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Symposium on Employment of Air Operations in the Fire Services

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EMPLOYMENT OF AIR OPERATIONS IN THE FIRE SERVICES

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OPENING REMARKS

R. Keith Arnold

Deputy Chief for Research, U.S. Forest Service, Washington, D.C.

I am glad to be general chairman of this meeting and to have the opportunity to point out to you that this could be a very critical meeting in the entire area of air operations for the fire services. This meeting is not an end in itself, but a beginning.

What are our objectives? What are we here for?

One, to assess the role of helicopters, particularly in air operations in the urban fire-fighting problem areas. Those of us connected with the broader field of forest fires continuously do that and we intend to take home the same questions for reassessment.

Two, to improve the communication between fire services and the aerospace industry. This is a critical area and we need to improve this dialogue. The proceedings of this meeting will be published and those of you who are registered will receive copies which will again provide a basis for initiating further dialogue.

Three, to apply a third dimension in urban and rural fire services to fire fighting. I think you will see this brought out clearly in the next two days.

Four (this is something very critical), to begin to determine criteria for the future development of helicopters. Most of them have been developed for certain specialized activities - some civilian and some military. But I think it is safe to say that we have not had the development of specific aerial fire-fighting tools and equipment. We need to begin to look at the specifications and we must look ten years ahead. What kind of fire-fighting vehicles and equipment do we need in this third dimension of space in 1980? This is a question to which we should address ourselves.

The strategy of this meeting is quite clear as you look at the program. First, we are looking at some of the fire-fighting operations. Second, we are looking at the aircraft and facilities. Then we will get down to the gut issues of strategy and tactics, and finally, we will have demonstrations.

So, with that in mind, I would like to present the Chairman of the morning session, Raymond M. Hill. I doubt if there is anyone here who does not know him as Chief Engineer and General Manager, Department of Fire, City of Los Angeles.

SESSION I

Chairman - Raymond M. Hill

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Mr. Hill: I think it is appropriate that Dr. Arnold be the General Chairman of this particular meeting, because he was the fellow that probably started it all a good many years ago. I recall back in 1954 going down to the big Marine base at Camp Pendleton, California, where a very extensive series of experiments were being carried out - looking at fire retardants and this kind of thing, the use of helicopters in laying hose lines, making water drops which at that time were quite small. This is where it all started - the use of helicopters for fire department operations. I recall that I was amazed at the amount of insight, research, and looking into the future that was going on (17 years ago). So, I do think that it is very appropriate that Dr. Arnold is our General Chairman for today's symposium.

Our first speaker is a close working partner of mine. He is the Chief of Los Angeles County Fire Department. We work back and forth on many, many fires because, when a fire occurs in the county, we go to help them keep it in the county. We do not want the fire to burn into the city. Chief Houts does not hesitate to send companies into the city. He is interested in keeping it in the city. We do work together back and forth on fires. We do not pay any attention to boundaries. We still have news media people who ask, "Well, how about this problem of boundaries, when you stop at the city limits and you do not go across?" I had newsmen ask me that less than a month ago. This is not true in our area. We work back and forth and we get to know each other quite well. It is one big operation. Chief Houts is a chief of a very unusual fire department, because we think of our California Division of Forestry and of the U.S. Forest Service as being primarily concerned with wildland fires. And then you have the structural fire-fighting departments. Chief Houts wears two hats, actually. He is the Chief Forester and Fire Warden for the county, and a fairly large portion of the Los Angeles County Fire Department has to do primarily with the wildland fire control. But, also, he has eight fire protection districts and he contracts with some 34 small cities within the county to provide fire protection for them. He has quite a varied operation; from purely rural to high urbanized, highly industrialized areas within the jurisdiction of his fire department. I recall one time his predecessor mentioned that two of his fire stations were over 100 miles apart, and there are not many fire departments that can make that statement.

It gives me great pleasure to present to you to discuss the Los Angeles County fire operations, the Chief Engineer of the Los Angeles County Fire Department, our Forester and Fire Warden, Chief Richard Houts.

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LOS ANGELES COUNTY OPERATIONS

Chicf Richard Houts

Los Angeles County Fire Department

It has been stated by a number of fire-fighting officials that, "aircraft have proven to be the most significant advancement in fire-fighting techniques in the past 50 years." I wish to state that I wholeheartedly agree with that statement; however, our experience has brought us one step further and I would modify this basic statement as follows: "The helicopter has proven to be the most advanced and significant tool available to the fire services in the last 50 years."

My comments are based on 15 years experience in the use of rotary-wing aircraft and six years experience in contracting for fixed-wing aircraft. During this time, we have made mistakes, as well as progress. Only through seminars of this type are we able to pass on the information necessary for you to take advantage of both.

We started operations in 1957 with one Bell Model 47-G2. This was replaced in 1962 with a 47-G3B-1 supercharged ship, capable of operating at the higher elevations encountered in Los Angeles County, the topography being from sea level to over 10,000 feet. In 1967, we put into service an 11-place Bell Model 204-B. The following year an additional 3-place turbine Model 206-A in 1969 and a 15-place Bell Model 205-A in July of last year, bringing the total to five helicopters. We are also attempting to add an additional 15-place machine for this summer (Figure 1).

The primary assignments for all units were oriented toward our watershed fire-fighting problems, but as this operation developed, applications in our urban areas became apparent, such as reconnaissance and command functions on greater alarm fires. Helicopters are extremely valuable for spotting and moving of ground units in and around large structure fires and especially on fires involving large industrial areas such as refineries, lumber yards, or any area involving numerous installations and buildings separated by access roads, parking areas, fenced yards, and undeveloped ground. As a command post or "eyes in the sky," the helicopter is unmatched by any other piece of equipment. As for operating procedures, about the best parallel I can give is that all helicopters in our Department are utilized the same as any other piece of fire apparatus. They are emergency equipment first, with routine assignments being given on a secondary basis or as seasonal requirements change.

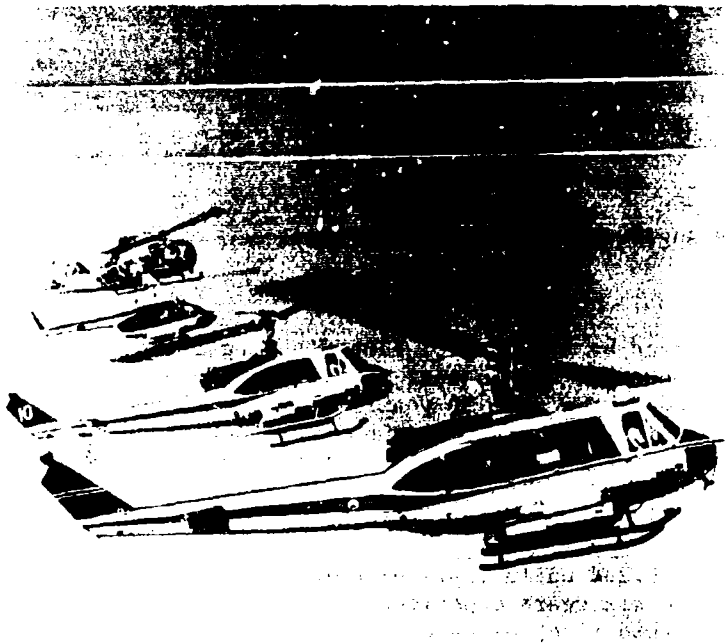

FIGURE 1. Los Angeles County Fire Department helicopter fleet.

During our active brush fire season, which will last from six to nine months each year, departmental helicopters are given "area assignments" with initial response zones, etc. The larger machines respond with a full load of fire fighters and retardant drop tanks (Figure 2). After depositing the crews on the fire lines, the helicopters immediately go into a retardant-dropping operation. The initial action helicopter is backed up by as many additional machines as are needed to handle the assignment. As additional aircraft become available, through the normal budgetary process, the number of area assignments will be increased with a significant reduction in response times. As we are presently operating, our maximum flight time into any area of department responsibility is approximately 15 minutes. We hope to cut this to about 5-7 minutes.

Routine assignments on a day-to-day basis are normally handled by the smaller aircraft or those especially suited to a given function, such as construction projects requiring sling loads, etc., with heavy emphasis given to not interfering with the primarily assigned fire-fighting aircraft. Examples of this type of assignments would be administrative flights, fire prevention activities, general transportation requests, demonstrations, and photo missions.

During periods of low fire danger, we go into what we commonly call our winter operation. This involves the transporting of work crews from our network of 12 forestry camps to various projects and returning them to camp daily. All work of this type is related to watershed problems and involves such things as: building and repairing of fire roads and firebreaks, construction of cisterns, brush clearance, and the maintenance of other facilities in remote areas of the mountains surrounding the Los Angeles basin. By selecting priority projects that would normally involve several hours of travel time by conventional means of transportation, we are well able to justify the added cost of flying the crews. This is accomplished by the increased man-hours available daily, and in most cases the increased productivity of the crews due to not having spent several hours driving and hiking into the areas.

We originally got into the helicopter field for the primary purpose of transporting men and material into remote areas where brush fires occur. With the development of larger second-generation turbine-powered helicopters, operational areas opened up that were previously the sole domain of the fixed-wing aircraft. I am speaking now of the dropping of fire retardants directly onto the fireline of "going" brush fires (Figure 3). We had known for a number of years the operational capabilities of the 3-place "piston-powered" helicopter; we were also well aware of its limitations. We knew for instance, that a 3-place helicopter capable of flying 100 gallons of retardant per load would in one hour's flight time, far exceed the total number of gallons delivered by a fixed-wing air tanker carrying 600 gallons per load, in the same time span. This is due to the short turnaround time of the helicopter operating at the fire site, while the fixed-wing aircraft must return to an established base to reload.

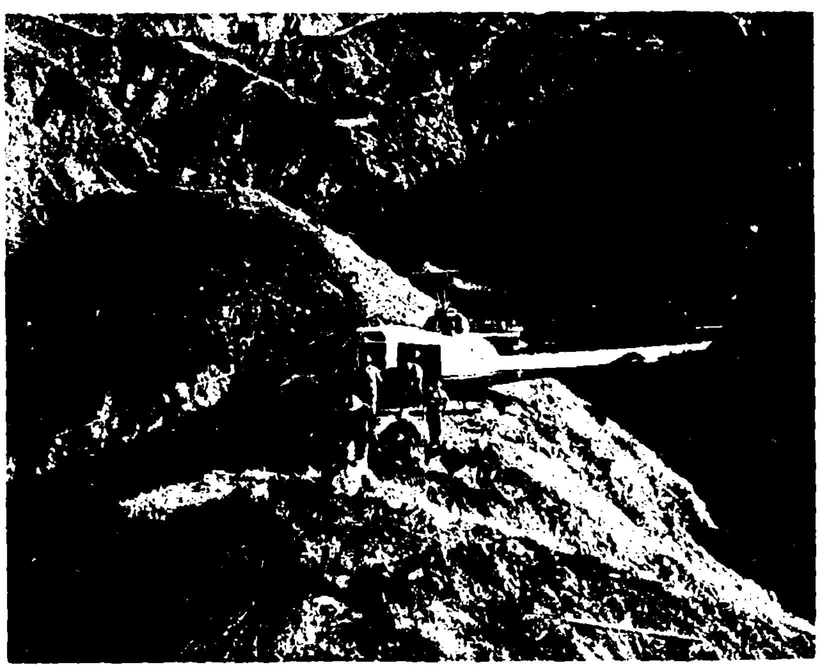

FIGURE 2. Los Angeles County helicopter unloading fire crew.

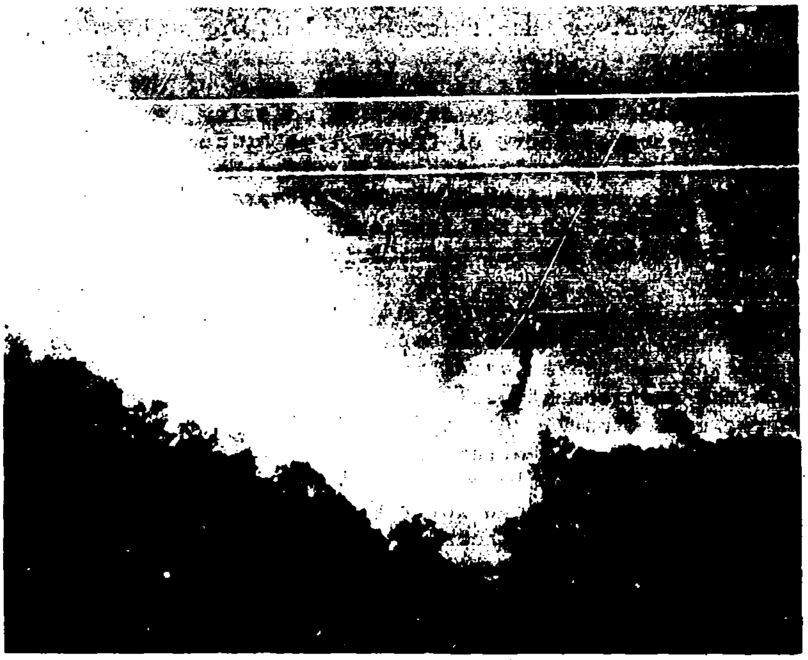

FIGURE 3. Direct attack on brush fire.

We were also very much aware of the inadequacy of a 100-gallon drop. As stated earlier, we were involved with the operation of fixed-wing tankers for a period of six years, these were six years of operational experience; prior to that we were involved for a number of years in the development of the air tankers program.

We were involved as a cooperating agency, the primary role being played by the U.S. Forest Service and the California State Division of Forestry, which are still the two leaders in the field. During those years of operation, due to the unique requirements of the Los Angeles County area, it became clear that the larger helicopter was better suited to our type of operation. Therefore, the decision was made to concentrate all our efforts in aerial fire fighting toward the helicopter in lieu of fixed-wing aircraft. Some of the factors considered in reaching this decision were:

- Higher delivery rate of retardants per hour
- Reduced delivery costs per gallon
- Greater accuracy of drops
- Multiple uses of the helicopter
- Greater safety to crews and ground personnel

Lower crew requirements, and last, but of equal importance to the fire services of southern California,

Actual strengthening of the overall program by switching to helicopters.

By switching to helicopters we were placing an additional tool at the disposal of all the fire agencies covered in the mutual aid and initial action agreements under which most agencies in our area participate. On the other hand, we can still obtain the use of the fixed-wing aircraft as needed through these same participating agencies.

Another operational use of the helicopter which I would like to comment on is its use as a rescue vehicle. We have used them in this field quite extensively. Originally, they were used solely in the mountain areas on search and rescue problems. These usually involved lost or injured hikers, hunters and fisherman, downed aircraft, as well as a full spectrum of misfortunes that can befall persons in remote mountainous terrain. These problems were in addition to injuries and mishaps involving our fire-fighting personnel engaged in fire suppression activities.

Recent interest on the Federal level has focused attention on the helicopter as an ambulance to be used in the highway safety program. We have for the past year been participating in this project through a study conducted by the University of California, Los Angeles. It involves transporting highway accident victims from outlying areas to hospitals providing adequate emergency services. One of the basic facts to come out of our study as well as others conducted throughout the County is: that a helicopter ambulance is not economically feasible, unless the aircraft has other functions which will help to offset the costs. We feel the fire service helicopters can fill both roles with no difficulty. Operationally, we have encountered no problems of any type.

No discussion of this type would be complete without commenting on personnel. Any operation or equipment is only as good as the personnel involved, and I am sure that the direction we chose to travel will be as controversial to this group as it was originally to some members in our own organization. We elected at the start of our helicopter operations to hire and utilize professional pilots; we have continued to follow that course. We do not have any provisions for in-service training of Department personnel to become pilots. We have what is probably the highest recruitment level for pilots of any helicopter operation in the country. To meet the minimum requirement, a pilot must have 4,000 hours of rotary-wing flight time, of which 1,500 hours must have been flown in mountainous terrain at altitudes over 4,000 feet above sea level. This requirement is tailored to our operation and may very well not fit your particular needs. The point is that there are hundreds of excellent, well-qualified pilots available, and not to use them can be fiscally, as well as operationally, disastrous. Should you hull-insure your aircraft, keep several facts in mind - the higher your crew qualification, the lower your insurance rate. Our savings in insurance premiums more than pays the salaries of two pilots each year. Another fact is that the better-qualified the pilots, the less chance of an accident. While I am not too familiar with existing operations in other parts of the country, I do know that of all the governmental operations on the West Coast that have been in business for any length of time, ours, with one exception, is the only one that is accident-free. The exception is the City of Pomona, California, which follows the same policy as ours. All others including our counterpart in county government, "the Sheriff Department," train Departmental people and without exception have an accident and incident record involving major aircraft damage, with some resulting fatalities to the occupants. We do use Departmental personnel in all supporting roles of our operation with the exception of our aircraft mechanics, who also are recruited from industry. I have a few slides with me which I would like to show to help explain our operation. I see that during the afternoon session you will have a panel on aircraft specifications and performance so I won't dwell on that other than to show equipment presently being utilized.

Also, I see Herb Shields scheduled for a presentation on helicopter accessories, so I will try and stay clear of his jurisdictional boundaries, and show only those items unique to our needs and operations.

Mr. Hill: Our next speaker has a program that I would say is strictly an urban operation. The Chicago Fire Department has been utilizing helicopters for some time and to tell us about its operations, we have the Chief of that Department. He bears a rather unusual title of Chief Fire Marshal. Very few of the fire chiefs around the country have that title. Curt Volkamer is not only the Chief of the second largest fire department in our country but is also the First Vice-President of the International Association of Fire Chiefs, and in a few months will become the President. So, without further ado, Curt Volkamer, Chief of the Chicago Fire Department.

CHICAGO FIRE DEPARTMENT OPERATIONS

Chief Curtis W. Volkamer, Chicago, Illinois

I am delighted to have been extended an invitation to present a paper at this symposium on "Employment of Air Operations in the Fire Service," and I welcome the opportunity to appear with a very distinguished panel of my colleagues who have been chosen to present their views on this topic as it affects their particular phase of air operations. The subject allotted to me for expansion is "Chicago Fire Department Operations," with due emphasis placed on helicopters and the tremendous contribution they make toward the fire defense of our city and the surrounding metropolitan area, inasmuch as the benefits of these units are not restricted to the corporate limits of the city of Chicago.

The fire service has come a long way since those pioneer days when the introduction of the hand pumper was heralded as a major break-through in fire-fighting potential. Research and development have resulted in aligning science as a definite factor in our grim and demanding profession. And, of course, the Chicago Fire Department has maintained a most remarkable progress rate under the capable and energetic leadership of Fire Commissioner Robert J. Quinn, leaving no stone unturned, no avenue unexplored, in order to effect an acceptable ratio of life and property loss compared with the total man and equipment hours employed to achieve this balance.

In recent years, Chicago and other progressive fire departments have revised their thinking, changed their attitudes, divorced themselves from antiquated ideas. I believe this present assembly will agree with me when I say that the fire service of today is far removed from its counterpart of former years, incorporating all aspects of scientific fire fighting in this era of specialization. A look at the record will show convincing evidence that this approach has produced desirable results.

Nationwide, statistics show that the death rate by fire annually surpasses the 12,000 mark. This figure has been more or less constant for some years. Your first reaction to this statement could be that this is indeed an appalling total, and well it might be. And yet, when we take into consideration the fact that the population of the United States has increased many millions over the years, the per capita fire death ratio has been substantially reduced. Let me hasten to add that it is regrettable that a per capita fire death ratio, however small, should exist at all. But human nature, being what it is, plus the myriad and unpredictable circumstances over which we have no control, I am afraid that this is one problem which will continue to present itself long after we have left the fire-fighting scene. However, let me assure you that we shall not relax our efforts to bring this ratio down to an irreducible minimum.

As you know, from time immemorial fire departments have stood as a bulwark for mankind against the destructive forces of nature, not only against the ravages of uncontrolled fire, man's greatest enemy, but also against the onslaught of tornadoes, floods, earthquakes, and other catastrophic occurrences. In the early days of fire fighting, man's efforts were not always rewarded with success as he threw all the resources at his command into the battle. His courage in the face of danger was never questioned, but the end results often left much to be desired, because at times his resources were pitifully weak and totally inadequate. To help turn the tide in its favor, the fire service searched diligently for a scientific approach to this age-old struggle - and found it. It pleases me to say that the Chicago Fire Department was quick to incorporate this innovation into its array of fire-fighting equipment.

This came in the form of a versatile heavier-than-air vehicle with powered propellers that enabled it to take off and land vertically, to move in any direction, or to remain stationary while airborne. This craft was a marked departure from the conventional fixed-wing airplane and resembled it in no way. This rotary-wing workhorse, called the helicopter, was the brainchild of an idea which Leonardo da Vinci had conceived some five hundred years ago. As a matter of fact, one of his early drawings, dated 1483, shows a contraption equipped with a rotating screw surface covered with fabric.

It is not my intention to discuss the helicopter as it whirls its way through successive stages of refinement. I am sure that on this panel there are men far more knowledgeable in the field of aerodynamics who will cover that phase quite adequately. I mention it merely to show that there was immediately available a unit which had been used most extensively and very effectively by the armed services, which had recognized its true potential for their specific needs. It remained for the Chicago Fire Department to introduce this most revolutionary unit into its fire service, reflecting the flexibility and the necessity of the fire service to adapt itself to any emergency.

Actually, the history of the helicopter in the Chicago Fire Department had its inception in 1958, when Fire Commissioner Robert J. Quinn took extensive instruction and received a helicopter pilot license from the FAA. This opened up a whole new vista, as he foresaw the tremendous possibilities of this unit. His vision was not confined to the immediate present, and he vowed that some day the Chicago Fire Department would have a helicopter division.

As head of Civil Defense, Commissioner Quinn thought in terms of the future - perhaps acquiring surplus helicopters, with no cost to the taxpayers of Chicago, to replace the helicopter which was leased from a local operator. He was encouraged by progressive-minded

Mayor Richard J. Daley, who urged him to explore every avenue to bring this new concept into being. Mayor Daley was convinced that this would become a most valuable arm of the Chicago Fire Department, working and co-operating with other agencies and bureaus of the city.

Realization of this dream came on September 18, 1965, at 3:05 p.m., when the fire department helicopter 47G4A responded to a call from the main fire alarm office: "Boat in distress on Lake Michigan; 5 persons aboard." At that precise moment, the Chicago Fire Department helicopter service was airborne, and the success of that first official mission was an indication of a long series of future successes in rescue operations of many varied types, some of which actually defy the imagination. As you know, all alarms are monitored and recorded on huge 24-hour tapes, and to the best of my knowledge, this particular recording has never been erased and is preserved in our archives to commemorate a truly historic occasion.

During the years prior to the acquisition of its own helicopter, the Chicago Fire Department leased a helicopter from a local agency. Fire Commissioner Quinn had used this unit a number of times to direct fire-fighting operations at large fires. This proved beyond a shadow of a doubt that supervision of extra alarms can be highly successful by providing information and giving specific directions, which ranged from notifying responding apparatus to avoid certain routes which had extremely heavy concentrations of traffic, to alerting individual companies as to the best vantage point at the scene of the fire, using car-to-car radio in the deployment of apparatus.

Commissioner Quinn was highly impressed by the effectiveness of this method of directing activities, which more than ever convinced him that helicopters would some day be a most important part of the fire service. Indeed, the rapid construction, at that time, of the vast networks of expressways in Chicago, some through the very heart of the City, literally demanded that this type of equipment be provided for the safety and welfare of the public. In his mind's eye, he envisioned a helicopter, fully equipped with life-giving and life-saving devices, serving as an ambulance, which could come to the aid of victims on our expressways and other inaccessible locations with extreme speed and maneuverability. Persons injured in accidents would be reached within minutes, regardless of traffic conditions (Figure 1). When one realizes that a person with a severed artery may bleed to death in about two minutes, or a person who has stopped breathing may die in a little over five minutes, this was a most sobering thought, and one which of necessity required the highest priority in the planning stages of this revolutionary addition to our Department.

