this procedure is impractical and the drainage is narrow, the next best choice may be to fly to it from another ridgetop helispot across the drainage. If the drainage is wide, it may be best to fly from a helispot in the drainage. However, smoke may become a limiting factor in operating from the valley helispot. In most cases, helispots should not be located in narrow drainages.

**Situation No. 2.** Fly to a valley helispot. In most cases, this probably can be done best from another helispot in the same valley. If this is unsafe or impractical, the best alternative would be to fly from an adjacent ridge. Probably, the last choice would be to fly from
a valley helispot located in another drainage if ridges separating them must be crossed.

Other Helispot Requirements

A. Helispot construction standards should equal or exceed those shown in Appendix B.

B. They must be manned by a heliport manager thoroughly trained in night operation techniques and equipment.

C. A kit for marking helispots and communicating with the pilot is essential. Suggested contents with estimated weights and costs of equipment are included in Table II (Appendix A).

D. Equipment for each helispot should be packaged into one or two fiberboard boxes for delivery by parachute, helicopter, truck or pack mule.

Helispot Marking Procedures

The following procedure for use of helispot equipment is suggested:

Situation No. 1. Narrow helispot (100 feet wide) cut in timber or brush. It is recommended that the entire boundary be marked with amber lights placed about 66 feet apart. A rectangular pattern is suggested. One green or blue light should be used to mark the center of the pad. If the level pad area is small or surrounded by stumps and rock outcroppings, additional amber lights should be used to delineate the pad area.

Obstacle lights should be used to illuminate hazardous snags, trees along the spot border, etc. For safety, one obstacle light can
used to illuminate the main rotor tips while the helicopter is on the pad.

Caution must be exercised so pilot is not blinded by lights while landing or on the ground. Obstacle lights, vehicle lights, high intensity strobe beacons and camera flash bulbs can momentarily blind the pilot.

Wind direction should be indicated with a lighted "V" or "T". Flashlights attached to white, translucent plastic golf club protector tubes are excellent. These are easily repositioned with changes in wind. Systems which are difficult to reposition should be avoided.

High intensity helispot identification beacons should be switched on only when helicopter is flying. It must be switched off when the helicopter is within a one-fourth mile radius of the helispot or at the pilot's request.

Only in an extreme emergency should a flight be made without radio communications.

**Situation No. 2.** Big field or meadow being used for a helispot. Amber boundary lights are not needed around the entire spot. Boundary lights should be used to mark an area between 50-100 feet wide by 100-200 feet long. A green or blue light should be used to mark the pad center. Additional amber boundary lights can be used as guide lights to mark approaches or turning points as recommended by the pilot.

Remaining equipment should be used as described in Situation No. 1.
Flight Routes

A. Flight routes must be selected by the pilot in the daylight. They should be planned over terrain having the best possibilities for emergency landings. Distances between heli-spots should be as short as possible. When it is necessary to fly across major drainages, about 1000 feet of altitude should be maintained for greater probability in reaching landing spots in an emergency.

B. Routes must be marked in advance with beacons. Suitable emergency landing areas should be marked with one or more lights of a different color. The pilot must select locations for route beacons and emergency landing area markers. Beacons can be placed by men on the ground or dropped by small parachute or other lowering systems. The helicopter can be used to move crews to distribute beacons. In some cases vehicles can be used.

Contents for route marking kits were not fully established, but a variety of lights appears desirable. A suggested list of equipment is given in Table III (Appendix A). For operational use kits should be packaged in fiberboard boxes for delivery by parachute. Modular kits are recommended.

Flight Procedures

Procedures for flying along ridges or drainages require no special mention over daytime operations. However, the pilot must follow the marked routes and maintain a safe altitude.
When flying to ridgetop helispots from wide valley helispots, it appears best to gain considerable altitude over the valley helispot before proceeding to the ridge. When flying from narrow canyons (which should be avoided) altitude will have to be gained by flying parallel to the drainage.

Weather

A. Forecasts—weather forecasts should always be obtained when planning night flying operations. Special attention should be given to predictions of thunderstorm activity, precipitation, passage of frontal systems, fog conditions and wind velocities.

B. Wind—winds should be less than 15 m.p.h. for night landings. Gusty and cross-wind landing conditions should be avoided.

C. Cloud cover—clear skies are generally the best from a visibility and stable-air standpoint. However, the amount of moonlight appears to play a more important part in night visibility than cloud cover. For example, test flights were made on one night with 10-tenths altostratus cloud cover. Yet moonlight was sufficient for good horizon reference. Horizon reference was poorer on some clear nights due to the lack of moonlight. Additional studies are needed to further define these conditions and limitations.