This kind of thinking, if it were to jell and materialize, would require a considerable amount of groundwork. Accordingly, Commissioner Quinn, after a long, hard look at the situation, took appropriate steps to bring this about.

First and foremost, pilots would be needed. Being a licensed pilot himself, he was aware of the tremendous job which faced him in

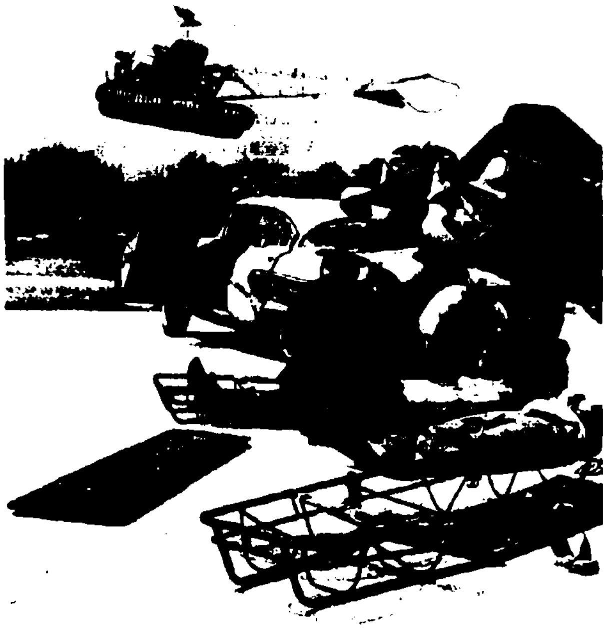

FIGURE 1. Chicago Fire Department helicopter provides rapid ambulance service.

training a group of competent pilots. He combed the records and files of the department for men who had helicopter training and found four firemen who were FAA-licensed helicopter pilots. These men were to form the nucleus of this branch of the department, and to them would fall the task of training additional pilots. To implement the program, the services of a local helicopter pilot were retained in a civilian capacity, and instruction of fire department personnel was begun immediately.

The result of this intensified training surpassed all expectations. Today, the Chicago Fire Department has 14 highly competent helicopter pilots, in addition to Commissioner Quinn. These men are licensed by the FAA and are officially designated by the title and job classification of helicopter pilots. They fly two helicopters, the second of which is a most modern, turbine-powered Bell 206A Jet Ranger which was activated on November 2, 1967. This latest unit is a 5-place craft with pop-out floats, 2 litters, and a hoist, with a rated top speed of 150 miles per hou .

As a further addition to our helicopter division, there is now being rebuilt an S-55 Sikorsky which will have a much stronger hoist, will be far more spacious, accommodating 6 litters, and is expected to have a much greater cruising range. It is our intention to do our utmost to provide the people of this area with the finest service possible, with particular emphasis on the part that the helicopter would play in supplying those vitally needed services.

Operating from Meigs Field on the lakefront, the helicopter service has proved to be an extremely valuable addition to the emergency services offered by the fire department. Piloted by department personnel, this unit has maintained watchful patrols and has responded to emergency situations in a manner that more than justifies its existence. Cruising high above traffic-snarled expressways or over the lakefront, the helicopter, with excellent visibility provided by its altitude, has often spotted trouble on the highway or a boat in distress and has sped to the rescue at speeds up to 150 miles an hour. Its response is measured in minutes - minutes which frequently can be the difference between a successful mission or failure.

Rescues of any kind on water present many unique and difficult problems. To facilitate rescues of this nature, these units are equipped with floats, inflatable rafts, and other devices calculated to reduce the element of chance to an absolute minimum. In its first year alone, the helicopter and its crew found 57 boats and small craft in various problem situations. How many of these would have resulted in fatalities can only be a matter of conjecture. Suffice it to say that the helicopter service has earned the undying gratitude of those who have been rescued from the waters of Lake Michigan. Records of the log show that nearly 180 lives were saved during the first full year of operation (Figure 2).

One of the most dramatic, yet swiftest rescues effected by the helicopter service was recorded on November 17, 1966, when a Lockheed twin-engine craft, attempting to abort a takeoff from Meigs Field, crashed into the icy waters of Lake Michigan. By a strange quirk of fate, this crash was seen by a member of the helicopter crew on duty who was standing in front of company quarters gazing out over the lake. You can imagine his surprise and consternation when he saw this craft suddenly plunge into the water. He shouted a warning to the pilot on duty and without a moment's hesitation, the helicopter flew to the scene and arrived just as one of the eight occupants of the crashed plane sank beneath the surface. The helicopter was set on that spot, and when the victim came back to the surface, he was rescued. The use of the inflatable life raft was highly instrumental in effecting the rescue of eight men who otherwise might have perished had it not been for the quick action of the helicopter crew.

The mere retelling of this incident sounds rather commonplace; but I believe, in justice to the personnel involved, that an analysis, or at least an elaboration of the entire action, is indicated at this point.

In the first place, it is most fortunate and almost providential that the crash was witnessed by a crew member. Had the notification of the incident been relayed by a civilian to the fire alarm office, which

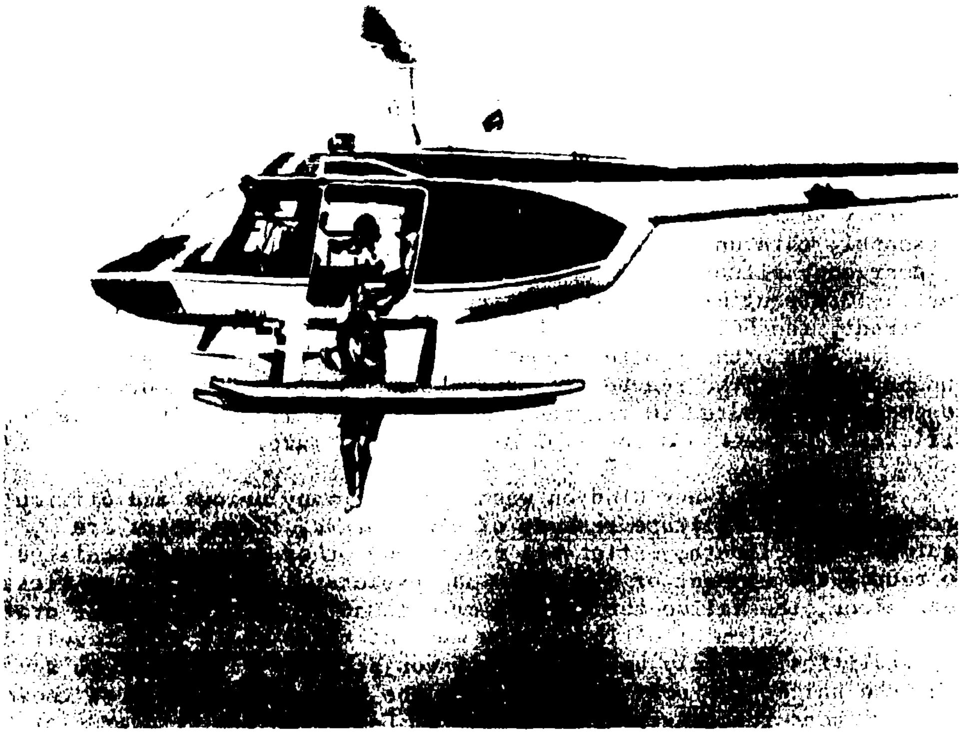

FIGURE 2. Water rescue from Lake Michigan.

transmits the alarm to the helicopter crew, no matter how expediently and quickly this were done, precious time would have been lost. In this instance, firsthand information, as it were, gave the helicopter crew an opportunity for rescue seldom available to rescue personnel.

Secondly, the pilot had to make an instant, on-the-spot decision. There simply wasn't time to confer with a superior officer or chief. I refer specifically to the matter of "revving-up" or "warming-up" the craft before take-off. I am told by those well-versed in these things, that a helicopter requires a "warm-up" of about 5 minutes. To take off before the 5-minute mark could result in serious consequences - loss of altitude, instability, difficulty in maneuvering, perhaps even a crash into those same icy waters with the loss of the helicopter and the chance of injury or even loss of life to the would-be rescuers. May I say that the telling of this phase of the incident took much longer than the time it took for the pilot to act. The decision was made to respond immediately, foregoing the customary "warm-up." He took into consideration the fact that it was a very cold day and that even if the victims were not killed on impact or were not drowned and somehow managed to stay afloat, they could not survive long, battered by those icy waves. Our official records show that the water temperature of Lake Michigan that day was near freezing, presenting a definite exposure and shock problem.

The helicopter was maneuvered as closely as possible to the downed aircraft, whose tail section was protruding out of the water, allowing absolutely no possibility of error in clearing the main tail rotor blades. The pilot removed his life jacket and threw it to a female survivor. The co-pilot positioned himself on the float to assist the victims to that precarious spot, two on the right float and three on the left float.

No other boats or rescue craft had as yet appeared on the scene to assist in this emergency, and since one of the female survivors appeared to be in deep shock, the decision was made to try to lift the helicopter into the air, even though they were now exceeding the gross carrying weight of the helicopter which was designed to carry three persons, including the pilot, or a total of 550 pounds. The helicopter now was carrying seven persons, whose combined weight was approximately 1,400 pounds, 850 pounds over lifting capacity.

At this point, the pilot experienced great difficulty in lifting the helicopter from the water, and the first few attempts failed. On the fourth attempt, the helicopter was successfully airborne, gained sufficient altitude to clear the rocks which protruded about 25 feet above the water line, and landed in the south parking lot where a Chicago Fire Department ambulance received the survivors and dispatched them to Mercy Hospital.

It is worthy of note that once the decision had been made to lift this tremendous weight, there was absolutely no thought of abandoning this course of action by jettisoning some of the cargo to reduce the load. With complete disregard for the safety of the helicopter and the crew, the pilot's action typified the true tradition of the Chicago Fire Department. For this deed, he was recommended for, and received, the Lambert Tree Medal, the highest honor which the Chicago Fire Department can bestow upon one of its members.

There have been many more instances where rescues were made in the vicinity of Meigs Field, one of the world's busiest small airports, all of them more or less carbon copies of previous rescues. However, it remained for the winter of 1966-67 to set the stage for an amazing display of the worth of this incredible unit, when the worst snow storm in the history of Chicago struck without warning on J[illegible], 1967. The record total snowfall of 23 inches virtually brought the City to a standstill. The City's protective services were seriously hampered. Ten and 12-foot drifts of snow made response by conventional apparatus difficult, if not impossible. It became crystal-clear that the only unit in the City's protective services with unlimited and almost complete freedom of movement was the fire department helicopter (Figure 3).

Every pilot in the department, including Fire Commissioner Quinn, was pressed into flying status. Working around the clock, the Fire Department helicopter crews flew 42 missions during and after

FIGURE 3. Chicago's rescue helicopter - never snowbound.

the storm. The helicopter service established many "firsts," some of them on a grand scale, such as picking up insulin at Louis Berg Hospital and delivering it to diabetics who were among the 1,200 persons who had taken refuge in Engine Company 80's quarters at 130th and the Calumet Expressway. Two doctors also were flown to this fire station to attend to the medical needs of this large group who taxed the capacity of this building to the limit, even though this fire station is one of the most spacious and most modern in our entire Department.

Deeds and actions performed by helicopter crews reached an almost unbelievable stage. Many injured persons were transported to the hospitals, including a 20-year-old boy with a broken neck. This boy was picked up at 130th and Exchange Avenue and brought to Christ Community Hospital for treatment. If I may, I would like to quote from the log and cite some of the rather unusual missions flown during this emergency:

Picked up a girl with a broken leg at 130th and Excanaba. Delivered to Cook County Trauma Center.

Pregnant woman from 132nd and Branard to waiting ambulance at 91st and South Chicago Avenue.

Picked up pneumonia patient at 67th and Harlem.
Delivered to Christ Community Hospital.

Woman suffered miscarriage at 128th and Escanaba, delivered to Christ Community Hospital.

Delivered insulin to Town and Country Motel at 147th and Calumet Expressway where 5 diabetics were stranded.

Picked up heart pace-maker in Des Plaines, Illinois. Delivered to Resurrection Hospital.

Picked up heart pace-maker at 211th and Western Avenue. Delivered to St. Lukes Hospital.

During this crisis, institutions and hospitals were isolated by storm conditions; and food, milk, blood serum, and medical supplies were flown in to relieve what could easily become an acute disaster situation. Milk, bread, and baby formula were delivered to La Rabida Sanitarium, St. Francis Hospital in Blue Island, St. Joseph Orphanage, Luther General, Holy Family, and Michael Reese. In some cases, doctors and/or interns were taken along.

Helicopter service was not limited to Chicago, vital supplies being flown to hospitals in Blue Island, Park Ridge, Des Plaines, and other suburban areas. Serum was flown to Calumet City; Sauk Village requested and received help. Fire Commissioner Quinn personally flew to Joliet, Illinois, picked up a four-year-old girl, and flew her to Cook County Hospital, where she underwent open-heart surgery.

When not engaged in flying emergency missions, the helicopter was used to survey the City's major expressways and main arteries crippled by the storm. Mayor Richard J. Daley took a two-hour, first-hand tour of the City; Commissioner Quinn viewed the traffic conditions and noted the locations of streets inaccessible to fire department apparatus. Other bureau officials were taken aloft to check on snow removal operations and stalled, abandoned vehicles, which were reported by the hundreds. All in all, this emergency marked the helicopter as an unqualified success; and as the City dug itself out, I am sure that many persons, who had received aid in one form or another, breathed a silent prayer of thanksgiving for the helicopter service.

Perhaps the most revolutionary of all developments, which by the way is another "first" in helicopter annals, is the Expressway Air Evacuation Program which was initiated on a full-time basis early in 1967 by Chicago, the first City in the country to do so. Patterned after the licensed heliport atop the Fire Academy, the Cook County Hospital landing area provides facilities for rapid and efficient transportation of victims whose condition requires hospital care. Other hospitals have been quick to see the value of this program, and have taken steps to provide helicopter landing areas, some are already in operation, while others are in various stages of completion.

This close cooperation between the fire department and the medical profession assures expressway accident victims of an airlift within minutes after the helicopter service has received the call for help.

A trial run of this Expressway Air Evacuation Program was made, using a far south section of the Dan Ryan which had been cordoned off for the project. We used cars from the police auto pound, manned them with probationary fire fighters supplied by the Fire Academy as victims. The cars were strategically placed so as to simulate a multiple-vehicle crash, with victims appropriately strewn about the scene. Then a call was made for a helicopter for an airlift of the victims.

It really was quite impressive and television station WGN thought enough of the production to film the entire proceedings as a documentary, starting with the helicopter receiving the call and taking off, to delivering the crash victims to the helipad at Cook County Hospital. A superimposed clock ticks away the seconds very dramatically as the rescue unfolds. Total elapsed time is 4 minutes, which incidentally is the name of the film which WGN has made and which I believe is available for viewing.

Extensive use of the helicopter came during the civil disorders on the west side of Chicago following the assassination of a prominent civil rights leader in 1968. Coverage of the tremendous fire area was made possible by this craft which charted the course of the fire as it raced from building to building and from block to block. Commissioner Quinn used this unexcelled vantage point to deploy fire apparatus to the best advantage, calling for some units to relocate with utmost haste and to take up new positions to contain the sweep of fire. In some cases, Commissioner Quinn actually saw buildings being put to the torch and was able to send available equipment to the scene. After the disturbances had been quelled and the fires extinguished, Commissioner Quinn flew Mayor Daley for a firsthand view of [illegible] burned-out area to determine what steps would be necessary to return the City to normal.

As further evidence of the wide range to which the helicopter has been put to use, both in terms of versatility and actual mileage, the Chicago Fire Department helicopter has flown to Gary, Indiana, and Milwaukee, Wisconsin, to pick up kidneys to be used in transplants. Another flight was to Hinsdale, Illinois, to pick up a three-month-old girl who could not breathe. She was delivered to Children's Memorial Hospital.

Cooperation with other agencies and bureaus of the City was never more forcibly demonstrated than the time when the Bureau of Forestry had the job of seeking out dead elm trees as a result of a blight. The area involved was from Harlem Avenue to Sayre, and from North Avenue to Diversey. It took six men two days to cover this area, and they found 317 dead elms. The Bureau of Forestry asked our cooperation in confirming these findings. The Fire Department helicopter flew forestry personnel, taking exactly 20 minutes, over the same area, and found 344 dead elms.

I know that bare statistics can be dull and uninteresting, if not actually boring. However, I feel I must present some, to show the wide scope of helicopter activities and to bolster my contention that this unit has far surpassed even the wildest claims for its utilization.

To date, there have been 2,539 separate and distinct fire department helicopter missions, 517 in 1970 alone, which has been the busiest year so far. Last year, helicopters responded to 151 accidents on our expressways and the Outer Drive, with 17 victims of these accidents being transported to hospitals.

There have been 168 responses on Lake Michigan, ranging from overturned boats, and boats in distress from other causes, to boats on fire. Thirty-two persons involved in these incidents were transported to shore.

Children like to sail on homemade rafts or ride the ice floes. During the year, we had nine children in distress on rafts or on ice floes being swept out into open waters. These were plucked from their obvious dangerous position and flown to safety.

We transported 29 burn victims to Cook County Hospital Burn Center and responded to explosions, elevated and train accidents, in addition to flying the Fire Department Bomb Squad to O'Hare Field 42 times to investigate bomb scares. One more item worthy of mention: a seaman aboard an ocean-going freighter required emergency medical treatment. He was removed from the vessel and flown to Cook County Hospital.

Twenty different City, State, and Federal agencies or bureaus were served by the Chicago Fire Department Helicopter Division during 1970. Among them were the Mayor's Office, Illinois Department of Economic Development, and the FBI.

In closing, may I say that I firmly believe that the fire department of any city, village, town, or hamlet has a definite commitment to the citizens thereof, to provide the best possible service in the matter of safety and welfare. The Chicago Fire Department has materially increased its capability to honor that commitment by the addition of its helicopter service.

Mr. Hill: You have heard about the operations of helicopters in a highly urbanized fire department from Curt Volkamer and from Chief Houts we heard from a fire department that has both highly urbanized widespread structural fire-fighting responsibilities as well as wildland fires. Now, purely from the forest fire point of view and the use of helicopters and aircraft of all types, we have as our next speaker the National Fire Officer of the U.S. Forest Service, Mr. Monte K. Pierce.

FOREST FIRE AIR ATTACK

Monte K. Pierce

National Air Officer, U.S. Forest Service, Washington, D.C.

By early morning last July 16 lightning activity had moved into the State of Washington area and a series of storms began progressing across the Cascade Mountain Forests. Activity was light on the Gifford Pinchot Forest with only five fires. The storm set seven fires on the Yakima Indian Reservation. Several storms originated on the west side of Snoqualmie National Forest, progressed eastward. During the course of the storms 227 lightning fires were started on the Snoqualmie, Mt. Baker, Okanogan, and Wenatchee National Forests. These storms also set 29 fires on the North Cascades and Rainier National Parks, and seven fires on the Colville Indian Reservation.

Mobilization of fire-fighting resources was extensive, to include 78 tankers and pumpers, 31 tractors, 15 aerial tankers, 38 helicopters, and over 6,000 fire fighters.

Aircraft use developed into the largest operation ever experienced in the Pacific Northwest region and probably one of the largest in the history of the Forest Service. Fixed-wing aircraft included about all types with 2-place T-34 leadplanes and 4-place reconnaissance, to Boeing 737 jet transports. Traffic became so great at two of the airports that portable FAA traffic control towers were brought in to handle the load.

Helicopters ranged from 3-place reconnaissance-transport-type to a large Boeing Vertol ship that carried about 20 passengers. Most of the copters were equipped to be used with buckets and many thousands of gallons of water were put on the fire by this method.

The Region was still cleaning up after the July "fire-bust" when on August 21 lightning again moved in over the region. Burning conditions in the Wenatchee area were the most extreme experienced in many years, and lightning strikes started more fires than would normally have occurred. Also, due to the high buildup of fire danger many of these fires had a tendency to reach blowup intensity very rapidly. By dawn of the morning of the 25th, it was evident that a number of fires would become campaign-size and the Forest and Region began to mobilize. In a couple of days a total of over 8,000 people were working directly on or supporting some 226 fires, 26 of which had become large. Here again, a tremendous amount of fire-fighting equipment and personnel were mobilized. During this last bust, over 50 helicopters of various sizes were used. Their use was not unusual and they performed as part of the team.

Helicopters have been used since 1947 to perform a wide variety of tasks in the multiple-use management of National Forest resources, such as range, wildlife, recreation, timber, and water. Since the first fire flight about 1950, the helicopter has become a common sight on most fires, especially in the West. It is very useful in quickly moving men for initial attack on small fires or men and equipment to hot spots on fire lines. The helicopter gives the fire boss a tool that permits him to observe all parts of the fire and adjust plans and strategy as the fire changes. To obtain the benefits provided by the helicopter, new concepts of transportation and fire-fighting methods and accessories are continually being developed.

Helijumpers are now part of many fire-fighting organizations. They are specially trained men wearing protective clothing similar to the smokejumper, who can jump without a parachute to fires from a helicopter hovering not more than 10 feet above the ground. In many cases these crews are able to reach a fire several hours before a ground crew (Figure 1).

Helicopters perform many essential fire suppression missions. Freight and some paracargo are transported. Smoke jumpers and their equipment are returned to their base faster, enabling them to jump on other fires. Fire fighters are carried by helicopter from the base camp to inaccessible spots on the fire line.

FIGURE 1. Helijumper needs no prepared landing site.

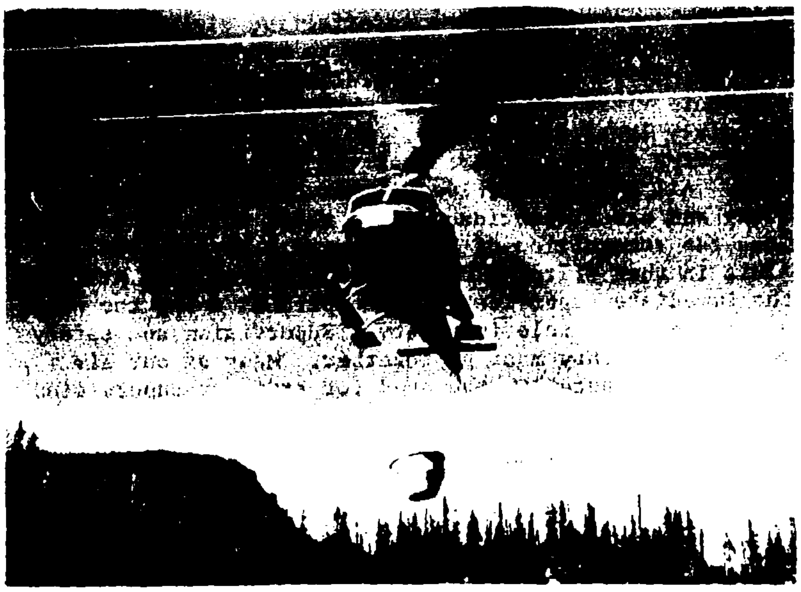

FIGURE 2. Helibucket dumps water or chemicals directly on fires.

Many helitack crews have been organized. These crews are transported by helicopters to a helispot near the fire for initial attack. This method of reaching fires faster has made it necessary to develop a system of main heliports and helispots in remote areas.

Since 1956, helitankers have been used to drop retardants on forest fires. To do this a light tank is attached usually between the skids or a specially designed bucket is suspended from a hook. The tank or bucket enables the pilot to drop liquid fire retardants on spot fires, flareups, and burning snags with more accuracy and in terrain where airplanes cannot maneuver (Figure 2).

Most Forest Service air operations are flown at altitudes from 5,000 to 10,000 feet. The manufacture of helicopters with better performance at these altitudes and development of efficient methods and equipment have been primarily responsible for the significant increase in use of helicopters by the U.S. Forest Service from 900 hours in 1956 to more than 26,000 hours in 1970.

During the last few years, two different makes of helicopters were put through flight tests in cooperation with Edwards Air Force Base. The results of these tests produced guidelines for management personnel in the use of helicopters for various activities. It is expected additional similar tests will be made in the future. Our regions and forests schedule training sessions each year to provide their personnel with information on the capabilities and limitations of helicopters for increased safety and efficiency.

Safety is an important element in effective air operations. No Forest Service air job is so important or so urgent that it cannot be done safely. Safety is integrated into all phases of air work to minimize or eliminate risks and hazards. Obtaining and maintaining a satisfactory safety level is not easy. It is not something that can be given a few minutes thought once a week and then forgotten for the rest of the time. All persons involved in air operations must have the thought of safety and use it continuously in their work. A good safety program requires the recognition of its importance by top-level management. This is then filtered down through appropriate staff or channels to the immediate supervisor and the persons doing the work. Management has an important role in safety. Supervision and safety are like Siamese twins - they must go together. Many of our air accidents have been attributed to the need for stronger supervision and control, especially at the operating level.

Much of the past work required by U.S. Forest Service has been done by the 3-place helicopter. We believe greater use might be possible with larger helicopters. One model was given a preliminary evaluation a few years ago. The test flights were conducted primarily for fire control operations. The results were favorable, showing it could be used for many assignments such as initial attack when a helitack crew could be flown directly to the fire. Helijumping and smokejumping could be accomplished from the helicopter. A descent mechanism could be used in areas where neither a landing nor parachute jump were feasible. Once the initial attack is accomplished, the helicopter could be used to ferry reinforcements or cargo. The extent to which large or small helicopters can be effectively and economically used in a given activity has to be determined. Mission requirements will dictate the specific needs (Figure 3).

The use of helicopters must be integrated with other aircraft and closely managed by trained personnel, especially on large fires. The safety, tactical, and financial considerations of helicopter operations increase as such operations expand on large fires.

The following points need to be considered fully for helicopter operations on large fires:

1. The need to establish several bases of operation at heliports and helispots. Each must be organized, equipped, and managed.

2. A heliport manager should be designated for each base.

3. Trained persons are needed to supervise loading and unloading, and to enforce safety requirements.

4. The number and size of helicopters that can operate from a base.

5. The types of missions to be flown as related to need for trained personnel or special equipment such as helitanker or hose lay.

FIGURE 3. Laying hose across timber country by helicopter.

6. Adequate radio communications for control and supervision.

7. Arrangements for logistics including helicopter fuel, maintenance, and other supplies.

8. Designation of helicopter boss for tactical operations.

9. Special operation procedures as may be dictated by the situation.

Projects are undertaken each year to develop and test new methods and accessories. Further work is needed on the project to develop the potential use of helicopters for night operations on forest fires. Preliminary investigation was limited to local operations such as transportation of men and equipment from a base camp at the fire to helispots near the fire line. After much investigation to determine most suitable helispot and enroute lighting equipment, several test flights were made. Progress reports showed favorable results. However, there is still much work to be done on this project before it can be given field tests under actual fire conditions.

About 10 years ago Carl E. Bergdorf, Fire Staff on the Daniel Boone National Forest, made a study to determine the feasibility of using a helitack program on the forest. A study plan was developed after an analysis of the situation and fire control problems on the area were considered. The objective was to investigate the operational and economic feasibility of using helicopters to transport men, equipment, and supplies in the initial attack phase of fire suppression and in the support of conventional ground forces. Initially, a crew leader and five fire fighters were trained to serve with the helicopter at the headquarters heliport. Later, several men were trained on each of the districts.

A summary of the operation showed good results to include:

1. Helicopter transport of men and equipment proved satisfactory during the two-year study. Many thousands of acres in half-hour control zones were reached within the time limitation by helicopter crew, where one hour or more was required by ground crews going to the same fires.

2. Small crews of two to six men achieved control of more than 85% of the fires with aid of the helicopters.

3. Initial attack by helitack crews cost less than other methods per acre of protected land, and it is believed they could have been effective on a large percentage of the fires if more helispots had been available.

4. Only two to four men are needed at the base heliport during a medium fire danger provided extra crew members are available near helispots where the helicopter may pick them up. These extra men in work status need ready communication with the dispatcher. The dispatcher at headquarters must have sufficient information to provide the helicopter pilot with compass headings and azimuth bearings and distance to landing spot fires. Helispots may be located by similar bearings and distance information.

The Forest Service considers the helicopter an important tool in the management and protection of our natural resources and is looking forward to greater and more diversified use in the future.

Mr. Hill: The next topic is fire fighting with helicopters in Viet Nam. To make this presentation, we have the Director of Emergency Operations for the U.S. Forest Service, Washington, D.C., Craig Chandler.

HELICOPTER FIRE FIGHTING IN VIET NAM

Craig C. Chandler

Director of Emergency Operations, U.S. Forest Service, Washington, D.C.

On January 30, 1968, the Viet Cong and North Vietnamese launched a series of carefully coordinated attacks against all 40 of South Viet Nam's major population centers. Because the attacks were timed to take advantage of the Vietnamese lunar New Year holiday, they became known as the Communist Tet offensive. During the Tet offensive these Vietnamese cities suffered heavily. And, just as was the case in those cities hit during World War II, the primary cause of damage was fire. Throughout the country, 75,000 buildings were destroyed or damaged - most of them in Saigon (Figure 1).

Saigon was designed to hold 500,000 people at the end of World War II, but between 1945 and 1968 the combination of general urban migration and an influx of refugees had swelled the population to something over 1,700,000. The newcomers first packed every existing building and then spilled out into the alleys, vacant lots, and any other available space. Residential areas consisted of a core of the original houses, which were usually stucco with tile or slate roofs, completely submerged in an interlocking mass of jerry-built shacks. These are invariably tin-roofed, with the studs and joists made from 2 x 4 lumber or bamboo poles, and the walls made of anything from reed matting to flattened beer cans stapled to cardboard. In 1968, the Saigon Fire Department was undermanned and poorly equipped; the city's water pressure was uncertain; and a good fire stop meant containing the fire to the block of origin (Figure 2).

Although the Tet offensive didn't last long, Saigon was hit by 40 days of sporadic rocket attacks in the four months that followed, and the specter of mass fire hung on everyone's mind. Barry Flamm, one of the Forest Service's AID team in Viet Nam, thought that the helicopter water dropping techniques that we use on forest fires might have a real place in Saigon fire fighting. He convinced the U.S. Ambassador. The Ambassador asked the Pentagon to look into it. The Pentagon asked the Forest Service to send a Research and Development team, and away we went.

We had assumed that the job would be pretty much of a picnic. The HU-1 helicopters, in plentiful supply all over Viet Nam, were rated on paper about the same as the Sikorskys that we used for aerial fire fighting in the United States. We had arranged for six 500-gallon helibuckets to be airlifted to Tan Son Nhuit Air Base and delivered to the Army Scientific Advisor's office. We expected that the outstanding

FIGURE 1. Tet offensive, 1968.

FIGURE 2. Aftermath of VC attack on Saigon, January 31, 1968.

question to be answered was whether air-dropped water could do any good on a tin-roofed building, and that, if the answer was yes, we would spend most of our time working out the tactics for an integrated air-ground fire control operation.

But life in Viet Nam is never that simple. The Tan Son Nhuit Airport was the second busiest in the world in 1968, and from previous experience we knew that cargo could easily get lost for weeks. After checking with the Pentagon we had carefully arranged for each crate to be stenciled with the correct address, and had also stenciled a secret code designation that was guaranteed to give our shipment priority treatment. When we arrived at the Scientific Advisor's office in Saigon we expected to find our buckets ready and waiting. They weren't.

After a hard day of leg work we discovered, to our horror, why they weren't. Nobody at the airport had ever heard of the Scientific Advisor's office. But the big problem was our secret expedite code. According to Air Force logistics regulations, cargo so marked may not be warehoused and must be forwarded within 48 hours. Since the receiving crew had no idea who or where the consignee was, they had stuck our buckets on the first large shipment out of town - where the receiving unit would also have to get rid of them within 48 hours. And, the buckets had left nearly 72 hours before. I had visions of chasing those buckets all the way to the North Vietnamese border - and maybe beyond. Fortunately, the trail doubled back and we caught up with the buckets in Cholon (a mere 8 miles away) three days later.

But by then we had encountered our second problem. The HU-1, by the book, has an adequate lift capacity to handle a 500-gallon water drop. But, in Viet Nam the ships are fitted with protective armor and extra weapons, and after adding the weight of the bucket and mounts, the residual sling left capacity allowed for about enough water to fill a medium-sized bird bath. The HU-1's were out.

The next step up in available helicopters was the Sikorsky CH 47-A, commonly called the "Chinook." Use of this ship put us in a brand new ball game, since no one had ever used twin-rotor helicopters for water drops before. We had to start from scratch and determine the proper height and drop speed requirements that would minimize rotor downwash and still give an effective dispersion pattern of liquid on the ground (Figure 3).

The Army kindly put the 147th Company of the 222nd Combat Support Aviation Battalion at our disposal. The battalion was stationed at the old French resort city of Vung Tau. Our tests were conducted on the beach facing the South China Sea, and except for a dearth of bathing beauties, more idyllic research conditions could scarcely be imagined. The tests were successful, and for those of you interested in technical details, the results will be published as an appendix to this paper (Figure 4).

In working with the Chinook pilots, we found a second important, but more prosaic mission for our bucket brigade. Throughout the

FIGURE 3. Loading helibucket in South China Sea.

interior mountains of South Viet Nam are isolated fire bases and outposts, supplied largely by helicopter. Whenever possible, the surrounding country is skinned down to raw dirt to provide a free field of fire. When the big Chinooks land or take off during the dry season, the dust is unbelievable. We wanted to investigate the possible use of water drops as flying sprinkler systems.

To me, the truly startling thing about this age of air transportation is the rapid contrast. In the commute from Saigon to Buon Breing, centuries are bridged in minutes. One can eat frog's legs in a French restaurant for lunch and dog stew with a knife for dinner. The soldier who steps on a mine in a swamp 100 miles from anywhere can be in a modern base hospital in two hours and in a bed at Walter Reed in less than 24.

One small difficulty in back-country R&D during those days before Vietnamization was that one was dependent on the Vietnamese Army for protection. At times it was difficult to tell who was protecting whom and from what!

Meanwhile, back in Saigon, someone had the brilliant idea that we should cap off our stay with a demonstration. Now I hate demonstrations, because if anything can possibly go wrong, it always does. But we found ourselves committed, on nine days notice, to put on a one-shot show for:

The U.S. Ambassador, his deputy and four assistants.
The First Minister to the Prime Minister of the Republic of Viet Nam.
The Director of Cabinet to the Prime Minister.
The Chief of Cabinet to the First Minister.
The Minister of Defense.
The Minister of Interior.
Two Province Chiefs.
The Commander of the Vietnamese Air Force.
The Saigon Chief of Police.
The Saigon Fire Chief
and CBS News.

The plan for the demonstration was to build a clutch of simulated refugee shacks, set them afire, douse the blaze with the buckets and have a Vietnamese fire crew move in and mop up.

Unfortunately, the demonstration had to be held at the U.S. Army Post at Long Binh for security reasons. The regular fire crew there were Americans, and we had to scratch-train a Vietnamese crew in

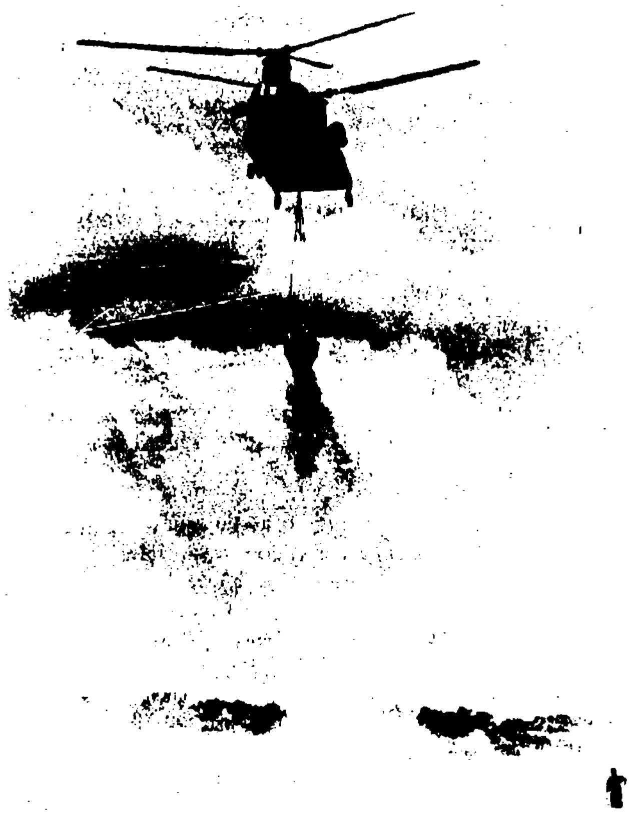

FIGURE 4. Helibucket drop tests.

a hurry. I will never again wonder about the origin of the phrase "just like a Chinese fire drill."

The demonstration came off on schedule. It is best summarized by quotes from the Navy Times, who gave us one of the kindest articles to see print.

"Buckets to Fight VC Fires"

"Long Binh, Viet Nam - another gadget has been added to the range of specialized equipment sent to Viet Nam. It's a 450-gallon fiberglass fire bucket which the U.S. Mission here says 'has been introduced to fight city fires such as the recent one in Cholon.'

"The idea, borrowed from the U.S. Forest Service, is to sling the bucket from the cargo hook of a chopper, swoop down over the nearest lake, stream or canal, then fly to the fire and dump the water.

"The U.S. Forest Service pilot who flew the first test flights with the new bucket was one member of the three-man team the Forest Service sent to Viet Nam a month ago to train Army chopper pilots in their use.

"Asked how the new device performed against real forest fires, the answer was 'numbah one.'

"It was more like 'numbah ten' when the new buckets were demonstrated yesterday at Long Binh Post.

"Four of the six buckets now on hand in Viet Nam were deployed against a Forest Service set fire near the ammunition supply depot here.

"The first chopper either waited too long or had trouble activating the electronic release device, missed the burning 'village' almost entirely, and deposited its load on the bystanding fire crew.

"The second Chinook was on target but it took a timely rainfall plus Vietnamese firemen to finish the job of putting out the last coals of the test fire.

"The new bucket brigade concept will most likely receive its all-too-literal baptism by fire in metropolitan Saigon when the expected 'third wave' communist offensive strikes the city."

As I said, that was one of the kinder articles. What CBS News did to us had to be seen to be believed.

But this story has a happy ending. The bucket brigade was used under fire, both in Saigon and in Tay Ninh City in 1969, and it worked as advertised. In 1970, the Marine Corps adopted the system for use on all their bases in Okinawa. And on January 25, 1971, the Washington Post carried a front page story, complete with three-column UPI photo of the waterfront market in Cholon where a massive fire was finally brought under control when U.S. helicopters doused the flames. The photo showed our Chinook and our bucket.

APPENDIX

Fire Fighting Capabilities of the CH-47A (Chinook) Helicopter Utilizing Twin 450-Gallon Retardant Dispensers

During late June and early July, 1968, tests were conducted at Vung Tau, South Vietnam, to determine the feasibility of using Forest Service helitanker equipment and tactics for cascading water or chemicals to suppress fires in densely populated urban areas of light wooden construction.

The tests were conducted with the Simms 450-gallon Retardant Dispenser slung 20 feet below the cargo hook of a CH-47A (Chinook) helicopter. Flight tests were performed with both single and tandem bucket loads. Drop pattern and fire suppression tests were conducted with single bucket loads only.

RESULTS

Flight Tests: Flights were performed over both land and water at altitudes of 150 to 2,000 feet. Loading was done in the South China Sea, approximately 500 yards offshore.

1) Both single and tandem bucket configurations are aerodynamically stable at all speeds tested (0-110 knots) with buckets full or empty.

2) With buckets full, spillage becomes appreciable (>20% of load) at speeds above 60 knots.

3) Loading time (from splashdown to lift off) varied between 15 and 30 seconds for both single and tandem loads.

4) Rotor downwash during filling is appreciable (>10-20 knots) over a 150 foot radius around the aircraft.

5) Although tests were not performed with additives, there was sufficient water turbulence produced in the buckets by vibration during flight, that mixing of surfactants, viscosity agents, or retardant chemicals would have been no problem.

Drop Pattern Tests: Drops were performed against fixed targets on dry beach sand from altitudes of 50 to 400 feet and airspeeds of 0 to 20 knots. Amounts were estimated by measuring depth of water penetration.

1) Rotor downwash >10 knots (sufficient to scatter burning embers) accompanies all drops made at a hover at all altitudes tested.

2) Rotor downwash is negligible at all altitudes above 200 feet provided aircraft maintains 3-5 knot forward ground speed.

3) At 200 feet altitude, 3-5 knot ground speed, no crosswind, the effective pattern (ground concentrations of 7-8.5 gal/100 ft^2) is 120 x 30 ft and total measurable pattern is 150 x 50 ft.

   a) Effective pattern is smaller at all increased ground speeds and becomes zero at approximately 20 knots.

   b) Head winds up to 10-15 knots (highest tested) have no measurable effect on effective pattern.

   c) Crosswinds above 5 knots tend to compress the effective pattern laterally, with the additional water all deposited on the upwind edge. The effective pattern in a 10-15 knot crosswind was 120 x 18 ft.

4) Utilizing the cargo hook hatch as a bomb sight, an experienced crew chief can center a pattern within ± 10 feet of a designated target at any altitude tested, and with head winds up to 10-15 knots, provided there is no crosswind.

   a) Crosswinds of 5-15 knots introduce lateral aiming errors up to ± 25 feet for drops made from 200 ft altitude, and ± 50 ft from 400 ft altitude.

5) Total time to reduce speed from cruise speed (60 knots) to drop speed (3-5 knots), aim, drop, and recover cruise speed varied from 20-30 seconds.

Fire Suppression Tests: Test structures consisted of simulated buildings 12 x 5 1/2 x 5 ft consisting of 900 lbs wood, 20 lbs cardboard and 10 gal JP-4. This is an equivalent urban fuel loading of 4.6 lbs/ft^2 or a forest fuel loading of 70 tons/acre. Initial attack drops were made 90 seconds after ignition (at time of peak heat output: 970,000 Btu/min). Structure was allowed to rekindle after each drop (or reignited with JP-4 if extinguished), and used as a target for subsequent drops. All drops were made from 200 ft altitude at 3-5 knots ground speed.

1) One properly positioned drop would suppress all flaming in 5 test structures (approximately 5

million Btu/min peak heat output).

2) Structures were rarely extinguished. Rekindle time varied between 8 and 10 minutes.

3) Thermal convection from the fires had no apparent effect on drop pattern or accuracy as contrasted with the drop pattern tests on the beach.

CONCLUSIONS

The CH-47A helicopter is potentially valuable as a tool for fighting conflagration fires in congested urban areas of light wooden construction. Each CH-47A, equipped with tandem 450 gallon dispensers can apply 5,400 gallons of water per hour to fires in the Saigon-Cholon area. This is sufficient to knock down fire at a rate of one acre per hour per helicopter. A three-ship squadron could have suppressed the worst of the recent Cholon fires in a little over two hours, provided ground fire-fighting capability for mop-up were available.

Ideally, the CH-47A should make fire retarding drops from an altitude of 200 feet, flying into the wind at 3-5 knots ground speed. In no instance should drops be made from lower altitudes or from a hover since rotor downwash will do more harm than the drop will good.

The CH-47A appears to be the best suited aircraft for fire-fighting purposes that is readily available to U.S. forces in-theater. The sling load restrictions on the HU-1 are such that 7 HU's are required to substitute for one CH-47A. The S-64 has a 20% greater sling load capacity than the CH-47A, but is less adaptable to fire control mission requirements.

DISCUSSION

Mr. Hill: We have gone from the Chinese fire drill to highly sophisticated operations and surely we generated some items for discussion and we have left little gaps here and there that ought to excite some questions.

Dr. Emmons (Harvard University): I will crack the ice. I have a rather detailed question that is probably completely obvious to anyone who has really been close to one of these things, but I do not happen to know the answer and would like to. What is the ground pattern? Does this come down as a heavy rain? Are there chunks of water so large that a man really should not be there when it lands? Or is it quite safe to get wet when it comes down? How heavy a dose do you put on the ground? How is it distributed?

Chief Houts: A lot depends on the altitude it drops from and the speed of your drop. Normally from a helicopter it comes down as a fairly heavy rain. There is nothing dangerous about it, and this is one of the good features of using the helicopter over a fixed-wing air tanker as a drop because with a fixed-wing tanker if you come in too low or too fast, it is a very dangerous situation.

Dr. Erwin (Bangor, Maine): What is the level of command for the helicopters? Is it part of the training of your command personnel? Is it used for pre-fire planning?

Chief Volkamer: If the Chairman will permit me, I will introduce two of our pilots. One of them can do the answering for me because I would be hacking through this. Lt. Tannehill and Lt. Hack, Chicago Fire Department pilots. Answering your question, Dr. Erwin, the helicopter service comes under that phase of dispatch by the fire alarm office that comes under the jurisdiction of the pilot in command at that time to operate and take whatever chances he feels necessary. Lt. Tannehill, can you elaborate on that?

Lt. Tannehill: Our chain of command is the Fire Commissioner, Chief Fire Marshal Volkamer, and of course, the officer in command of the unit at the time of the incident. We are cleared to go to anything on Lake Michigan or in the City of Chicago; anything that is out of the City of Chicago is with the permission of the Commissioner, and the Chief Fire Marshal.

Dr. Erwin: My question was what is the level of command function? Is it used solely by the Chief of the department? Is it used by a District Chief? In other words, who is the one who is to direct the fire from this piece of apparatus?

Chief Volkamer: As was indicated in my talk this morning, we do not use our helicopter nearly as much in fire-fighting strategy as does the County of Los Angeles or probably Los Angeles City, being in such close proximity to the County. The Commissioner, as I pointed out, has from time-to-time, flown over multiple-alarm fires; so have I. These are unusual circumstances where we might observe from above such incidents as the riot problems. Naturally, it was used at that time. We have had only one or two other occasions where we have actually lifted people off roofs - one in the Stock Yards during a fire in the yard where one of the workmen was injured. Other than that ours is mainly for rescue as I pointed out - rescue on the Lake, or freeway accidents.

To follow up on your question, perhaps getting a little more specific, I am sure that Chief Houts used something similar to this and he can pick up where I leave off. In our general area, if we have more than 16 companies on a fire, we have a Deputy Chief and an Assistant Chief there at the command post.