D. Precipitation, mist or fog—in most cases these weather conditions will restrict night flying activities.

E. Thunderstorms—caution will have to be exercised if thunderstorms are present.
Visibility

Visibility and the pilot's vision can be affected by many inter-related factors, including weather, topography, vegetative cover, moonlight, smoke, reflection and glare of lights, and many other factors.

Visibility is the key to safe visual night flying operations of the nature described in this report. If good ground reference cannot be maintained due to adverse features of one or more factors, flights should not be made.

The pilot should understand the problems of night vision and guard against vertigo.

Visibility and ground reference can be enhanced by careful location of helispots and flight routes to avoid smoke and dark canyons. Light colored soil, rocks, vegetation and cultural features such as roads, can be used to good advantage in providing ground reference.

The effects of smoke on night flying should receive top priority in future studies.

Terrain

Hypothetical problems served to indicate that in most cases, terrain will not be a limiting factor by itself. If visibility and weather conditions are favorable, in most cases, terrain will not restrict flying if flight routes and helispots are located as recommended in this report.
CHAPTER V

RECOMMENDATIONS

1. It is recommended that the U.S. Forest Service continue the work described in this report.

2. Future equipment studies recommended are:
   A. Test emergency landing flares for helicopter.
   B. Evaluate Bonzer TRN=70 radar altimeter.
   C. Development of angle-of-approach landing indicator.
   D. Determine optimums in helispot and route marking equipment for operational use.
   E. Determine optimum equipment for placing route markers in inaccessible and heavily timbered areas.
   F. Work on integrated helmet, radio communications equipment, so one man can direct and attach sling loads to hovering helicopter.
   G. Conduct further studies on use of amber colored glasses.

3. Conduct studies to determine and define flying limitations in regard to smoke, wind, other visibility factors, and terrain.

4. Studies of hypothetical situations to determine the probability of flying at night are suggested.

5. Conduct additional studies to determine optimum flying procedures for given general situations.
6. U. S. Forest Service study the problems of implementing night flying on fires. Specific areas needing study are:

A. Pilot flying hour limitations—two or three pilots may be needed for each helicopter.

B. Training of fire overhead personnel to recognize the problems and possibilities of night flying.

C. Training programs for ground support crews and pilots.
LIST OF REFERENCES
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### TABLE I

**HELICOPTER EQUIPMENT**

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Item and Model</th>
<th>Source</th>
<th>Est. Cost</th>
<th>Approx. Wt. (Pounds)</th>
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<tbody>
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<td>1 ea.</td>
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<tr>
<td>1 ea.</td>
<td>Directional Gyro, Non Tumbling Type, Electric</td>
<td>Aircraft instrument suppliers</td>
<td>$400</td>
<td>3.5</td>
</tr>
<tr>
<td>1 ea.</td>
<td>Inverter</td>
<td>Aircraft instrument suppliers</td>
<td>$200</td>
<td>6.0</td>
</tr>
<tr>
<td>1 ea.</td>
<td>Radio--Forest Service Air Net Aircraft Radio</td>
<td>Motorola, Inc.</td>
<td>$500</td>
<td>15.0</td>
</tr>
<tr>
<td>* 1 ea.</td>
<td>Radar Altimeter, TRN-70</td>
<td>Bonzer Inc., Shawnee, Kansas</td>
<td>$475</td>
<td>2.0</td>
</tr>
<tr>
<td>* 1 ea.</td>
<td>Flare Rack, Includes 3 1-1/2 min. Parachute Flares</td>
<td>Harvell-Kilgore Corp., Bolivar, Tenn.</td>
<td>$100</td>
<td>10.0</td>
</tr>
</tbody>
</table>