Mr. Hill: In general, if it is a rough-terrain-type fire such as brush areas, one of these men is nearly always in the helicopter at all times. Now the Deputy Chief is in overall command of the fire and, if he is up in the helicopter, he leaves the Assistant Chief to run the fire and direct the operation, or he will come back down and tell the Assistant Chief to go up. And, so, almost always, one of these men is in the helicopter. If the fire gets up around 25 to 30 companies or more, I, myself, will go to the fire. So, we have an Assistant Chief, a Deputy Chief, and myself there. One of us is always in one of the helicopters feeding information back to the command post. Also, we use them on structure fires in high-rise buildings, for example. Less than two months ago, we had a fire up in a restaurant on the 22nd floor of a building. It was a multiple-alarm fire with an Assistant Chief in charge. The Assistant Chief during the active fire fighting of this fire was in the helicopter hovering at the 22nd floor level and watching and directing the operations from that point. One other question that you asked was that of pre-fire planning. We use helicopters extensively during that portion of the year when they are not on high-hazard patrol or on standby for operation at fires. This time of year, June, for example, we do a lot of training work with the chief officers throughout the department. We have used the helicopter to completely map all the rough terrain areas of the City and we have done this on a quarter-square-mile basis and when we get up into the long valleys, we will do it on a quarter-mile wide and a half-mile long. We have four complete sets of slides of this sort. We have one set in each command truck. You can put them on a projector, throw them on a screen. You have sheets of paper there. You can draw out exactly where a man's sector is. He can look at the slide area and talk about where you want him to go. "Here is your sector, you'll have five or six companies. You're in charge from here to there." Tear off the sheet of paper and he takes it with him. We also do this for large complexes - "target hazards" we call them. You have a large shopping complex of several square blocks. All of these are very carefully mapped from aerial photographs. As I say, complete sets are in our command truck. Dick, do you want to elaborate on that?

Chief Houts: Our operation is basically the same, the only difference being that during the high fire-hazard seasons, our helicopters are on initial attack and, in many cases, they arrive before the ground equipment does. But, whoever the commanding officer is on a particular fire at any given time, he is the man who makes decisions regarding the use of the helicopter. As the fire develops into a campaign fire, then we go into air operation with an air officer, but his priorities are still determined by the operations chief.

Mr. Hill: One other thing might be mentioned. Chief Houts mentioned the high-hazard type. In the brush areas that we have within the City limits of Los Angeles (there are over 100 square miles of brush), there are a lot of extremely high-value homes. They want the rustic effect, so they plop them right down in the middle of the brush. We keep two machines in the air all day long on high-hazard days. They are flying with an observer who continually watches, and they carry a drop tank fully loaded with water. Another little side effect: on February 9 of this year we had a very severe earthquake. We had four machines flyable on that particular day. We have five machines, three Jet Rangers and two of the 47G's. We put four machines in the air immediately with observers just cruising to look for fires and for problem areas, because it takes quite some time before you know whether telephone service is working or not. And, in fact, the dam that you heard so much about that was severly damaged - this was spotted by one of our Assistant Chiefs from the air. At the Veteran's Facility where so many people lost their lives and where Chief Houts' men worked for three days on the rescue activity, one of my deputy chiefs was the first man to spot this from the air and landed there. Their facilities were out. They had no telephone communications. Their radio communications and their radio net happened to be in the building that collapsed. So they had no communication with the outside. This sort of thing is easily spotted from the air, so the helicopters are very valuable from this point of view.

Mr. Eggleston (Southwest Research Institute): What techniques do you use so that the airborne officer can positively identify locations on the ground?

Mr. Hill: We have 20-power binoculars that are gyrostabilized. A helicopter shakes quite a bit and 20-power binoculars even standing on the ground shake quite a bit, but ours are gyrostabilized. They cost $4,700 apiece. They are battery-operated gyro and you can read license plates. People go back into the brush areas and dump, which is against the law. We snag their license plates, get a police car into the fire road, and get them as they come out. You can read street signs. Quite often for fires in brush areas, you can spot them from the air much quicker than if somebody from the ground calls and gives a specific address. You could send all of your companies to that address and it might be the wrong side of the fire. So you have the initial advantage of initial attack companies on foot on the best side of the fire. I have been up in a helicopter and on the radio, and even if we were so far up that we could not read the street signs, we would see the apparatus coming and we could say "turn right at the next corner," and let them go a couple of blocks, turn right again, and guide them right into the fire from the air. It is an extremely valuable adjunct to fire fighting to get them on the proper side. We roll on initial alarm; we roll five engines and a truck on any fire reported in a brush area and, this way, you can get them on the proper side of the fire.

Mr. Heilman (U.S. Forest Service, Milwaukee): I would like to ask the L.A. County and Chicago City men if they use helicopters at night, and, if so, what kind of lighting equipment do they use?

Mr. Hill: Our night operations are very limited. We have used them on going fires at night. We have the kind of lighting equipment that the aircraft comes with. Other than that we have been experimenting with different types of lights over the years and have not come up with anything satisfactory. The one with that type of light called the "night sun," is quite expensive. We have not yet been able to justify that in the budget. The Sheriff uses it, but normally our operations are during the daytime. In the mountainous terrain, the various agencies such as the Telephone Company and the Edison Company have seen fit over the years to string wires throughout the mountains and it makes it very dangerous to fly. So we try to operate only during the daylight hours.

Chief Houts: We also engage in night operations. We have done a lot of night rescues. If it is something that requires a light similar to the "night sun," we, in the past, have called the police department. Their patrol helicopters are equipped with the "night sun." If, for example, a car goes over a steep cliff, then the "night sun" will sit up there and our men will go down with the working machine to pull them out. We are installing a "night sun" on one of our helicopters right now. We have also done quite a bit of night work on water drops at fires. I recall a very bad fire of last September, which at about 11:30 at night slopped over Topanga Canyon (a very bad canyon for us) and I and one of my pilots flew up there and took a hard look at it. The wind had died down quite a bit, but it would come up again about 6:00 in the morning. There are many dwellings in this particular canyon so we got three machines airborne with tanks and we went in and pounded it for about an hour and 45 minutes with water and actually killed the fire. There was enough light from the fire itself to pound it and we hit it pretty hard. These were Jet Rangers, with 140 gallon tanks.

Question from audience: I believe you have been using your helicopters for freeway pickups of accident victims. Have you experienced any difficulties landing your choppers on the freeway from the standpoint of other passing vehicles?

Chief Houts: We haven't had any difficulties. Most of our problems are off the road, dunebuggies and things of that sort that we have picked up from the freeways several times. We have excellent cooperation from the Highway Patrol and Sheriff's office. Normally when they go to the freeway, they try to land off on the side as much as possible. They have had no operational difficulties. If you have freeways that are badly clogged, you have great difficulty getting an ambulance to the accident. We have learned to put a helicopter overhead when an ambulance car goes out and let it direct the ambulance to the scene, even though we may not land the helicopter.

Chief Volkamer: Our helicopter often times responds to accidents on the expressway and lands in the median strip or just off the expressway. In some instances they will lift the victim directly to the hospital at certain times of the day. But the helicopter as a rule lands in the median strip and removes the victim to the side of the highway and the ambulance removes him from there.

Mr. Hirsch (Northern Forest Fire Laboratory, Missoula, Montana): In the fire detection kind of patrol that you fly in the L.A. area, is the smog seriously limiting your efficiency? In trying to do liaison work on large fires, how seriously does smoke hamper your ability? These questions are aimed at possible applications of forward looking infrared sets or other electronic devices in this sort of a situation.

Mr. Hill: Smog has never given us this kind of problem. It does not get that thick and we do fly at rather low altitudes when we are on high-hazard patrol at the fire itself. When you have a large extensive fire, of course the smoke can be quite a problem. In general, there is not too much point in flying to the interior of the burn; you are watching the direction it is burning so that you can move companies to make a stand if the fire is going to skirt a group of houses or whether it is going to burn right in. When you are using the 47G's (the little bubble helicopter with the reciprocating engines) we stay outside of the fire area. They do not have the power of the Jet Rangers; we do not hesitate to go right over the fire with the Jet Rangers because they have enough power to pull out if you get into a tight situation. However, I think one of our pilot's comment is rather significant - when you are bucking the 60 and 70 mile an hour winds and the extremely turbulent air over the fire, the pilot says to us, "We are not really flying these things, we are just keeping them from crashing," which makes you think, "I had better get back to the ground and send the Deputy Chief up." If it is the Deputy Chief, he thinks it is a good time to send the Assistant Deputy Chief up.

Mr. Hirsch: A good deal of our experience involving large fires has been in finding these spot fires.

Mr. Hill: We found that in the presence of a smoked-up atmosphere trying to do it visually is very difficult. When you get right down on the edge of the fire (we fly down on the edge of the perimeter of the fire within 50, 75, or 100 feet), the smoke is usually no problem there, but if its spotting ahead of you and it is being driven by one of these 60-mile-an-hour Santa Ana winds and you have the smoke really laying over, you cannot see too much. But you are not going to get in front and work on that kind of fire anyway. When a Santa Ana wind comes in off the desert, blowing the fire at 60 or 70 miles an hour, you do not stop the fire. It has got to burn into real light fuel or the wind will have to die down before you can get in front of it. You are working on a side operation trying to pinch it in, and getting in and saving as many homes as you can, and you are really not interested in spot fires in front. You are not going to put crews in there anyway. Not when it is being pushed by a 70-mile-an-hour wind. Many times I have gone in over the fire and told the pilot "alright now get with the wind and let's go through and across the front and keep flying in that direction so that I can tell where the fire's going to be an hour from now," so I will know pretty much how fast it is burning and how many companies it will take so you can start making preparations and keep moving command posts ahead. In fact the fire we had last September - we had the same fire in 1967 and we knew how fast it would move - and we put it out at the Ventura Freeway at about 5:30 a.m. the next morning. There, because it burns into very light fuel along side of the Ventura Freeway and we have a chance. We do get down very close to the fire in flying this type of mission.

Mr. Eggleston: I would like to ask if on any night operations against these fires there has been any problem in the pilot maintaining ground reference when he is staring into the intense glare of a fire?

Mr. Hill: Our experience has been limited. We do, if we do not have any other choice, put the ships into the operation, but I have not heard of any problems. The pilots would be able to answer that better than I.

Chief Houts: I have been up in helicopters on these large extensive fires and found scouting missions and we get right down close and watch the fires. The pilots have not indicated any problems to me. Actually it is not like some of the pictures we saw here where you have intense mountains of flame that the pilot is looking into. It is rather a scattered affair and you have high flames on the front but the fire and brush burns through a rather narrow front where it is really flaming and there are lots of glowing and burning behind it for a couple of miles perhaps, but your heavy flaming front is a relatively shallow front. The brush burns very fast and the initial flaming combustion goes up with it.

Mr. Shields (San Dimas Equipment Development Center, U.S. Forest Service): One question that bothers me about the high intensity lights, as we found two years ago, concerns the back scatter you get from any kind of atmospheric haze, moisture, or anything. And from the pilot's standpoint it turns on an extremely bright light. All he gets is a white-out and he cannot see a thing. On the ground you can see quite well; the light does get to the ground. I wonder how these fellows have solved this problem in their flight operations because of course you lose your horizon.

Mr. Eggleston: I raised the question specifically because I was observing some Air Force operations from the command helicopter. In that case, the pilot flying the ship was trying to stay on instruments; the co-pilot had his head stuck out the left-hand side and was trying to maintain ground reference as best he could to help the pilot. Here is where you have an essentially dark area with a brilliant fire in the center and it is a very real problem for them.

Mr. Hill: I may not be getting to the exact thing that you are driving at, maybe I am missing the point. In fire operations we are not using the light. The fire itself provides the target that you want, so you do not need the light. We use the lights only in rescue operations. We always send two ships on a night rescue and one ship sits up high enough to provide the light and the other ship goes down and does the rescue work. The pilot on the rescue ship in tight close quarters has no lights on his ship at all. He is down in the light from the other ship so we have no problem. The pilot up above may have some problems, but the fellow who is down doing the close very careful work of extricating somebody is not working in his own light. The other ship is there to provide the light. We always send two ships out on a night rescue, which is one of the reasons we keep two pilots on duty around the clock.

Mr. Huffman (Aerospace Corporation, San Bernadino, California): Have helicopters been used in fighting fires in structures, aside from in Viet Nam? Have you actually used them in either retardant delivery, water delivery, or to carry the hose?

Mr. Hill: We have not used them in water drops. One of the problems there is that unless the fire ignites a roof from outside, it is not going to be very satisfactory. If the fire is from inside, say it has burned through the roof, the main body of fire is inside and you are not going to get water out or in on the fire very effectively. We do use choppers to haul equipment, men, and hose lines to the roof of buildings. When you have a fire on the 35th floor of a 42-story building and the power is knocked out and you are contemplating walking up there with all your equipment, it is a lot easier to lift men up to the roof and let them walk down. Of course, that is not ideal either but it is easier to go down than up. We had a fire on the 37th floor of a building where the elevator was out and it took us 26 minutes to get there.

Mr. Chandler (U.S. Forest Service, Washington, D.C.): I would like to elaborate a little on the use of water drops on structural fires. The key that made it a success in Vietnam was the flimsiness of the construction and the fact that the studs are only 2" x 4" and therefore the drop will take the roof out. You have a tin roof and when you drop on it, it goes. The big difficulty is that you have to keep the helicopter moving; you cannot drop from a hover with a large helicopter because your rotor downwash will do you more harm than the drop will do good. So when you drop the water while moving, you leave a rain shadow behind every standing study and you get rekindles. You have to follow-up with a ground crew. Why do you have to follow-up with two drops going in opposite directions? Because when he is moving you always leave a shadow behind everything standing. Just for the record, we did drop on several structures on the September fires. They were roof fires, incipient fires, and the drops did knock that fire out. We dropped on autos also that were burning, convertibles especially, when the roofs burn off; now this is not a growing brush fire, it just happened that a ship was over the area and he dropped in there and saved the automobile.

SESSION II

Chairman - R. Keith Arnold

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Dr. Arnold: We were to open this afternoon session with a panel discussion on Manufacturers Specifications and Aircraft Performance by representatives of the Bell and Vought companies, and later this afternoon have a talk on Helicopter Accessories for Fire Fighting, to be given by Herbert J. Shields of the Forest Service Equipment Development Center at San Dimas, California. I think Mr. Shields' talk will be a good introduction to the panel discussion, so I am asking him to present his paper at this time.

FIRE-FIGHTING ACCESSORIES FOR HELICOPTERS

Herbert J. Shields

U.S. Forest Service Equipment Development Center, San Dimas, California

Many groups have developed accessories to be utilized on rotary-winged aircraft to assist in control of fires. For example, the Air Force has used a "packaged" fire extinguisher kit for use in immediate rescue of crewmen from crashed aircraft. Simultaneously, rotor downwash is used to direct smoke and flames away from the cockpit. The Forest Service, for many years, has utilized the helicopter for laying fire hose, transporting pumping equipment, dropping chemicals and water, reconnaissance, and of course, personnel and cargo. In order to utilize helicopters for fighting fires, it is necessary to match the capability of the helicopter and hardware with the defined task to be performed. Helicopter performance information has become more reliable and useful in recent years.

Aircraft

The first major component of any system is the type and model helicopter and its capabilities of performance. In the past, we had to take what was offered, but now almost any performance can be selected. This performance is basically: useful lifting load, hovering capabilities, and altitude performance. Stability and control problems certainly must be considered during initial certification, and also should be re-examined during add-on accessory flight tests (Figure 1).

The major constraints to operating helicopters to their maximum capabilities are power losses due to temperature increases and air density decreases because of altitude. Power losses at Denver would be far higher than in Chicago or Washington D.C.

There are some aerodynamic losses, but these are secondary to basic power plant performance degradation. There are now test techniques

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FIGURE 1. High altitude performance testing.

that can provide useful performance information in the two major areas in which we are interested: hovering capabilities (height and load) and takeoff distances. Hovering skid height depends upon weight, ambient temperature, power available, and altitude. Similarly, the length of the takeoff run depends on weight, temperature, altitude, power available, and airspeed selected for the climbout. Takeoff distance can, therefore, be related to the maximum hovering skid height that can be achieved, and to the airspeed selected for the climbout. All of these variables can be related by the following functions:

$$C_P = \frac{BHP \times 550}{\rho A (\Omega R)^3}$$

$$C_T = \frac{W}{\rho A (\Omega R)^2}$$

Where: BHP = Brake Horsepower
ρ = Air Density, slugs/ft^3
A = Rotor Disc Area - square feet
Ω = Rotor Velocity, Radians/sec.
R = Rotor Radius - feet
W = Gross weight, lbs.

These two coefficients of power and thrust (C_P & C_T) can be related to provide us with a picture of the performance in which we are interested when extracting data for flight manuals. However, one word of caution is in order. It is necessary to acquire these data under representative altitude conditions. There are also some variations caused by compressibility effects that will begin to show up in larger machines or at fairly high altitudes. These test techniques are the backbone of better flight manuals and performance information.

Selection

Now that we can define performance, our selection needs to be geared to the mission. As one wag suggested; "in urban areas where the buildings are close together, use small helicopters, and where they're far apart, use large ones."

However, it is obvious that most helicopters, with the exception of the Sikorsky Flying Crane and one or two other experimental models, have been designed to carry people. It is time that we started orienting helicopter design to the mission. Other than transportation of fire crews, the basic operational requirement has been cargo-hauling, by aerial discharge or aerial delivery from point to point. Of course, the ability to sustain hovering flight is one characteristic that is most useful but has other implications.

Tasks

The next step should be to catalog jobs that can be performed by such a flying-machine. These tasks may be defined because of accessibility from the air, or because ground mobility is impaired or nonexistent.

Transportation and Tactical Uses

A. Personnel
    1. Fire Crews
        a. Letdown delivery from a hover, or jumping
        b. Landing
    2. Rescue
    3. Medical
B. Equipment and Cargo
    1. Ground
        a. Conventional fire-fighting tools and hardware
        b. Cargo and supplies for supporting ground fire-fighting mission
    2. Airborne
        a. Application Systems
            (1) Free fall
                (a) Resupply
                (b) Fire Suppression
            (2) Nozzle
                (a) Resupply
                (b) Fire Suppression
            (3) Chemical
                (a) Liquid
                (b) Dry
                (c) Foam
        b. Hose lay or distribution systems
        c. Smoke and wind control
            (1) Rotor wake
            (2) Hover downwash

d. Reconnaissance
   (1) Mapping
   (2) Remote Sensing
e. Cargo
   (1) Free fall
   (2) Parachute ("Helichuting")
f. Backfiring
g. Night operations

Personnel Transport

This is one area that is being efficiently performed with existing machines, when considering point-to-point delivery.

In the realm of aerial delivery by hoist, rapelling, or rescue, most hardware devices are add-on accessories. There are specially designed devices for most currently used helicopters.

Many thousands of "hover-jumps" have been made for initial attack on fires. These are made where low ground cover will not permit landing. Special steps have been developed for safety of the helijumper (Figure 2).

FIGURE 2. Helijumper.

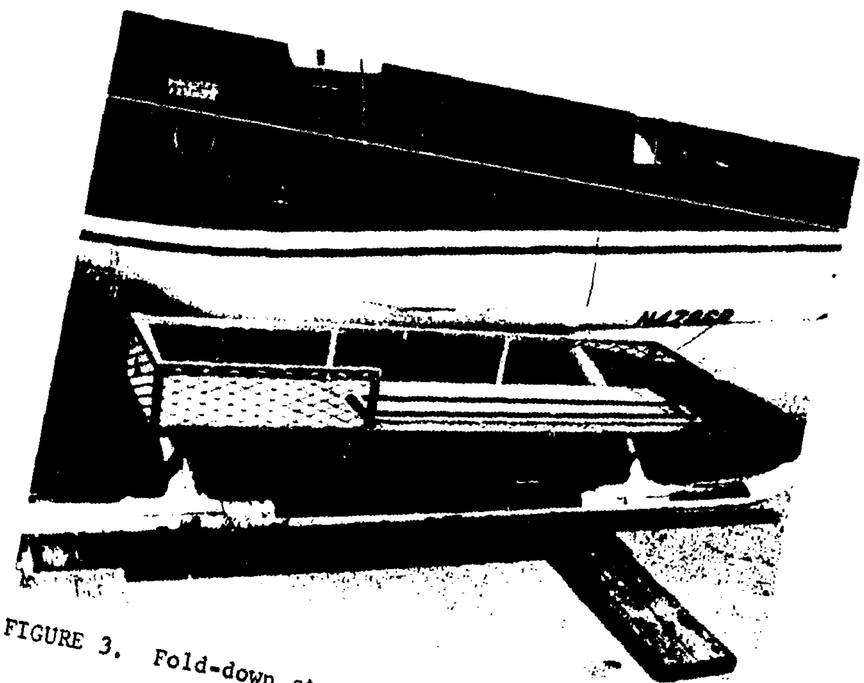

FIGURE 3. Fold-down step-in cargo rack.

Equipment and Cargo

Unless cargo is supplemental "cargo rack size" or can be carried inside the helicopter, the major method is by sling carry. This has meant providing slings and containers compatible with helicopter performance within the operating environment.

There has been much work done in evaluating characteristics and effects of sling loads on helicopter stability and control. Single point vs. multiple point hookup and carry lines can ease flight limitations but complicate delivery hardware.

As speeds increase, it becomes necessary to evaluate individual flight limitations and the performance envelope for different machines.

Airborne Techniques

Free cascading of water and fire retardants on forest fires has been performed from fixed tanks made from fiber glass, fabric, metal, and combinations thereof. In addition, sling carried buckets have been made from the same variety of materials.

Some fire operations have included dropping of water and retardants into sumps and storage tanks for distribution by conventional ground pump and hose. This can provide rapid airborne resupply of a remote operation.

FIGURE 4. Fiber glass bucket, foreground; Fabric tank, center; Aluminum tank, rear.

Some work has also been done to develop airborne delivery of liquids through hoses and pipes while in flight. Unanswered questions are: What nozzle configuration is needed? What effect does rotor downwash have on the stream? Can we hover safely near enought to the target? Up to now, payload limitations have restricted broader use of this technique. Improvement of out-of-ground effect (OGE) performance of helicopters should enhance the potential of this kind of application.

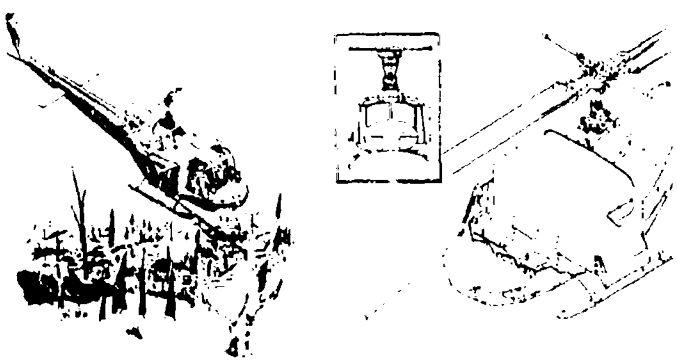

FIGURE 5. Nozzle delivery concept.

Chemicals

Use of chemical fire retardants and suppressants has been increasing with the availability of ground support capabilities. Careful inspection procedures need to be incorporated to provide a continual check against corrosion of helicopter components from chemical splash.

Hose Laying

Hose lay techniques were developed in 1956 by the Forest Service, utilizing a dispensing tray from which up to 1,000 feet of fabric fire hose could be flaked out while in flight. Later techniques developed by the Los Angeles County Fire Department included a release bar for dropping up to 10 rolls of hose in sequence. Airborne hose laying should be particularly appropriate for urban situations when street accessibility is limited.

Smoke and Wind

Helicopters achieve their lifting capabilities by thrusting a large volume of air downward while in flight. They create a "rotor wake" in forward flight, and "downwash" when in a hover.

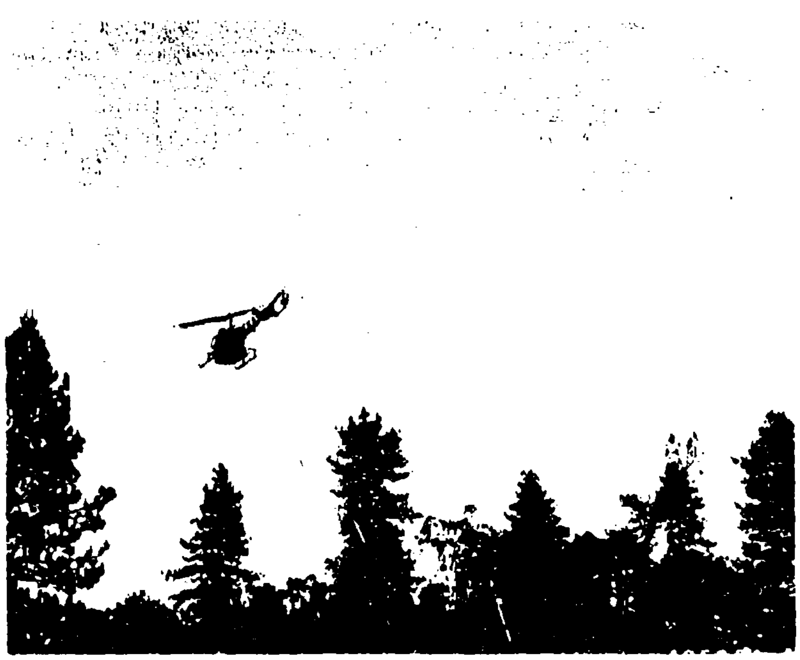

FIGURE 6. Hose-lay tray.

From known helicopter flight dynamics, the induced velocity in a hover at the rotor disc is related by.

$$V_h = k\sqrt{\frac{W_T}{2A\rho V}}$$

Where: V_h = Induced velocity in a hover, feet/sec

W_T = Gross weight, lbs

A = Rotor disc area, square ft

ρ = Air density, slugs/ft^3

For forward flight, the average induced velocity at the rotor disc becomes:

$$V_o = \frac{W_T}{2A\rho V}$$

V_o = average vertical induced velocity at the rotor

Where: V = Forward speed

(The final downwash below the rotor disc contracts to $2V_o$)

It is obvious that the relationship between the two main variables, W_T/A, or weight over disc area, becomes the common description of "disc loading." Thus, we can relate excessive effects from downwash in large, heavy helicopters with relatively short, widecord blades. Longer blades would help alleviate this problem by lowering disc loading. For example, the hover downwash on a "Huey" (Bell 204) is about 50 mph at the disc.

Application of sprays or possibly foam systems may be able to utilize rotor vortices generated in forward flight, since they provide excellent foliage coverage when formed close to the ground. Little known work has been conducted in injecting fire-fighting foams or chemicals into hover downwash. Normally, downwash and wake must be avoided or understood in order to prevent an upsetting input to fire conditions. As indicated here, however, there may be situations such as smoke or wind conditions that can be controlled with properly directed downwash energy.

Reconnaissance

The helicopter was first used in its fire role as an aerial observation and mapping platform, and this has continued to be a primary function because of its flight characteristics and visibility. In recent years, television equipment has been developed for airborne

FIGURE 7. Helicopter observation in 1947.

transmission. Infrared equipment is in use with fixed-wing aircraft for mapping through smoke, but has not been utilized significantly with rotorcraft. However there should be no reason why it should not be adaptable.

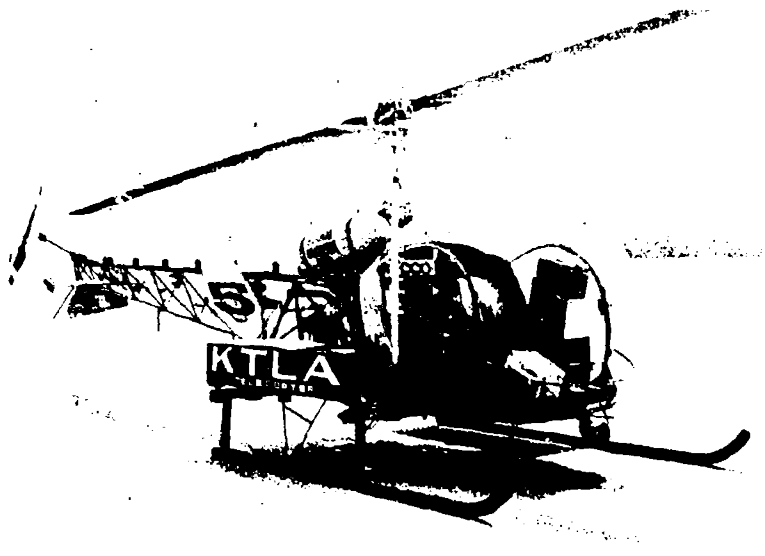

FIGURE 8. Airborne TV in 1968.

Cargo Dropping

Energy absorption materials have made free fall delivery of properly selected and packaged items practical. For example, a block of ice is nature's way of providing a durable package for drinking water. Hand tools and other supplies are frequently dropped from low level passes. Cargo "pushing" may be a most satisfactory method in the future when large machines are available. Skycrane helicopters may permit prepackaged cargo on pallets or bins to permit rapid handling.

Early work with light helicopters also generated use of small parachutes for dropping cargo (or "Helichuting"). The equipment was simple, and accuracy of dropping was excellent. Normal paracargo parachutes were utilized with the addition of safety pull-off covers to prevent accidental deployment until released.

Backfiring

The light helicopter has been used as an aerial platform for dispensing fusees, Very pistol cartridges, and other incendiary devices. One helicopter operator even developed an airborne flamethrower, but wisely, no pilot was found who would fly it.

This is one area for wildfire control that needs helicopter hardware development. Automatic, external, jettisonable equipment is advantageous over cockpit operated weaponry.

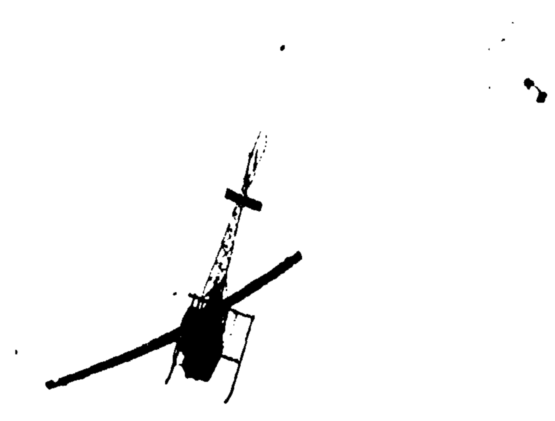

FIGURE 9. "Helichuting."

Night Flying

Night flying of helicopters is routine in urban areas for point-to-point travel. Where no horizon exists such flight becomes dependent on instruments. The Forest Service has experimented with lighting systems for marking en route courses and landing areas. The helicopters were also supplemented with additional instruments, which included a radar altimeter. Results were excellent, except when operating under conditions of smoke on a fire, when ground marker systems were obliterated. Electronic equipment is now available which would eliminate visual ground reference requirements and could make such operations practical in the future.

Safety

The most important factor in developing techniques and hardware for fire fighting is safety to personnel, both airborne and on the ground. The helicopter is such a versatile machine that it is easy for an aggressive pilot to find himself somewhat compromised regarding reserve performance. As compared with airport operations, he has no tower to advise of winds, runway, and assurance of clear airspace. An easy situation can degenerate rapidly with slight misjudgment.

Since helicopter performance is also tied in closely with total gross weight, it follows that the ability to rapidly jettison accessories would be helpful in an emergency. Early accessory development work required that all equipment be jettisonable both electrically and mechanically. Also, electric release controls had to be located on the cyclic control stick, and manual release devices had to be convenient to a foot pedal or the left hand (adjacent to collective control). Modern machines have somewhat neglected this secondary feature, usually only being able to discharge the contents. The exception, of course, is anything suspended from a cargo hook.

It was mentioned earlier that higher speeds will require careful examination of effects of external devices on aerodynamic stability. This problem has already become serious. For example, installation of spoilers on one fixed helitank were required to eliminate airflow that affected longitudinal stability at higher air speeds.

Summary

This paper has attempted to catalog the need for understanding the operation and performance characteristics of helicopters before designing missions and associated equipment.

There are many tasks that have been successfully performed from the air, and many that will be developed. There is a need for helicopters developed as flying "cargo hooks" - in lieu of being passenger vehicles modified for other uses.

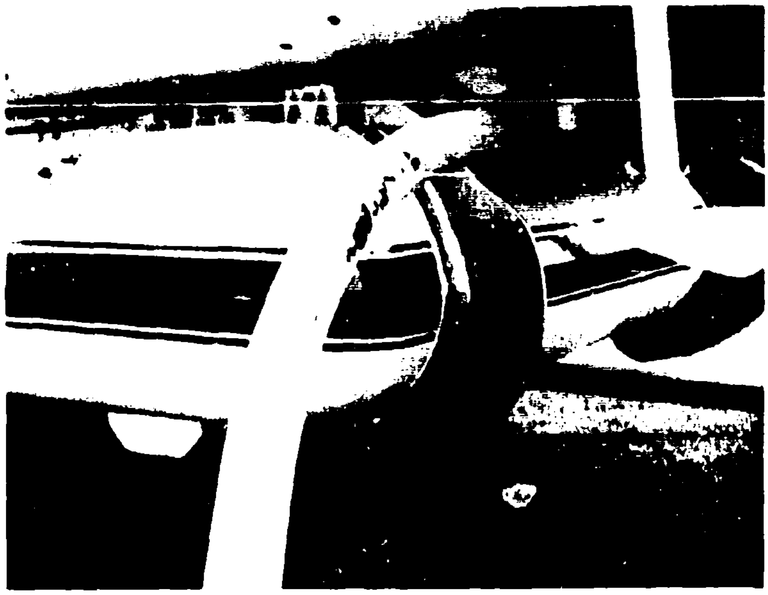

FIGURE 10. Spoilers or "fences" on leading edge of helitank.

There is a real future for hardware of all types to revolutionize initial response to fires, based on the good work and systems that have evolved in the last decade.

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Dr. Arnold: I would now like to introduce the members of the panel - Mr. Jim Garrison, Sales Engineering Manager and Mr. Jim Lindsey, Aerial Applications Project Manager from the Bell Helicopter Company. Mr. J.G. Armstrong, Manager Marketing and Mr. Paul Domanovsky, Vice-President of the Vought Helicopter Company. I have asked Mr. Shields, and Mr. Shay Huffman of the Aerospace Corporation to join the panel. Mr. Huffman is Director of Systems Applications and has been involved in application of aircraft to forestry operations generally.

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PANEL DISCUSSION

Manufacturer's Specifications and Aircraft Performance

Mr. Domanovsky (Vought Helicopter Incorporated): Vought Helicopter, Incorporated is a wholly owned subsidiary of LTV Aerospace Corporation. It entered the helicopter field in July 1969 after a careful diversification study indicated that there was room for another quality helicopter manufacturer in the United States and Canada marketplace. After due consideration of the different options available for entering the helicopter field, the decision was made to enter into a cooperative agreement with Societe Nationale Industrielle Aerospatiale of France. This company had some 40 years experience in the rotary-wing field, its current products represented quality helicopters, and its advanced technology was impressive. The agreement consists of phases including assembly, market, and total support of current Aerospatiale products, U.S. overhaul of dynamic components, manufacture in the U.S., under license, of one or more of the Aerospatiale helicopters, and most important to participate in a technical transfusion program in which VHI engineers would spend extended tours in France, actually working with the Aerospatiale engineers. Through this multi-phased learning program combined with resources of the LTV Aerospace Corporation and U.S. helicopter specialists, VHI expects to become a viable helicopter manufacturer in its own right. The first, second, and fourth phases of the cooperative program are well underway and planning for the third phase, U.S. manufacture of Aerospatiale products, is underway.

In the past year and one half, VHI has sold some 60 of the Alouette II and III helicopters in the United States and Canada and supports some 15 more in the same territory.

The VHI product line consists of two well-known seasoned helicopters, the Alouette II and III, and two of the most advanced helicopters in production today. The characteristics of the Alouette II, Alouette III, SA 341 Gazelle, and SA 330 Puma are summarized in Table I. As already mentioned, the Alouettes are well-known worldwide with over 2,000 having been delivered to date. The SA 341 multi-purpose 5-place turbine is now in production and VHI's first demonstrator will be delivered late this year. Most notable features of this advanced light helicopter are the anti-torque ducted fan submerged in the base of the vertical fin and the semi-articulated rotor head and plastic blades. This rotor is equipped with elastomeric lead-lag dampers which provide a spring-viscous effect resulting in a greatly simplified low-maintenance rotor head. Both of these features represent significant technological advancements helping make the helicopter a safer, more reliable, easier maintained aircraft.

The SA 330 Puma is an advanced transport with a 17 seat capacity in the passenger mode. It has been on a 3-month demonstration tour of the United States and is now available for delivery to commercial customers.

TABLE 1

Summary of Characteristics Vought Helicopter Incorporated Helicopters

	SA 318C Alouette II	SA 341 Gazelle	SA 316B Alouette III	SA 330 Puma
Engine Designation	Astazou II A Fixed Shaft	Astazou III N Fixed Shaft	Artouste III B Fixed Shaft	(2) Turmo IV B Free Turbine
Engine Max. Thermal HP	543	592	870	1,415 each
Max. Gross Weight, lb	3,650	3,750	4,850	14,110
Empty Weight, lb	1,990	1,907	2,470	7,720
Max. Useful Load, lb	1,660	1,843	2,380	6,390
Never-Exceed Velocity at Max. GW,SL,mph	127	192	130	175
Fast Cruise Velocity at Max. GW,SL,mph	112	158	114	165
Service Ceiling at 90% Max. GW, ft.	12,900	18,500	15,800	16,800
IGE Hover Ceiling at 90% Max. GW, ft.	8,550	14,500	12,800	13,500
OGE Hover Ceiling at 90% Max. GW, ft.	6,250	13,750	8,700	10,600
Rate of Climb at 90% Max. GW,SL, fpm	1,580	2,260	1,310	1,840
Maximum Range, SL, mi	430	403	292	384
Endurance, SL, hr.	5.3	3.75	3.0	2.95

One of the most important requirements of safe and efficient operation of helicopters in roles such as fire fighting is to ensure that weight and power limitations are observed while operating under varying altitudes and temperatures. The design philosophy of the VHI product line includes design for power margin to permit maintaining high power levels over high temperatures and altitudes. For example, the Artouste III B engine of the Alouette III has a thermal rating of 870 h.p. while at sea level standard conditions only 500 h.p. is required to hover at maximum gross weight. This permits maximum shaft horsepower to be obtained to temperatures above 100°F at sea level and to altitudes in excess of 16,000 feet under normal temperature lapse rate.

To assist the pilot in determining what his maximum weight limitations are at his destination, a simple circular slide-rule-type of computer is mounted on the instrument panel and surrounds the collective pitch indicator. By noting outside air temperature and pressure altitude the pilot can quickly determine, with the power computer, the maximum gross weight at which the atmospheric conditions at his destination will permit him to safely operate. Other information which the computer can yield includes density altitude, best cruise altitude, maximum permissible collective pitch setting, and actual gross weight (determined under hovering condition). Through the use of this simple computer safe and efficient operating conditions can be readily determined by the pilot.

Under development at VHI is a device for statically determining the actual weight and center-of-gravity of the loaded helicopter. This system, called "Safe-Weigh," consists of four load cells, electrical circuitry and visual indicators. Two of the load sensors are placed laterally and two longitudinally. Through the use of appropriate electrical circuitry and display the pilot can immediately determine his weight and center-of-gravity without performing the actual computations manually. In the type of operations conducted by the Forest Service while fire fighting this is especially important as tools and equipment of unknown weights are often loaded. The "Safe-Weigh" system has been tested in the laboratory and results indicate accuracies of 1 percent of full scale.

In summary, Vought Helicopter Incorporated has in its inventory light helicopters which possess capabilities for meeting helicopter requirements for fire fighting. In particular, the Alouette III, with its nearly 2,400-pound useful load capability, its high altitude and high temperature capabilities, and its operating simplicity, is ideally suited to meeting the present needs of forest fire fighting. VHI is continually developing means to improve the capabilities of the air vehicle and will work with the Fire Research Committee and Forestry officials in applying aerospace technology to improving the tools available for the fire-fighting problem.

Dr. Arnold: Thank you. This is becoming an international meeting. We have discussed the Chinese fire drill and now we have the French hook. Mr. Garrison.

Mr. Garrison (Bell Helicopter Company): We are located in Fort Worth, Texas. We market six different commercial helicopters. Three of these are our model series: the 47G5, 47G4A, and 47G3B2. The 47-series helicopters are economical, versatile, and rugged. This series helicopter is the most widely used commercial helicopter in the world. We first obtained a FAA certification on the model 47 series in 1947 and since then we have manufactured approximately 4,500. Half of these have been in the commercial field. The 47G5 is a 3-place machine with a national designated gross weight of 2,850 pounds.

Our standard configuration, weight empty, of the 47G5 is 1,712 pounds giving us a maximum useful load of 1,138 pounds and we have a maximum external hook load arrival of a thousand pounds. Maximum air speed on all three of these machines is 105 miles an hour, that is our V&E air speed. Our cruising speed on the 47G5 is 81 miles an hour at maximum continuous power and it has a range of 238 miles, and endurance of four hours. It is powered by the Lycoming VO-435 engine which has an engine rating of 265 horsepower and has a takeoff maximum continuous horsepower rating of 260 and 220 maximum continuous. The 47G4A, also a 3-place machine, has a maximum design gross weight of 2,950 pounds. Its standard configuration weight empty of 1,880 pounds gives us a maximum useful load of 1,070 pounds. It also has a capability of 1,000 pounds on the hook and has a cruise speed of 85 miles an hour and a range of 244 miles. The engine for the 47G4A is the Lycoming VO-540 model with a maximum continuous rating of 305 shaft horsepower. Installed, we derated to 280 horsepower for takeoff and 220 horsepower maximum continuous.

This gives, as pointed out earlier by several other people, altitude and hot-bay performance over and above the G5A.

Next, we have a 47G3B2 which is a turbo supercharged 435 engine and it is designed primarily for hot-bay and altitude operation. It has a gross weight 2,950 pounds. Our standard configuration weight empty of 1,937 gives it a maximum useful load of 1,013 pounds and its cruising speed is 81 miles an hour with a 239 mile range.

Next in order of size in the Bell produce line is the Jet Ranger. The Jet Ranger is a very popular helicopter as evidenced by the fact that some 2,000 are now in service throughout the world. Approximately half of those are commercial, which is particularly impressive since it has only been certified for the last five years. The Jet Ranger is powered by an Allison 250 turbine engine and has the following characteristics: Five-place machine, gross weight internally is 3,000 pounds and for external load it has an FAA approved weight of 3,350 pounds. Standard configuration weight empty is 1,4[illegible]0 pounds giving it a maximum internal useful load of 1,520 pounds a maximum useful load, including external and internal, of 1,870 pounds. Maximum air speed is 150 miles an hour and 131 miles per hour cruising speed. It has a range of 351 miles.

Recently, in the month of April this year, we certified what we call our Jet Ranger Two, which has the 250C20 Allison engine with rated takeoff power of 400, but we still flatrated the 317 horsepower in the Jet Ranger. This gives us very good altitude performance because it is a flatrated installation. The Jet Ranger makes an excellent ambulance configuration, as was shown by Chief Houts. He had the two litters inside. The advantage of carrying the litter patients inside is that there is no performance degradation and the ship can be converted rapidly from a 5-place machine to a 2-litter configuration with a medical attendant and a pilot. We will demonstrate this tomorrow afternoon.

Our next product line is the 205A1. This aircraft is rugged, dependable, and offers a tremendous utility capability. It is an outgrowth of the famous Bell Huey series of which close to 10,000 have been manufactured. The 205A1 is a 15-place vehicle, has a gross weight internally of 9,500 pounds, external gross weight approved is 10,500 pounds. Standard configuration weight empty is 5,197 pounds giving it a maximum internal useful load of 4,300 pounds, with maximum useful load, including hook capabilities, of 5,303 pounds. Maximum air speed is 138 miles an hour and it has a range of 311 miles. It is powered by the T5313A Lycoming gas turbine engine which has a takeoff rating of 1,400 horsepower with maximum continuous rating of 1,250. It is derated in our installation to 1,250 horsepower and 1,100 maximum continuous. We have designed a fire-fighting kit to go with this series helicopter; this kit carries a light water solution in the fuselage. It can carry up to 100 gallons depending on the configuration of the tank. You can start with the 25-gallon capability in 25-gallon increments to 100 gallons, and the boom is 9 feet long, stores alongside of the helicopter and it can extend to 16 feet. It can be positioned straight forward, or at about 90 degrees. The design and intent are, of course, for crash rescue, and it was designed to cut a 15-feet-wide, 40-feet-long swath into a crashed or burning vehicle and allow evacuation of the occupants.

Next-in-order of our product line and the last one that I will tell you about, is a Bell Model 212. This ship was certified by the FAA last October. It is powered by the Pratt and Whitney PT6T3 twin-pack engine. Each engine develops 900 horsepower takeoff and 800 horsepower maximum continuous. Some of the other characteristics of this machine are that it is a 15-place, has a maximum gross weight internal of 10,000 pounds, maximum gross weight external of 10,500 pounds. Standard configuration weight-empty is roughly 6,000 pounds, giving it a maximum useful load internal of 4,000 pounds and a maximum continuous load external of 4,500 pounds. Maximum air speed is 150 miles an hour and it has a 300 mile range.

In closing, I would like to advance a thought about rooftop heliports, and I have copies of a paper that describes the rescue of some 43 persons from a burning building ' Mexico. In this age of high-rise office and apartment buildings, the .se of a rooftop heliport will greatly improve the chances of evacuation of people who might be trapped on the roof from any kind of a disaster, such as explosion or fire.

DISCUSSION

Mr. Huffman: Aerospace Corporation is not in the helicopter business. We primarily do technical management for the Air Force and Space and Missile programs. I have been working with Dr. Arnold and Mr. Barrows and others on the sort of technology in the defense industry that might be brought to bear on the Forest Service and its fire problems. I would like to ask the audience what they might like to see in the area of new developments in the next five to ten years. Mr. Shields has raised the point of getting away from purely personnel transport to a helicopter that is less modular and adaptable to many missions. I would like to ask the fire chiefs what they would like to see come from the various helicopter companies in the next five years.

Chief Houts: I think Mr. Shields' comments about the modular type of helicopter are very fitting. I think that the feature we are going to have to think about is transporting pumping equipment tanks, unit loads that we can take in and drop, and things of this sort. The units that I showed earlier with the tank and the pump are satisfactory but they can be updated. We have not been able to do it as yet. Your increased capacity and drop tanks will require new internal configuration too.

Mr. Huffman: From a fire program standpoint, how high a payload or capacity would you like to see helicopters make available?