* Requirement of these items is uncertain at this time.
<table>
<thead>
<tr>
<th>Quantity</th>
<th>Item and Model</th>
<th>Source</th>
<th>Est. Cost (Unit)</th>
<th>Approx. Wt. (Unit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 ea.</td>
<td>Radio--Motorola HT Series, Handie Talkie (Include extra batteries)</td>
<td>Motorola Inc.</td>
<td>$516.00</td>
<td>2.00</td>
</tr>
<tr>
<td>1 ea.</td>
<td>Beacon, High Intensity Strobe Sky-Lite Model RX 7214-1</td>
<td>Gas Equipment and Engineering Co.</td>
<td>$175.00</td>
<td>20.00</td>
</tr>
<tr>
<td>1 ea.</td>
<td>Belt Weather Kit</td>
<td>GSA</td>
<td>$13.00</td>
<td>0.50</td>
</tr>
<tr>
<td>4 ea.</td>
<td>Flashlights, Direction Signalling w/8 inch plastic yellow wands</td>
<td>GSA</td>
<td>$1.20</td>
<td>0.50</td>
</tr>
<tr>
<td>2 sets</td>
<td>Streamers, Signal, Crepe Paper</td>
<td>---</td>
<td>Negligible</td>
<td></td>
</tr>
<tr>
<td>6 ea.</td>
<td>Lights, Obstacle Marking 12-volt Burgess Radar--Light</td>
<td>Sporting Goods Store</td>
<td>$10.00</td>
<td>4.00</td>
</tr>
<tr>
<td>4 ea.</td>
<td>Batteries, 6-volt, Eveready 7414, Burgess F4PL or Ray-O-Vac A-6</td>
<td>Radio Supply Stores</td>
<td>$0.75</td>
<td>1.50</td>
</tr>
<tr>
<td>20 ea.</td>
<td>Lights, Boundary Marker (amber lens) 6-volt flashers</td>
<td>Electrade Corp., Kansas City, Mo.</td>
<td>$1.00</td>
<td>Negligible</td>
</tr>
<tr>
<td>1 ea.</td>
<td>Light Helipad Marker (green lens) 6-volt flasher</td>
<td>Electrade Corp., Kansas City, Mo.</td>
<td>$1.00</td>
<td>Negligible</td>
</tr>
<tr>
<td>2 ea.</td>
<td>Tubes, Plastic, White Translucent 1-1/2 inch dia. by 40 inches long</td>
<td>Sporting Goods Stores</td>
<td>$1.00</td>
<td>Negligible</td>
</tr>
</tbody>
</table>
TABLE III

CONTENTS - ROUTE MARKING KIT

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Item and Model</th>
<th>Source</th>
<th>Est. Unit Cost</th>
<th>Est. Weight (Pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 ea.</td>
<td>Lights, Route Marker Strobe ACR 4E</td>
<td>ACR Electronics Corp. New York, N.Y.</td>
<td>$80.00</td>
<td>1.5</td>
</tr>
<tr>
<td>14 ea.</td>
<td>Lights, Route Marker (amber lens) 6-volt flasher</td>
<td>Electrade Corp. Kansas City, Mo.</td>
<td>$1.00</td>
<td>Negligible</td>
</tr>
<tr>
<td>16 ea.</td>
<td>Lights, Emergency Landing Area Marker (blue lens)</td>
<td>Electrade Corp.</td>
<td>$1.00</td>
<td>Negligible</td>
</tr>
<tr>
<td>30 ea.</td>
<td>Batteries, 6-volt, Eveready 744, Burgess FlPl or Ray-O-Vac A-6</td>
<td>Radio Supply Stores</td>
<td>$ .75</td>
<td>1.5</td>
</tr>
<tr>
<td>6 ea.</td>
<td>Parachutes, 5-ft. diameter silk</td>
<td>Texaco Experiments Inc. Richmond, Va.</td>
<td>$7.75</td>
<td>1.0</td>
</tr>
<tr>
<td>* 6 ea.</td>
<td>Lights, Route Marker w/solar switch, Type IT-261</td>
<td>ITT Electronics Inc. Clifton, N. J.</td>
<td>$35.00</td>
<td>3.0</td>
</tr>
<tr>
<td>* Undeter.</td>
<td>Lights, Route Marker w/solar switch, Escolite Model 7000</td>
<td>Electronic Specialties Co. Batavia, Ill.</td>
<td>$65.00</td>
<td>20.0</td>
</tr>
</tbody>
</table>

* Requirement of these items is uncertain at this time.
Figure 16. Helispot construction guidelines.
APPENDIX C

Temporary Form

TEST NO. (ED&T 1206.1)

Date: __________________

Observers: ________________________________________________

Observers in Helicopter: ______________________________________

Location: _________________________________________________

Ground Elevations: Spot #1. _________________________________
                  Spot #2. _________________________________
                  Spot #3. _________________________________

Weather Conditions (Hour): ________________________________

Wind Velocity: ____________________ Temperature: ____________

Wind Direction: ____________________ Dew Point: ______________

Sky Cover: ________________________

Helicopter (Model): ____________________ Pilot: __________________

Film References: __________________________________________
1. **Objective:**

   **Comments:**

2. **Objective:**

   **Comments:**