Mr. Hill: Our standard pumper is 20,000 pounds, how about that? What we would like is to have a helicopter deliver the standard pumper anywhere in the city. I certainly see this in the future and probably not-too-distant future. I think all of us in the fire service are faced with city budgets; our write-up to the maximum taxable income and gross in the future looks pretty good and we should be thinking along those lines. Our operations are much like the military operations - you never know where the enemy is going to decide to fight you, and we never know where the enemy is going to break out with a fire, and our problem is that about 90 percent of our operation is concerned with small fires and we need only first-aid-type operation. So, small lightly manned units could be scattered throughout the city. The other 10 percent of the fires require a larger number of men and heavier equipment. This would be a much better way to fight even if we had to go to such things as flying cranes which is expensive, but still not as expensive as what we have now. For example, I have $22 million worth of rolling stock in the city today to deliver pumping capacity to any one of some 65 square miles. Chief Houts pointed out that he has some 2,200 square miles. So moving large numbers of men and large pieces of equipment is not too far around the corner, and it should be available so that we can do a better job and really do it for less money.

Mr. Huffman: If I interpret you correctly, this helicopter operation is not generally used in fighting fires in buildings or homes. What you seem to suggest, in effect, is that you should take the wheels and engines out of your fire trucks and substitute a new motive power that will reduce the time of response. Where you run into the ever-increasing traffic problem in urban areas for ground vehicles, my impression is that eventually we will not be able to rely on ground transportation for fire equipment.

Dr. Christian (Underwriters' Laboratories, Inc., Chicago, Illinois): I would like to comment on the dialogue between the fire chiefs and the helicopter manufacturers. What is needed is to find a common ground. You speak of 20,000 pounds; you should ask how much this could be reduced and yet have desired delivery. The helicopter will always be an expensive way of lifting heavy loads but it gives extra speed and maneuverability. For example, could you redesign the pump to cut the weight down?

Mr. Garrison: That is a good point. Any time you talk about weight, you must tie it to the kind of capability you want. Do you wish to be able to hover out of ground effect, say, at 4,000 feet at 95 degrees, which is standard hovering out of ground effect category with 6,000 pounds with 8,000 pounds, or 10,000 pounds. When you talk about payload, you must tie it to an atmospheric and temperature condition also, as far as the manufacturer is concerned.

Question from the audience: Is anyone planning to design a helicopter that can be utilized for fire emergency?

Answer: We are looking at all kinds of marketing areas and products, but I cannot say that we have a specific design aimed at this particular market area. You are looking at things five years from now and we are doing the same, but we are still thinking in terms of utility category, of designing a machine for multi-purpose use which we think would be essential to a fire department. As I understand the operation of most fire departments, they feel that the utility capability is essential to their successful operation.

Dr. Arnold: We are looking for something that can be utilized specifically for our purposes, which means that you will incorporate a certain number of utilities features. I think it would be very important if you designed a vehicle that could be utilized just like a fire truck. One that could be used for an aircraft fire at an airport, or a brush fire of 30,000 acres.

Mr. Clougherty (National Bureau of Standards, Washington, D.C.): What is the feasibility of this cable setup that you have below the helicopter?

Mr. Hill: We are talking about high-rise structures now. Fires come out the windows at the lower levels where they can be handled. But with the high-rise, we are going to get some fires not at lower levels and we cannot handle them from outside. They are beyond the reach of aerialized snorkels, and you can forget them as far as outside fire fighting is concerned.

Mr. Clougherty: What would be the feasibility of going back to a roof deal of hanging a hose staging as such?

Mr. Hill: It would be feasible. The roofs would have a waterline or standby line up there. We would have to get water there and possibly the hose there. But the question is how do we get down the face of the building? Many times you have a bad time getting in from the stairways, particularly if it is one large area. We do not have access to outside fire fighting at the present time because you cannot go beyond 10 stories. We need some kind of arrangement whereby we slide down the front of that building from the roof; some way to put manpower down. This would be a way of getting water on the fire on a 20th story, which is impossible today.

Mr. Chandler: I have a question with regard to the 25-gallon modular unit. What are you putting out of that? That is on liquid fuel fires, evidently.

Answer: FC194 6 percent light water solution.

Mr. Chandler: How long will 100 gallons hold a path open? With our experience on gallonage on forest fires, it would not last very long.

Answer: The 50 gallon size held open in excess of 5 minutes.

Mr. Shields: I would like to get back to talking about performance. There are two ways to get better performance out of helicopters. One is to supercharge engines so that you get the same power at altitude and the second is to put a great big engine in with a lot of power. What limits these things is the transmission rotor system. They can put only so much horsepower through, so at sea level they can only use part of the horsepower. The question we need to address to the manufacturers is "are you developing a new transmission and rotor system?" because this is the heart of the helicopter. You can come out with all the new models you want using the 47 rotor system and the 204B rotor system, but are you really looking ahead to matching the turbines that we are getting in the future? I think really the engine manufacturers are ahead of us and we are not able to utilize all this horsepower. Am I asking you a fair question?

Mr. Garrison: The answer to your question is "yes" and I am sure it is true of all helicopter manufacturers. We are looking at operating our transmissions, and we are looking at different kinds of rotor systems. We are looking at 4-blade rotor systems, even though Bell Helicopter has been basically a 2-blade company. We have always made 2-bladed rotor systems and semi-articulated rotor systems and we like them and we believe in them, but we are looking at other systems too. We are looking at the 1055 engine installation. You may have heard that. The 1055 has a capability of somewhere around 7,000 pounds on the hook and it is used to pull a 200 horsepower transmission.

Chief Swindle (Fire Department, Birmingham, Alabama): We do not have any helicopters that belong to the City of Birmingham but in the City, the Federal government has a lot. There are six cranes on our airport three miles from the downtown section. They belong to the Air National Guard. Unfortunately, they are not manned 24 hours or we would use them more. But we do have facilities when the pilots are there and we are in the process of trying to find some way to use these flying cranes whenever they are needed.

Question from audience: What about pop-out floats?

Mr. Garrison: I am not all that familiar with the pop-out floats in operation. I have only seen sketches. There are specialists in materials working on this problem. We are quite interested in this because we recognize the requirement for landing on water and I think that with a lighter system, pop-out floats are fine, but the weight of the system is such that it would not be competitive with a lightweight material that is streamlined that will serve the purpose of landing both on land and on water.

Questioner: I was thinking in particular of landing on brush or trees or something other than pavement. In other words, operation in the woods.

Mr. Garrison: There you have to have some kind of material to beef up the underside. One of the things we are working on that I think would be of interest to you is what we call our emergency flotation kit for our Model 212 which is a lighter float system. It would not be designed for continuous operation off the water but in the event you were forced down you would pop them and they would keep the aircraft afloat and upright.

Dr. Arnold: We've been concerned right along with safety with all the rules of operations. We saw on the forest service fire last summer a need to set up some emergency FAA control operations, so that the next subject is quite appropriate for continuation at this point. We have looked at fires, we have looked at helicopters, now let's look at heliports and FAA rules. Eric Thorsell of the FAA in Washington is here to present this to us.

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HELICOPTER FLIGHT RESTRICTION AND FIRE SERVICE OPERATIONS

Eric R. Thorsell

Federal Aviation Administration, Washington, D.C.

I have been asked to discuss the restriction imposed on helicopter flights over congested areas and the use of this type aircraft in fire service operations.

The major functions of the Federal Aviation Administration (FAA) are to encourage and foster development of civil aeronautics and to promote safety in air commerce. Accordingly, the FAA has developed Federal Aviation Regulations (FAR) in accordance with the Federal Aviation Act of 1958. As we are particularly concerned with helicopter operations, I believe we can limit this discussion to FAR Parts 91 and 135 which establish flight limitations.

FAR 91, paragraph 79 states: Except when necessary for takeoff or landing, no person may operate an aircraft below the following altitudes:

Anywhere. An altitude allowing, if a power unit fails, an emergency landing without undue hazard to persons or property on the surface.

Over congested areas. Over any congested area of a city, town or settlement or over any open air assembly of persons, an altitude of 1,000 feet above the highest obstacle within a horizontal radius of 2,000 feet of the aircraft.

Over other than congested areas. An altitude of 500 feet above the surface except over open water or sparsely populated areas. In that case the aircraft may not be operated closer than 500 feet to any person, vessel, vehicle, or structure.

Helicopters. Helicopters may be operated at less than the minimums prescribed in over congested areas and over other than congested areas paragraphs, if the operation is conducted without hazard to persons or property on the surface. In addition, each person operating a helicopter shall comply with routes or altitudes specifically prescribed for helicopters by the Administrator.

Paragraphs 89 of FAR 135 Helicopter Operations: Emergency Landing Areas.

> No person may operate a helicopter unless areas are available which allow an emergency landing to be made

without undue hazard to passengers or to persons or property on the surface. For the purpose of this section, areas such as school yards, parking lots, recreation areas, highways, shopping centers, and public docks are not considered available for possible emergency use when they are occupied by persons or vehicles, unless there are unoccupied parts thereof that are large enough to allow a landing without that hazard.

These two paragraphs cover the major operational limitations placed on helicopter operations by the FAA. Local political subdivisions may have other self-imposed restrictions. Therefore, it would be advisable to determine if any local laws exist which may affect helicopter operations, and if these are applicable to emergency operations.

The history of vertical takeoff and landing aircraft shows that as early as 1907 brief hops were being made by this type aircraft. However, not until 1923 when the autogiro was produced did rotation-wing aircraft prove practical. This was the half-way mark to a truly vertical takeoff and landing type aircraft. In 1939, the first successful helicopter was produced. However, it was not until 1943 that the military services developed the first practical unit, and placed it in operation.

The CAA, predecessor to the FAA, certificated civilian helicopters in 1946 and they immediately found their way into a wide range of uses. Helicopter operations have expanded rapidly since that time, and a large part of this activity is performed by commercial operators. The versatility of the helicopter has resulted in an impressive list of activities. Some of these are:

1. The helicopter is now used in traffic control and crime abatement activities in more than 50 cities.

2. The helicopter ambulance has become an integral part of the emergency medical system in many metropolitan areas.

3. The U.S. Coast Guard, police, fire, commercial operators, and the military services have proved the value of the helicopter in search and rescue operations innumerable times on both land and at sea.

4. In times of natural disasters, such as floods and snowstorms, the helicopter is often the only vehicle capable of rescue work and alleviating many critical situations.

5. Time-conscious firms are turning more and more to the helicopter for intra-city transportation of its executives and also for its own operations; e.g., real estate firms and banking institutions have recently discovered the benefits of helicopters in aerial survey work.

6. State and Federal Forest Services use the helicopter for fire fighting, reseeding, and spraying. The U.S. Forest Service maintains approximately 300 permanent heliports and 10,000 emergency landing areas.

7. The helicopter provides effective application services to control insect and weed pests in farming, industrial, and community activities.

8. The petroleum industry for years has operated helicopters in connection with its offshore site activities. In some areas, the helicopter is the only practical means for oil and mineral exploration.

9. The hoisting and placement of power poles, high-voltage powerlines, and pipelines by helicopters is now commonplace. The helicopter is also used for line patrol.

10. At present, scheduled helicopter service exists in four major cities of the U.S. - Los Angeles, San Francisco, New York, and Chicago. Passenger transportation is also being provided by helicopter air taxi operators in many cities and towns throughout the country on a charter or contract basis.

Undoubtedly, its use in rescue operation which consists of either removing persons from or delivering emergency material or personnel to the site of an accident inaccessible to other modes of transportation or where speed is vital is where its performance is most impressive. In this connection, consider the transportation of fire fighters, fire extinguishing materials or both to the fire grounds. During these latter operations, it was observed that the helicopter rotor downthrust appeared to benefit the ground fire-fighting activities relating to aircraft fuel spills or pool fires. To develop factual data relative to these phenomena the FAA initiated a test program (Figure 1) at National Aviation Facilities Experimental Center (NAFEC), Atlantic City, New Jersey, to determine among other items:

1. The extent, if any, and how the downwash from helicopter rotors could extend the escape time and survival time for occupants of a large transport type aircraft (Figure 2).

2. The ability of the helicopters and ground fire-fighting equipment can be used jointly to extend escape time and survival time for occupants of a larger transport-type aircraft.

3. The ability of the helicopter to establish and maintain a safe rescue path.

4. The ability of the helicopter and ground fire-fighting equipment to jointly establish and maintain a safe rescue path when varying rates of application of fire extinguishing agent are applied.

The results of the tests conducted in this program are contained in FAA published <u>Report No. RD 65-50 Post Crash Fire-Fighting</u>

FIGURE 1. FAA crash fire tests.

FIGURE 2. Helicopter approaching crash site.

Studies on Transport Category Aircraft dated May 1965. This report concluded in part that:

1. Helicopter downwash can be of assistance when a crashed transport aircraft is exposed to fire solely on one side and the wind is parallel to the fuselage; however, it can be detrimental if fire exists on both sides or on either side when the wind is perpendicular to the fuselage (Figure 3).

2. A helicopter and water/foam trucks working jointly can extend escape time for a crashed transport aircraft exposed to fire solely on its upwind side. However, downwash can have adverse effects on ground fire-fighting operations.

3. The helicopter was unable to cut a rescue path through flames from a completely fuel-wetted area.

The detrimental effect of the helicopter downwash referred to above results from ground debris being picked up and blown against the fire fighter, and difficulties fire fighters have in maneuvering and directing foam streams when working under helicopters.

In January 1969, NAFEC conducted another series of tests using a military fire suppression kit and helicopter on a fire surrounding a single engine tactical type F-86 aircraft. From these tests it was concluded that:

1. The helicopter rotor wash had a tendency to increase the air temperature and to decrease the heat flux since approximately 60 percent of the total destructive thermal energy of a free burning pool

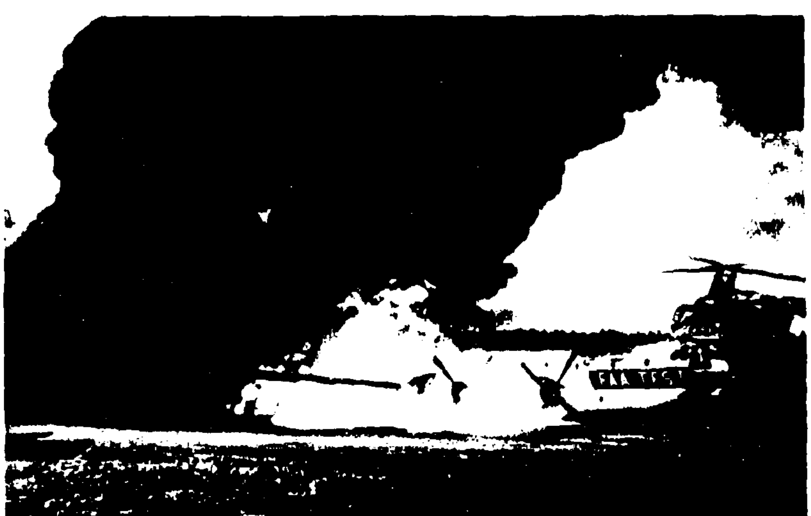

FIGURE 3. Rotor downwash holds flames away from exits.

fire is caused by radiation from the fire plume, considerable advantage may be gained in rapid fire suppression by controlled use of rotor wash.

2. The most effective use of helicopters rotor downwash existed when the fire rescue path was 25 to 30 feet in width.

We find in most tests that as long as we can maintain the integrity of the fuselage, we can keep the temperature in the fuselage below 200 degrees, which is livable. In one instance, the fire was small when it first started and we were able to keep the fire away from the side of the fuselage and we did not get a burn through or disintegration. Once the fuselage disintegrated, the temperature went to 1,800 degrees in about 8 seconds. So the life survival factor after the burned through fuselage was about 8 seconds. We have pretty well substantiated that it does not even have to be right under the fuselage. If the fuselage is downwind of the fire and is in the fire plume it will burn through in about 40 to 45 seconds, even a rather small fire, not necessarily a conflagration.

Dr. Arnold: Communications are essential and here we have Assistant Chief Neil McCullom, again from the city of Los Angeles, and I know that he is going to have some very detailed information, cautions, and necessities pertaining to communications.

COMMUNICATIONS ARE ESSENTIAL

Neil R. McCullom

Assistant Chief Los Angeles City Fire Department

One of the most significant forward steps ever taken by the fire service was the implementation of radio as a means of communication for use by control centers and for on-scene operations. It has provided a control capability that has made it possible to obtain maximum deployment and flexibility from our forces.

However, with this capability and the constant increase in fire-service-related incidents, has come the problem of excessive radio traffic. This problem is further complicated by the difficulties encountered when an attempt is made to obtain additional radio frequencies, not to mention the cost of implementing such frequencies. Another problem that is being faced is the present increase in multi-agency operations and the need for a common or mutual-aid frequency.

On the Los Angeles City Fire Department we, like most other organizations, preplan the solutions to our problems whenever possible. In connection with our radio system we have recently adopted a 20-year master plan. At the present time our system consists of four tactical or operating frequencies, one command frequency, one service frequency, and one rescue ambulance frequency. The master plan provides for the following on an incremental basis, with Phases II and III to be implemented as radio traffic warrants.

FIRE-FIGHTING EQUIPMENT

Phase I (To become operational at time of change over to our new Command and Control System)

First Line Equipment

A. One control channel.
B. Three tactical channels.
C. Status entry device for vehicular reporting of status.
D. Device for signaling the Control Center.
E. Aircraft and Marine radios where required.

Chief's Vehicles

The following will be provided in addition to the above:
A. One command channel.
B. One service channel.

Service Vehicles

A. One service channel.
B. Device for signaling the Control Center.

Command and Control Center

A. At each console transmit-receive capability on all LAFD channels. The use of a transmitter at any specific site will not preclude the use of other transmitters on other channels at the same site. Nor will receivers, other than those tuned to the same channel, be affected.
B. At selected consoles the capability to transmit and/or receive on frequencies of other jurisdictions.
C. Provision for receipt of vehicles status reporting, radio channel signaling, and future addition of vehicular teleprinters.

Portable Radios

A. Control and tactical channels.
B. Command frequencies on all portable radios issued to Chief Officers.
C. Future portable radios to be multi-channel with four or more channels.

Mobile Command Post

Radio capability to be similiar to Command and Control Center.

Phase II

First Line Equipment and Chief's Vehicles

A. Prior to implementation of Phase II consideration will be given to moving the entire fire department radio system to UHF.
B. Provide one four frequency UHF radio and activate a second control channel and three new tactical channels. This will bring the number of control channels to two and the number of tactical channels to six.

Helicopters

Provide a closed circuit television system for helicopter to field command post and/or Command and Control Center.

Phase III

Ambulances

A. Device for vehicular teleprinters.
B. Equipment for vehicular patient monitoring.

OPERATIONAL PROCEDURES

Fire-fighting and ambulance equipment not assigned to an incident will have their radios switched to the control channel(s).

When a unit is dispatched to an incident, the Control Center will assign a tactical channel.

In the event of a major incident, the service channel may be commandeered for use as an additional command channel. Thus, a separate command channel and one or more tactical channels can be employed at a major fire while maintaining routine channel assignments for the balance of the City.

Helicopters in our Department are looked upon as another tool. They are being used more and more and their value is definitely recognized. The primary value from a command standpoint is their reconnaissance capability which permits more positive tactical planning. During the initial stages of simultaneous major incidents, a top command

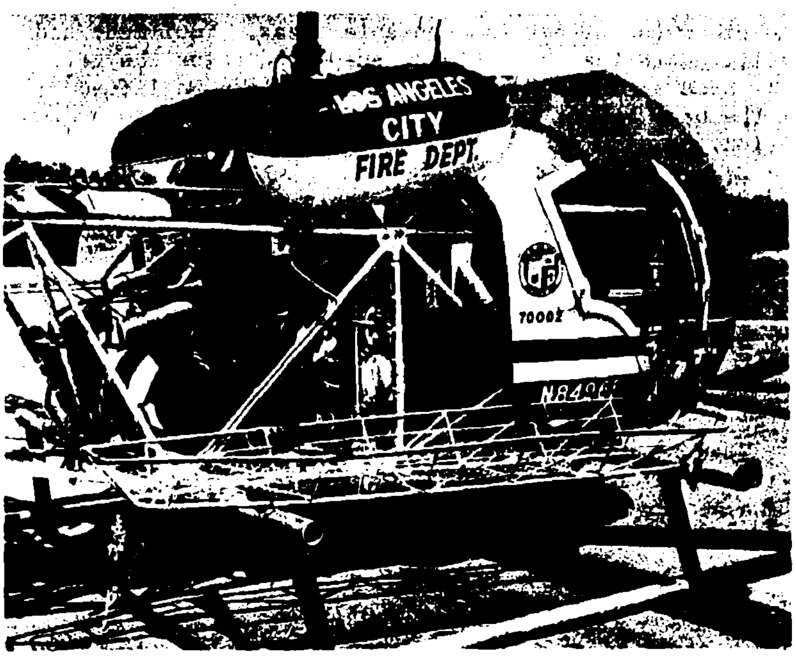

FIGURE 1. Modern fire-fighting equipment requires modern communications.

officer can supervise a number of such incidents by using a helicopter as an airborne command post. During these operations, it is essential for effective operations to assign each major incident a name, e.g., Laurel Canyon Fire, Verdugo Mountain Fire.

At the present time, we have five helicopters, two are the piston type and three the turbine type. They are used for a variety of operations, e.g., reconnaissance and command, rescue operations, water drops, personnel and equipment transportation, patrols and surveys, photographic missions.

All may be used for rescue work. The three jets are equipped with two internal litter kits. This arrangement allows room for the pilot, a medical attendant, and two patients inside the helicopter. The other two helicopters can be equipped with external litter baskets. Although this operation is less desirable from the patient's standpoint, it can be and is used very effectively in mountain operations where there is no adequate landing site available.

Frequently at brush fires our helicopters are used to make water drops, special tanks are temporarily attached for this purpose. Water drops can be very effective in slowing a fire's progress until ground crews can effect a containment. Generally, we do not try to attack the head of a large brush fire due to the relatively small volume of water carried. Instead we concentrate on the flanks of the fire and on spot fires.

At brush fires, access by personnel is somewhat restricted due to the terrain, making helicopters ideal tools for transporting men and equipment to otherwise almost inaccessable areas. Equipment and hose can be air lifted inside the cabin or suspended below the helicopter or, in the case of large amounts of hose, it can be lifted directly out of the hose bed of the fire apparatus and laid to a designated location.

During our brush fire season, which lasts sometimes as long as eight months, regular patrols are flown over mountain areas during daylight hours. The area patrolled is about 135 square miles. In addition to fires, pilots are on the alert for illegal traffic on fire roads. On numerous occasions fires have been completely extinguished or held in check by immediate water drops.

Recently our helicopters were used during a major fire in a high-rise building. The initial size-up was made from a helicopter at eye level at the 21st floor. Men, hose, and equipment, were lifted to the roof from an adjacent parking lot. Because of the potential of flying brands, one helicopter was used for patrol purposes; it sighted roof and lower floor fires which were exposures from the fire on the 21st floor.

Our helicopters are equipped with the same Fire Department radio capability as other first line fire equipment. In addition, they have a 360 channel aircraft radio plus provisions for the quick installation of portable radios with frequencies of other jurisdictions.

In order to provide needed redundancy each helicopter is equipped with two separate and complete Fire Department radios. Because of extensive maintenance problems with the original radios, we are now using motorcycle radios. These radios are not adversely affected by vibration. Additionally, the motorcycle radios are lighter in weight and are sufficiently smaller to permit the above mentioned dual radio installation.

Switching capability for all radio equipment in our helicopters is provided by a small (approximately 5" by 6") mixer panel. Due to being unable to purchase this panel at a reasonable cost, the Electronics Division of the Department of Public Utilities and Transportation designed and developed the panel in their own shop. This mixer panel is the heart of the helicopters' airborne radio system. It consists of two identical control panels, one for the pilot and one for the co-pilot or passenger. It meets the specialized needs of both the Fire and Police Departments while basically remaining the same unit, thereby providing interchangability. It provides a switching capability for the six LAFD radio channels, the aircraft radio, the public address system, and the cabin intercom. The switches are easy to read and to operate, they are well illuminated for night operations.

All of the aforementioned plans and operations are somewhat overshadowed by the computer supported Command and Control system which is being implemented for the Fire Department.

At the present time, we have three dispatch centers, each being responsible for a portion of the City. Under the new system, all three will be combined into a single control center which will be located in

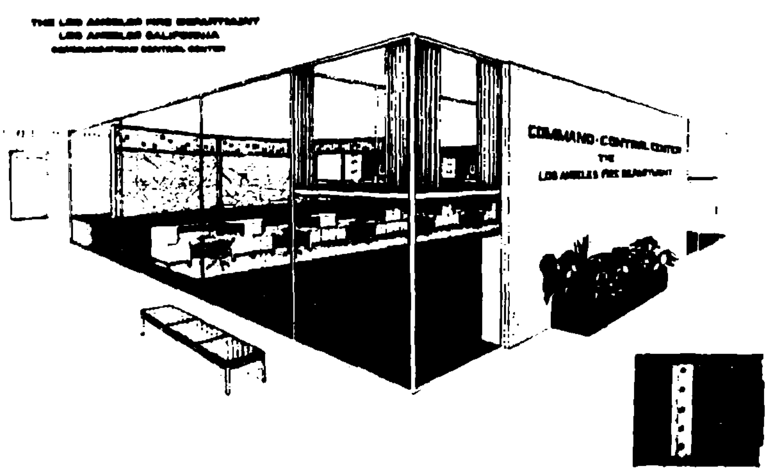

FIGURE 2. Artist's conception of Los Angeles County Fire Department command and control center. (Now under construction.)

a new City Hall annex presently under construction. The new center will be on the 4th and 5th sublevels in a blast-resistant area.

The basic objective of the C & C system will be to simplify and automate predetermined command and control procedures so as to minimize time, manpower, and probability of error in deploying fire forces. Thus within the constraints of required judgmental decisions, automation can be incorporated to a optimum degree.

The general features of the C & C system include:

A. Rapid access to operational data such as street index files and emergency procedures, to provide personnel with quick and accurate information.

B. Computer controlled displays which will augment a dispatcher's memory and obviate his need for personally maintaining the status of men and apparatus.

C. Automatic recording of C & C transactions in order to greatly simplify record keeping and to provide a ready source for operational and statistical data.

The major functions of the computer supported system that are needed to satisfy the above objectives are as follows:

A. Maintaining status of fire units.

B. Identification of appropriate alarm assignments.

C. Maintaining status of active incidents.

The C & C system designed for the Los Angeles City Fire Department is based upon the philosophy of single-point operation, that is, each dispatcher will have the capability of handling any incident from receipt of alarm until final disposition. A dispatcher will thus be able to receive emergency calls, dispatch appropriate assignments, update unit status files, and perform other C & C functions. All sources of operating information and all communication links will be instantly available to each dispatcher.

The single-point operation is provided by dispatch consoles containing an input keyboard, a cathode-ray-tube display, a microfilm unit, necessary communications switching, and other miscellaneous equipment.

The dispatcher will be able to exercise complete control over all functions and may alter or even eliminate any action proposed by the system.

Manual backup capability will be provided so that in no event will the dispatching capability of the Department be less than what it is under present operations.

In addition to the information available to the dispatcher through his console, basic status information will be instantaneously and continually displayed on a large wall mounted status board and map.

A mezzanine-type room is provided above and overlooking the C & C operations floor area, for daily use by the Division Commander. A fully equipped console is provided in this room. These facilities will be used by top command personnel during a major incident(s), for overall Departmental control.

Dr. Arnold: We have ranged from specifications and performance to heliports, from FAA rules to communications, and now we will hear about operation and safety problems which throughout the day have been a pervasive element. You will be extremely interested in the paper on this subject now to be presented by Mr. Alec Fergusson, President, Western Helicopters, Inc., Rialto, California.

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OPERATION AND SAFETY PROBLEMS

Alec Fergusson

President, Western Helicopters, Inc., Rialto, California

The commercial helicopter operator who elects to follow government contract work incidental to forest fire suppression, must be prepared and capable of handling a multitude of operational problems related to business administration. He will immediately be aware of terrific financial requirements. It will be necessary for him to arrange for much larger amounts of financing than is necessary in any other small business. These large amounts are made necessary basically, by the high initial costs of today's modern helicopters. I can assure you, that while I might think the helicopter is the greatest thing since Adam and Eve discovered sex, I also find that lending agencies lately appear to feel there must be something immoral about them, especially when you mention you need a few hundred thousand dollars to buy one. You will find that this problem is evident to every helicopter operator, both large and small. In addition to the large amounts of capital for fixed assets required, the operator will find that daily operating cash is always a problem. All costs, with the exception of labor, far exceed the financial requirement of other businesses with the same annual gross. In addition to the money problems so very characteristic to the helicopter business, the operator must be able to handle the day-to-day administration of a complex, technical, and even sometimes a traumatic business. One of the complex problems of operating helicopters, is acquiring the necessary insurance. This alone will be found to be a tiring and time-consuming problem. The market is limited, and it really appears few are interested in selling helicopter insurance. Most policies are typewritten and it takes a lot of study to find that despite the terrific premium, the London underwriter has left more open doors than you would believe so that he may get away from a loss. It might be interesting to note here that the financing and insuring of a new helicopter will average about 28% of its new cost each year. This fixed overhead cost would make it a complete and unacceptable expense in any other business. The operator who works with government contracts is faced with this cost. If the operator you contract with is not capable of realistically administrating a difficult type of business, he will not be capable of servicing a government contract successfully, and everyone ends up a loser, including the contracting agency.

Besides the administration problems, the operator must also determine what helicopter, make, size, and power he wishes to operate. In this particular case, he really does not have a wide choice, either of the make or manufacturer, or of the size or make of engine or turbine.

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It must be realized, that we have really only three American manufacturers of general commercial helicopters. While one has a fairly broad line, two really only have a single light turbine each to offer. With these light through medium and heavy American-made helicopters, there are only two makes of engines and turbines available. In addition to the American-made machines, there is one European manufacturer offering a light and a medium turbine powered unit. With the limited model and make of helicopters available, probably the determining factor most often applied by the operator, in determining his choice, is the specified helicopter required in the contract specifications he has elected to bid, but even that is contingent on his ability to acquire the necessary financing. Too often these specified machines do not prove to be the performers that the manufacturer's representative has led the specification writer to believe. There is no question the operator has to first determine the size of machine he can afford, and then he attempts to figure out, if there is a choice available, which one will best operate in his type of work for the most reasonable cost, only to find, often, it won't fit the specifications, so he ends up buying the other one so he may successfully get a contract award.

The helicopter operator soon finds that he has assumed a terrific annual fixed cost overhead, what with his payments and interest on his equipment and his terrific cost of insurance which is normally written on an annual basis. This, plus the fact that to have qualified personnel available, he must keep them on the payroll year around, he now must have some salesmanship. If he is going to be able to handle this overhead, he must, during non-fire season, develop some operating revenue, other than forestry, to give cash flow for this overhead. If he cannot sell or negotiate some revenue, he won't have dependable and capable personnel around to serve you next season. Those here who have had experience with helicopter contractors will agree with me that the majority of problems they have had with operators has been with those who only become active during fire season.

After the administration problems are handled, the commercial operator must become a superior personnel manager. He first must endeavor to obtain the very best of qualified pilots and mechanics. While the operator is certainly responsible for the overall hiring of all personnel, he must be particularly cognizant of hiring pilots. While that helicopter is in the air, THAT pilot not only will have the operators investment in his control, but, much more important, he could have YOUR life in his hands. That pilot selection must not be made because he is a friend of a friend, or because he has low time and will work cheap, or any other irresponsible reason, as then everyone could unfortunately suffer a terrible loss. No, when hiring pilots, he should hire those that have a proven background of experience in the type of helicopter flying the operator is engaged, or intends to be engaged in. This is especially true of forestry-type flying. The pilot that might have had a few thousand hours flying offshore, or in metropolitan areas, and yes those that have been flying in the lowlands of Viet Nam, are not worth a damn in the mountains. The twisting winds, heat, density altitude, dust, and difficult working conditions, are all conducive to making difficult problems. A pilot with experience can cope with and often avoid these problems. If such personnel with the necessary experience are not available, then the contractor must be prepared to stand the expense of training his own before they go out on contract. Today we have literally thousands of returning military veterans with a good solid base of flight training behind them. While they might have the experience of being shot at, very few have been concerned with "mountain flying" and its related problems. To their credit, the commercial helicopter operator, with some effort, can give them the additional experience, which will make them safe and competent pilots on forest fire operations. In handling pilots, after their employ, the operator must be firm, fair, and alert, ready to immediately correct the situation if he hears of, or observes any carelessness, show-off flying, lack of courtesy, and especially any obvious drinking problem.

When hiring the maintenance personnel for his helicopters, the operator must remember that while the pilot in the air is responsible for the safety of the helicopter and passengers, if his mechanics are not experienced and qualified, they could cause as great a safety hazard to those passengers and helicopter, as a poor pilot might. The operator must discuss thoroughly the experience and background training of the mechanics he intends to hire, and must assure himself they have the qualifications to maintain the helicopters he is operating. In addition, they must have a current FAA A&P license, and be obviously interested and concerned in doing a good job. After hiring a mechanic, if the operator will take an interest in the work performance of the mechanic, during the first few weeks, it is not difficult to determine if he was a good choice. An operator with sufficient flying equipment that makes it possible to support a qualified maintenance supervisor, and provided he made a good selection when hiring that individual, can be relieved of considerable responsibility of his maintenance personnel. Good maintenance starts with good mechanics, but without the support of an operator who is prepared to pay fair wages, supply adequate and decent working facilities, and provide a wide range of special tools and equipment, these mechanics, no matter how good, cannot alone provide safe maintenance.

One of the next problems the helicopter operator finds, is that there is an endless need for special equipment. This includes cargo racks, cargo hooks and H frames, borate dropping bags, buckets and tanks, spraying equipment, seeding equipment, helicopter trailers, sling equipment hardware, portable radios, special intercomm equipment installed in helicopters to facilitate use of forestry radios, and external public address systems and sirens, as some examples. He also needs a considerable fleet of service trucks equipped with fuel tanks, pumps, filters, fire extinguishers, and field support tools. If he is going to operate large turbine equipment on forestry contracts, he will have to have a tank truck for jet fuel. Yet, unfortunately for the operator, forest fires don't burn adjacent to airports where fuel is available, and jet fuel is always a problem to find within a few hundred miles of the fire. If the contractor has not organized a fully supported field operation, he will not obtain the flight revenue he must maintain to service his fixed costs and necessary daily cash flow, and will not be supplying the quality of service the forest service needs. It also must be realized that a considerable amount of this equipment is usually only used a few months of the year, during fire season, and that the cost must be recovered in a relatively few fire seasons, as experience shows that new and better equipment is brought out often as greater knowledge is obtained from more use of helicopters in forest fire suppression.

Another operational problem for the helicopter operator engaged in forestry contracts, is that often he has to take contracts several hundred miles from home base. If he is successful with close to home contracts, he suddenly finds his equipment and crews are dispatched to a fire several hundred miles away. He must be able to support his operation under the most unlikely conditions, with support equipment and maintenance personnel even when it often moves around like a Barnum and Bailey circus. There is naturally increased daily costs when his personnel and equipment are required to be away from home base and he must have ready cash for these costs.

The most important aspect of this business is SAFETY and probably the first basic requirement in setting up a SAFE helicopter operation is to set down a company safety policy. All personnel look to the operator to give guidance on how his business is run, and I cannot think of any more important direction one could give than the one you give on safety to your flight and maintenance personnel. If you can instill in your pilots the philosophy that they are "professional pilots" while in your employ, and they were hired because they showed the ability and stability a professional has, and if they want to be a hero or stunt pilot they absolutely will not be around your company, I feel that that company is off to a good start on safety, insofar as their flight operations are concerned. With the maintenance personnel you have to show confidence in their opinions, but yet must impress them strongly that if there is any question about the air worthiness of a questioned part your orders are to replace it, despite the fact it might be a heavy cost. If management unreasonably tries to cut cost corners on maintenance, you can hardly blame a mechanic who does slipshod work just to speed it up. No, to allow poor maintenance will only lead to the financial collapse of an operation. To save a dollar and risk a life will never balance a ledger anywhere. The company management must impress flight and maintenance personnel daily that their company is interested in safe operations only, and the operator must personally see that safety policy is followed. We use the following short quote, author unknown, on all company forms personnel handle, and I quote, "THE AIR, TO EVEN GREATER EXTENT THAN THE SEA, IS TERRIBLY UNFORGIVING OF ANY CARELESSNESS, INCAPACITY, OR NEGLECT." My thanks to the unknown author who put so much in such a few words. I cannot think of a more appropriate saying for those engaged in air operations relative to fire suppression.

After setting down a firm safety policy, the operator must show his sincerity by supplying every item that can help make the helicopter operation safe. The first, and probably most important is to supply shoulder harness for the pilot, along with a modern crash helmet with electronics installed. We supply and maintain for each pilot a crash helmet, and shoulder harness for any type of flying with abnormal exposure. This includes forestry flying, and it is well understood that a pilot who does not use company-furnished safety equipment will not remain in our employ. We find that a professional pilot will use his harness and helmet without any question, and the pilot that does not is not the type we employ. In addition to hardware supplied pilots, ground crews are thoroughly instructed in safety insofar as their work goes. With support trucks, every fuel tank is equipped with adequate fuel filters, sump drains, and instructions are given constantly on their use and of daily service. Trucks are all equipped with adequate fire extinguishers, and portable radios are supplied on all external load work. Safety is the most important facet of the helicopter business and it takes daily alertness to changes necessary in safety policy. External sling load work is critiqued before and after job is done with both flight and ground crew present, and recommendations on safety are applied, taken from the comments of all concerned. With aerial application work, commonly called "spraying", only qualified personnel that have been trained in the specifics of application flying, and those trained in the handling of chemicals are used.

It can be assumed that a helicopter operation that has good business management will also have a safe operation, because without safety being a daily concern, no business will be successful, and without applying good business judgment, no operation can afford the equipment and personnel that make a safe operation.

Today I have tried to outline the administration, maintenance, and safety problems of the helicopter operator engaged in forest flying contract work. Certainly, in the interest of staying within the alloted time, I must have missed several, and amongst them would be the varying requirements of government agencies requesting contractors' services, whereby the service required is the same, but the specifications are written based on local preference and not necessarily good judgment.

The terrific increase by manufacturers in cost of spare parts, sometimes as much as 25-50% a year, the ever-changing local, State and Federal regulations, and the increase of taxes and fees would be just a few of the operational problems not covered here today.

DISCUSSION

Mr. Kerr (Office of Civil Defense, Washington, D.C.): Earlier this afternoon I heard a challenge, from the panel directed to the fire service, to state exactly what was required in the way of helicopter performance. Maybe we can do something towards responding in the course of the next months or a year. There may be barriers that I do not understand. For example, if a conclusion were reached that, in places where the topography is like that along the Eastern seaboard, the operational requirements could be serviced by a helicopter that need not go above 500 feet, in that case would there be enough market for the aircraft manufacturers to produce such a helicopter? Would it be feasible to make a chopper never to go above 500 feet that would cost one-tenth as much as one that had to go to 40,000 feet? Are there other simplified performance requirements of that type that could be accepted by the fire service in areas where the geography is favorable? We heard about mountain helicopters; a great part of the U.S. does not need mountain helicopters.

Mr. Domanovsky: That is an interesting point. There are a lot of helicopters that operate over water. A very large percentage of the commercial helicopters in the U.S. do. While we have not all the facts, I think we would be interested in knowing what the potential market would be for something like Mr. Kerr describes. It is technically feasible certainly, and it would be a lower cost helicopter if we did not have to compromise for altitude performance. From a manufacturing standpoint, I think it can be done. Mr. Kerr, we certainly will look for an output from your committee to get to the industry.

Dr. Emmons (Harvard University): My question may be partly in the nature of a statement directed to people in the industry. I think perhaps it has come to light that a specific answer to their question "what do the fire services need and want in the helicopter?" might be in this direction. I think Chief McCullom pinpointed one need when he said there were problems when parts of the urban area were isolated because of traffic, meaning that you could not get ground forces to the scene of a fire. Another area that is quite obvious is fighting fires in rural isolated areas. To me this indicates that perhaps the industry should be looking for a self-contained single unit capable of bringing in a hard core of men, maybe four of five men with equipment and with water, self-contained to the extent that they could cope with some kind of a fire situation. Maybe not a large one, but at least the striking force that may never be supported by ground forces, simply because they are too far away or they are not able to get to the scene because of traffic. We have isolated areas that may be 50 or 60 miles away from the fire department. A very limited capability. There is a great need for helicopter potential that can come in and make a strike with this type of capability.

Mr. Suggs (Petroleum Helicopters, Inc., New Orleans, Louisiana): I just saw a helicopter the other day in Paris, with 42 ton load capacity. Unfortunately, it is Russian. Our technology is adequate to keep up with them. We had one ourselves in Mill Ten in Louisiana that lifted 44,000 pounds. You tell us what you want and we can make it. You are not going to get a helicopter for one-tenth of what it costs. You are lucky next year if you get it for double what it costs now. Military has quit producing and we are in bad shape.

Lt. Lansdowne (Fire Department, Madison, Wisconsin): I would like to address myself to a problem mentioned earlier - this seemingly illegal flying of the helicopter pilots. I believe Lt. Tannehill might discuss this.

Lt. Tannehill: We have a waiver from the FAA in Chicago that allows us to do low flying and land at any area we so desire as an emergency vehicle. With this low waiver flying it nullifies our million dollar policy for public liability. So we are looking at it again this year before we sign the waiver.

SESSION III

Chairman - Merle S. Lowden

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Dr. Arnold: The chairman this morning needs no introduction to anyone in this group. A great change in fire in the U.S. has taken place with the retirement of Merle Lowden who has directed one of the larger fire departments, and I think it is safe to say that Merle did retire in a blaze of glory during the past year. Is that what we would have called the lightning bust in Oregon and Washington last year? Merle, we are glad you did take your valuable time to come and chair this closing session for us.

Mr. Lowden: We had a lot of preliminary preparation for today. I think that yesterday's program gave us a good background. Today we are going to get down to actually doing the job. To start off our morning program, our first speaker directs one of the large air operations in the country. I think without question it is his state that carries on the greatest operation in air operations in controlling fires and being involved with fire work. He has been with the state of California for 24 years, has had his present job as Deputy State Forester for eight years, and has had a world of experience. I have known him a long time and worked closely with him. I am very happy to present John Hastings, Deputy State Forester of California.

INTEGRATING AIR ATTACK WITH FIRE-FIGHTING STRATEGY

John S. Hastings

California Division of Forestry, Sacramento, California

A wildland fire protection system depends upon three lines of defense. The first is prevention of as many fires as possible from starting by controlling the sources of ignition and manipulating the fuels in which ignitions occur. The second is quick control of any fires while they are still small. Third is holding to a minimum the damage and cost of runaway fires that develop in spite of these provisions.

To accomplish the foregoing, in California, the State Forester's Fire Protection Plan provides a "basic fire protection" system that seeks a balance of prevention, detection, and ground and air attack forces supported by a program of risk and hazard reduction and the construction of fire defense improvements of "built-in" fire protection.

The Division of Forestry's wildland fire control system is composed of nine elements. These are detection; dispatch and communications; ground attack; air attack; fire defense improvements; mutual and

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outside aid; research; training; and support services. In my judgment, these are not substantially different from those composing a municipal fire control system (Figure 1).

Detection utilizes fixed lookouts, aircraft, local citizens, and mobile ground patrols to detect and report all wildfires promptly enough to permit control while they are small.

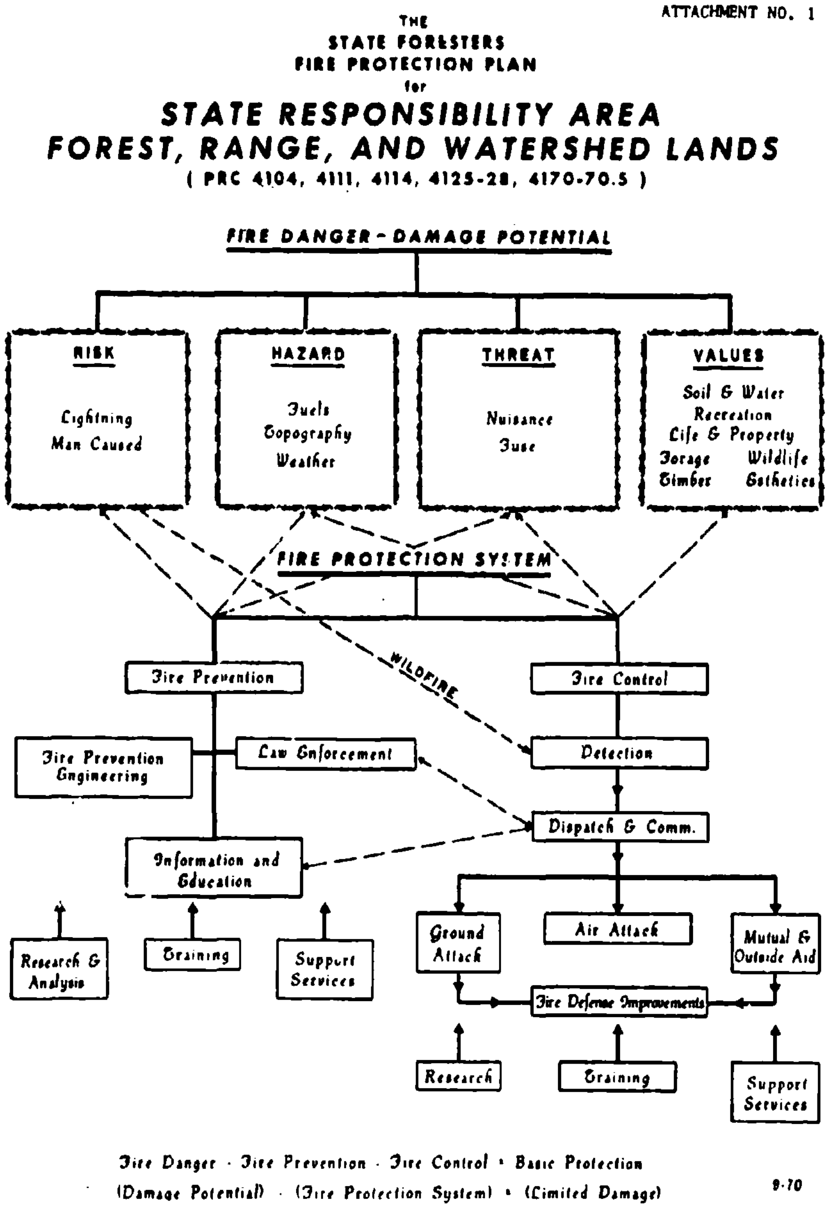

FIGURE 1. State Foresters Fire Protection Plan for state responsibility area, forest, range, and watershed lands.

Dispatch and Communications utilizes a variety of communications media to receive, interpret, and identify alarms and to allocate and dispatch fire-fighting units to respond. In addition, this element provides a network for emergency and non-emergency communications between the various administrative levels and units of the organization, and a fire-ground communications system.

Ground Attack is the use of ground mobile units, fire pumper crews, bulldozer-transport crews, and hand-tool crews, for the control of wildland fires.

Air Attack is the use of air mobile equipment, light aircraft, fixed-wing airtankers, and helicopters in the control of wildland fires.

Fire Defense Improvements are units of "built-in" fire protection - fire access roads, trails, heliports, helispots, fuelbreaks, firebreaks, water cisterns, and safety islands - constructed as a part of fire control preparedness, to break up large expanses of flammable fuels through land and fuel treatment. (The intent here can be compared to the efforts of municipal fire protection services for "compartmentation" to minimize fire spread.)

Mutual and Outside Aid recognizes that no one agency can afford to plan and support an organization to meet the maximum situation and that all efforts must be taken to insure that, when needed, available local resources and cooperators will be available and can be utilized.

Research and Training are self-explanatory.

Support Services includes personnel to meet clerical, fiscal and management services needs; procurement and supply; engineering, maintenance and construction of improvements; mobile equipment management; and cooking and feeding.

Strategy has been defined as generalship, or the science of planning and directing large-scale operations and of maneuvering forces into the most advantageous position prior to actual engagement with the fire. It is the decision of what can be done relative to the fire control problem as influenced by weather, terrain, available control points (such as fire defense improvements), fuel types, forces available, logistics problems, and values and threats involved. It is the broad plan of fire suppression action conceived by the Fire Boss to meet organizational control objectives.

Tactics is the science of arranging and maneuvering personnel and equipment in action with the fire. It is the action, the application of men and equipment in fire suppression action to effect the strategic plan.

The strategy and tactics of wildland fire control require the planned, skillful coordination and integration of ground and air attack forces - including mutual and outside aid and the use of fire defense improvements - to suppress wildland fires by perimeter control or the construction of "fire line" by hand crews, fire pumper crews, bulldozers, airtankers, or helicopters (Figure 2).

Wildland perimeter fire control or line construction involves "breaking the fire triangle" of heat, oxygen and fuel, by cooling, by smothering, by fuel removal or breaking the "combustion chain" with fire retardant chemicals. The foregoing is accomplished by men and equipment using either direct attack or indirect attack tactics, establishing the fire perimeter at either the burning edge of the fire, near to it, or a considerable distance away, with the objective of establishing cleared breaks or lines that completely encircle the fire with all of the fuel inside of the breaks or lines burned out, or otherwise rendered "dead out." Direct attack involves working at or near the fire edge using the tactics of hot spotting, cold trailing, burning out, scratch line construction, line construction parallel to, but near the fire perimeter, or application of water or chemicals directly to the fire's perimeter. Indirect attack intends retreating to some distance from the burning perimeter, utilizing points of topographic convenience, roads, breaks in fuel continuity, fire defense improvements, or other fire barriers - natural or constructed - from which backfires can be set or the fire successfully held by men and equipment established at those points. Good strategy may require both direct and indirect attack measures along the fire edge at the same time.

Air attack, through its versatility, speed, and mobility, has a unique capability to place water, chemicals, and personnel at the initiating fire for first attack in advance of ground mobile forces; and, after arrival of ground mobile units, to continue to support their direct or indirect attack efforts. Although air attack and ground attack are integrated and correlated, air attack is considered generally to be supplemental to and in support of ground attack because of flight

FIGURE 2. Strategy and tactics of wildland fire control require planned coordination and integration of ground and air attack forces.

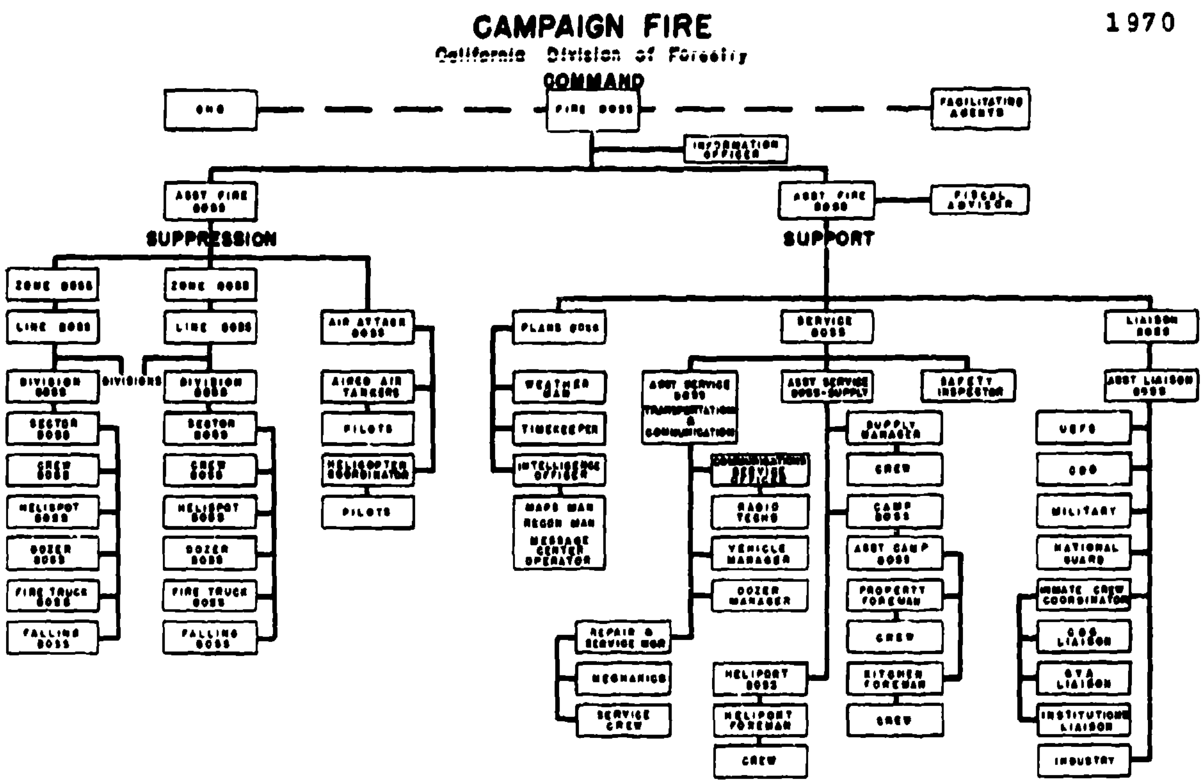

FIGURE 3. Campaign Fire - California Division of Forestry.

limitations during periods of darkness, low visibility, high winds, and the smoke and turbulence of large fires. Air attack permits fire control personnel to use tactics previously not possible and a more rapid adjustment to changing fire situations. This is particularly applicable to the rapidly spreading fire situation where there is great need for the flexibility and mobility which aircraft can provide.

It is most necessary that air attack operations be closely coordinated with those of the ground attack forces. Effective coordination is dependent upon an adequate system of communications and established channels of command and responsibilities which tie the air attack to the ground attack organization for a coordinated effort (Figure 3).

Airtankers and helicopters may be used in many ways on a single fire, but their use must be coordinated with an established chain of command, to provide the right tool at the right time and to insure a safe air attack operation. Pilots should know, when dispatched, who has aircraft control at the fire, and aircraft control should establish the most suitable patterns and coordination for aircraft separation.

Because of their speed, airtankers can frequently arrive at initiating wildfires in advance of ground forces. Thus, it is quite important that airtanker pilots be trained in fire control techniques and fire behavior. Since experience has shown that airtankers are most effective on wildland fires while still small, airtankers are dispatched as rapidly as fire trucks and other forces. Airtankers can frequently retard the spread of an initiating fire until ground forces can arrive. In many places they can accomplish successful first attack where it would be impossible to take action with ground forces because of a lack of access or because of safety for men and equipment. By effective drop techniques, airtankers can sometimes entirely contain a small fire, dependent upon types of fuel and fire intensity. If there is a series of separate fire starts occurring almost simultaneously in the same general area, airtankers can normally be more profitably used on the small and isolated fires. In California, we have adopted a policy of diverting airtankers from going fires to take first action on new fire starts in recognition of their effective efforts on small fires.

After first attack, airtankers can be most effective working in close support of the direct attack efforts of hand tool crews, fire trucks, and bulldozers, as they attack the flanks or head of the fire. Airtankers can cool the fire head or hot spots to permit effective action by ground forces; can take action on spot fires when it is not safe to put ground forces into the area; can strengthen existing fire lines with retardant materials; and can orbit and reconnoiter for and take action on slopovers or spot fires. Airtanker action to cool the head of the fire and any hot spots, serves to reduce the spread by spotting.

When fires are spreading rapidly and the control effort is fluid, care must be exercised to avoid independent action being taken by aerial forces because of their greater mobility. This is evidenced by the number of retardant drops that have been made on a "head" only to be "out flanked" due to the lack of an "anchor point." The closer the application of retardant can be to the line construction forces, the more effective the aerial support will be. However, often fire retardant drops are made in support of bulldozers with no consideration by air attack as to whether the bulldozer can negotiate the terrain in close enough proximity to the retardant line to avoid leaving a large unburned, untreated area. This also happens when air effort is in support of hand tool crews to a lesser extent. Close coordination and common recognition of a logical "anchor point" will avoid this.

In the interest of getting a load of retardant on the fire as soon as possible, airtankers frequently make their drops immediately upon arrival. The time between drops may be too long to give ground crews the support needed to pick up the head of a fire in rough terrain. It may be desirable to "hold" one or more aircraft in orbit until a sufficient strike force is available to pick up a substantial portion of the fire rather than leaving a crew "dangling" or exposed in a deep ravine with heavy fuels.

In indirect action, airtankers may pretreat lines of topographic advantage along the flanks or ahead of the fire so that it may be contained when it burns to these lines. Retardant drops along roads or previously constructed fuelbreaks or firebreaks, may serve to reinforce the value of these as fire barriers when the fire burns to them. During critical periods of a backfiring operation, an orbiting airtanker may be desirable to provide immediate action on any spot fires.

Helicopters, because of their speed and mobility, can do much to decrease the time required to place first attack personnel at an initiating fire. The ability to operate in areas inaccessible to ground crews and equipment and even airtankers, makes the helicopter a valuable fire control tool. Its ability to operate from highly restricted areas utilizing prepared or unprepared locations at or near the fire, and its vertical takeoff and landing characteristics which permit it to remain above a selected spot, make it a valuable piece of equipment for close support action, increasing the capability of the ground mobile units of firetrucks, bulldozers and hand tool crews, and of aerial tankers.

As a first attack force, a helitack unit has certain special capabilities. These are:

1. Can place a small crew of highly trained fire fighters at the site of a remote fire quickly. The helicopter can land the men at or near the fire, or enable crewmen to jump near the fire and prepare a landing site. Frequently this can be accomplished working with airtankers in advance of the arrival of ground mobile units. Helicopters are especially valuable in transporting crews over clogged highways and freeways when fire engines might be delayed many minutes by such traffic.

2. Can add fire fighters to the fire line quickly, by contacting incoming crews by radio and arranging to pick up men from those crews at reinforcement points along the route of travel. These "crew pick-up points" may be preplanned and established adjacent to the highway and road systems, to decrease response time. They may involve building helispots.

3. Can provide an early source of fire intelligence to the Ranger Unit Headquarters by reporting back to the dispatcher regarding the best type of attack on the fire and the resources needed.

The helitack foreman has a wide choice of alternatives or tactics on how to proceed. These are:

1. If the fire is small and spreading slowly, he may go to work with his fire fighters to obtain early control of the fire through the use of hand tools.

2. Assign his fire fighters to help direct the activities of local volunteers on the fire.

3. Order the helicopter to rendezvous with the incoming helitack service vehicle and return to the fire with additional crewmen and/or equipment.

4. After laying out the activities of his fire fighters, go with the helicopter to establish radio contact with incoming ground units and arrange to pick up additional crewmen for ferrying to the fire line.

5. Use the helicopter to ferry men from one part of the fire to more critical points.

6. Establish a helitanker operation, dropping water or chemical retardants to slow the head of the fire, to hit hot spots, or spot fires, or to cool the fire just ahead of ground units constructing line.

7. If water is plentiful adjacent to the fire, establish a hose lay along one flank by using the high-pressure pump and hose from the helitack service vehicle.

8. If water is located near, but not adjacent to the fire, use portable tank pumps and hose from the helitack service vehicle and ferry water from the nearest water source to the portable tank.

In a multiple-fire situation such as a concentration of lightning fires, or an outbreak of incendiarism, helicopters can move small groups of people to each fire start rapidly, or move personnel from one fire to another as conditions change, frequently in support of airtanker action.

In an extended attack, or large fire situation, the helicopter can:

1. Serve as an aerial command post; facilitate briefing and overview by command officers; assist in air attack coordination and direct forces to an assigned mission, utilizing radio or external voice amplifiers.

2. Provide a valuable means of gathering critically needed fire intelligence or fire information, including the use of cameras or television; perform reconnaissance and mapping; and assist with communications relay. May also assist with obtaining a vertical profile of fire weather elements.

3. Transport tools, water, food and equipment to the fire line; establish and service remote fire camps; service bulldozers; and lay telephone wire.

4. Support ground units by reducing fire intensity just ahead of the ground units with helitanker drops of water or chemical solutions. Can supply to any remote or critical location a portable water tank, hose, pumps, and men to form a valuable suppression or mop-up unit. The tank is supplied with water by the helicopter hovering over the tank and dropping water. Repeated drops from some water source will provide a continuing water supply for crews pumping water on the fire. Can ferry men, equipment, and supplies to and from remote or critical sections of the fire line. Can attack spot fires or critical hot spots

quickly with trained men or by helitanker drops of water or retardants. Can patrol extensive areas, watch for hot spots or flare-ups, and provide general surveillance, minimizing the need to divert forces unnecessarily because of reported smokes, facilitating mop-up and patrol.

5. Can recover injured personnel from remote fire line locations and fly them directly to a hospital if necessary, or transport medical personnel to an accident scene.

6. Utilizing loudspeakers attached under the helicopter, can assist in evacuation of threatened citizens or fire fighters or can issue fire suppression instructions.

Helicopters can also be used for night illumination when installed with high-intensity searchlights. With the increasing concern of municipal fire services for the problems of fire control in high-rise buildings, it would appear that the helicopter can assist city fire departments in fire attack through establishing hose lays, ventilation, reconnaissance, night lighting, etc.

Mr. Lowden: Going on with our actual "doing" jobs now, particularly in our forest fire operations, chemicals are becoming increasingly important the last few years. Our next speaker, Jack Barrows, has had a wide background of experience in connection with chemicals as well as other phases of fire control. He was formerly Director of the Northern Laboratory of Missoula, Montana. Prior to that he was with the U.S. Park Service and for about five or six years now he has been division director working closely with me in Washington. We have had many interesting experiences, and he can bring you much valuable information, I know.

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FIRE-FIGHTING CHEMICALS

J. S. Barrows

Director, Division of Forest Fire and Atmospheric Sciences Research
U.S. Forest Service, Washington, D.C.

Aerial delivery of fire retardants is a well established forest fire-fighting procedure throughout the United States and Canada. The retardants are either water or chemicals. During 1970, the U.S. Forest Service used both helicopters and fixed-wing aircraft to deliver more than 13 million gallons of retardants to hundreds of fires. Additional millions of gallons of retardants were dropped on fires by land management agencies of the Department of the Interior, state and county fire control organizations and the Provencal forestry departments of Canada.

History

Since the beginning of organized forest fire control, man has been seeking potent fire-fighting substances and effective methods for their application. All fire control organizations have long had capabilities for application of water and chemicals from ground-based equipment. However, in forest fire control the lack of mobility of ground equipment greatly limits the use of this method. Rugged mountain country and the high rate of spread of many forest fires are factors often posing an insurmountable barrier to the tank truck or the fire fighter with a nozzle in his hand.

Immediately following World War II significant efforts were started to fully explore the possibilities for aerial delivery of fire retardants. The great expansion in aviation provided a variety of new aircraft and techniques for aerial fire fighting in forest areas.

In 1946 the Forest Service and the U.S. Air Force activated a major experimental program at Missoula, Montana, to develop and test aerial bombing methods for fire control. Two P-47 fighters, one B-25 medium bomber, and one B-29 heavy bomber were assigned to the program. Extensive tests were made of contained delivery of water and foaming compounds on both experimental and wildfires. Aluminum wing tanks were converted to bombs loaded with fire retardant. Low level attacks were made with the fighter aircraft. Fire retardant bombs equipped with proximity fuses and a burster were dropped from the B-29 flying at medium altitudes. These provided tests of treetop level bursts of fire retardant. One of the memorable experiences of these historic experiments was the scene of whole clumps of tall pine trees suddenly painted white with foam from a salvo of proximity fused bombs.

FIGURE 1. B-17 making retardant drop on Tool Box Fire, Silver Lake District, Oregon. July 22, 1966.

The experiments at Missoula concluded that fire retardants could be delivered rather precisely to fire targets by aerial bombing techniques. However, the experiments also concluded that the bombs used did not provide adequate dispersal of the retardant. Perhaps most important was the conclusion that aluminum-cased retardant bombs were extremely dangerous to personnel on the ground. Recommendations were made to explore other types of containers and cascade delivery systems.

In 1954 Operation Fire Stop was organized in California as a cooperative fire research and development program of several Federal and State agencies. One of the major objectives of Fire Stop was to fully test aerial delivery of fire retardants. The Fire Stop work plan issued on February 15, 1954, stated:

> "Some of the 'tools' which will be tried are: aerial water bombing and sprays from conventional aircraft and helicopters, aerial backfiring from predetermined control lines, the use of fog barriers and smoke barriers to slow fire spread, chemicals and sprays to retard the fire, the use of backfire to turn or slow down running fire fronts."

The 1954 work plan also stated:

> "Set a large number of mass fires and small fires with high mass fire potential under appropriate burning conditions and determine the effects on them of laying down barriers of various forms of water and chemicals."

The results of these pioneering experiments are well known to the fire control community. The Fire Stop progress report issued December 1, 1954, stated:

> "Fire retardant studies show that readily available chemicals can be sprayed in water solution on forest fuels to make limited quantities of water go farther and to extend the time that prewetting of those fuels is effective. Flanks and rear of a fire and sometimes even the head can be stopped by chemical fire lines. A hot crown fire in heavy brush will often drop out of the crowns when it hits chemically treated fuels and its rate of spread may thus be reduced by as much as 50 percent. Backfires can be started from chemical lines which can be put in more quickly than adequate lines can be cleared. Smouldering spot fires can be held down by chemicals until conventional ground forces can attack them. It also appears that chemical fire lines may be put in by aerial application. A torpedo bomber was rigged to drop 600 gallons of water or chemicals from its bomb bay. This craft puts a heavy drench over an area 50 feet wide and 270 feet long. The Sikorsky S-55, the Hiller model 12-B, and the Bell model 47 helicopters were used for water bombing and to lay hose (1,000 to 2,000 feet can be laid over rough terrain in less time than it takes to charge the line). In addition, the larger Sikorsky was used to drop 100 gallons of water by free fall on spot fires and along fire lines and for delivery of a small hook-on 'helitanker' unit made up of a 100-gallon tank, small pump, and 300 feet of hose."

Chemicals

Immediately following the Fire Stop experiments, forest fire control agencies were ready to start aerial delivery of fire retardants in fire-fighting operations. In 1956 the air tanker became a part of the fire-fighting forces in California and in 1957 cascade delivery of fire retardants was started in the Northern Rocky Mountain region.

The demonstrated potential for aerial delivery focused new attention on the types of fire retardants needed for these operations. Previous research dating back to 1931 had shown the potential effectiveness of ammonium phosphate solutions. However, in the initial aerial fire-fighting operations a major concern was delivery of retardants that would adhere to fuels along the fronts of advancing fires. The Fire Stop experiments demonstrated this requirement. At this time joint forestry and chemical industry efforts developed the approach of using a solution of sodium calcium borate for this purpose. This retardant achieved quick initial acceptance and the term borate bomber soon became a byword in forest fire-fighting circles.

Joint efforts by fire-fighting organizations, chemical industries, and fire research soon discovered that other types of retardants could be more effectively and safely used. While the heavy borate slurry could be applied rather accurately to fire targets and could cover fuels with an insulating jacket, it had several important shortcomings. Borate slurry is toxic to vegetation and has little or no effect on pyrolysis. Swelling bentonite clay evolved as one of the first replacements for borate. It is a less toxic material but like borate is a retardant in which the effectiveness depends primarily upon the amount of water that it holds. The widespread use of bentonite slurry was short-lived because active research and development activities soon developed a whole family of fire retardants adapted to a variety of forest fire control jobs.

Forest fire retardants as we know them today can be classified into two broad groups. One group consists of short-term or water modifying retardants. This group includes wetting agents, such as wet water, various viscous agents such as CMC (sodium carboxymethyl-cellulose) and the synthetic organic polymer known as Gelgard. Also in this group are the water carrier clays such as bentonite.

The second group consists of long-term or flame inhibiting chemicals. In this group are the most commonly used chemicals in forest fire control - the ammonium phosphates and ammonium sulfate. The ammonium phosphates are used in dry form for mixture with water or liquid concentrate form, also for mixture with water. The well-known retardant Phos-Chek contains diammonium phosphate, CMC for thickening purposes, corrosion and spoilage inhibitors and a color pigment to insure visibility of the drops by pilots. This product is also manufactured in a lower centipoise form for application from ground tankers.

The major ammonium sulphate retardant is known as Fire-Trol. It consists of ammonium sulphate, thickened by attapulgite clay and has a corrosion inhibitor and a color pigment. Attapulgite clay is similar to bentonite, but is less affected by water temperature, hardness, or impurities.

Both of these long-term retardants - Phos-Chek and Fire-Trol - are supplied in dry form to airtanker bases where they are mixed with water and pumped into the aircraft. They provide effective slurries with centipoise ranges of 800 to 1,200 for Phos-Chek and 1,400 to 2,000 for Fire Trol. Such slurries have the dual advantage of coating both aerial and ground fuels and of containing flame-inhibiting chemicals having long-term characteristics.

Fire Retardant Research, Development and Evaluation Program

A major concern for all forest fire control organizations is the selection of the best retardant for specific forest fire situations. In addition, fire control managers need answers to these questions: How much retardant is needed according to variations in fuels and fire danger? How long will the retardant be effective? What patterns and concentrations can be achieved from aircraft flying at various speeds and flight attitudes? What are the best design characteristics for aerial delivery systems? What are the appropriate roles in fire retardant delivery for both fixed wing aircraft and helicopters? (Figure 2.)

Answers to these questions are coming from a broad cooperative program involving participation by the Forest Service fire research laboratories and equipment development centers, the chemical industry and many private, State and Federal fire control agencies.

The laboratory phase of this program is centered at the U.S. Forest Service Northern Forest Fire Laboratory, Missoula, Montana. Here the principal missions are determination of the effects of retardants and the requirements for application of retardants. The Missoula laboratory also develops criteria for field performance, standards for field evaluation, and application requirements for predominant types of fuels.

In the laboratory program retardants are applied in controlled amounts to forest fuel beds. These treated beds are burned in a combustion chamber where studies can be made of retardant effectiveness under controlled conditions for temperature, relative humidity, and fuel moisture. A more critical burning test of promising chemicals is performed in a special fire wind tunnel where the significant moisture, temperature, and windspeed factors can be controlled and varied (Figure 3).

Results of laboratory experiments are providing a fundamental understanding of fire retardant effectiveness under various environmental and fuel conditions. Under the more severe burning conditions with low humidity and moderate wind conditions long-term retardants are generally

FIGURE 2. Helicopter dropping retardant.

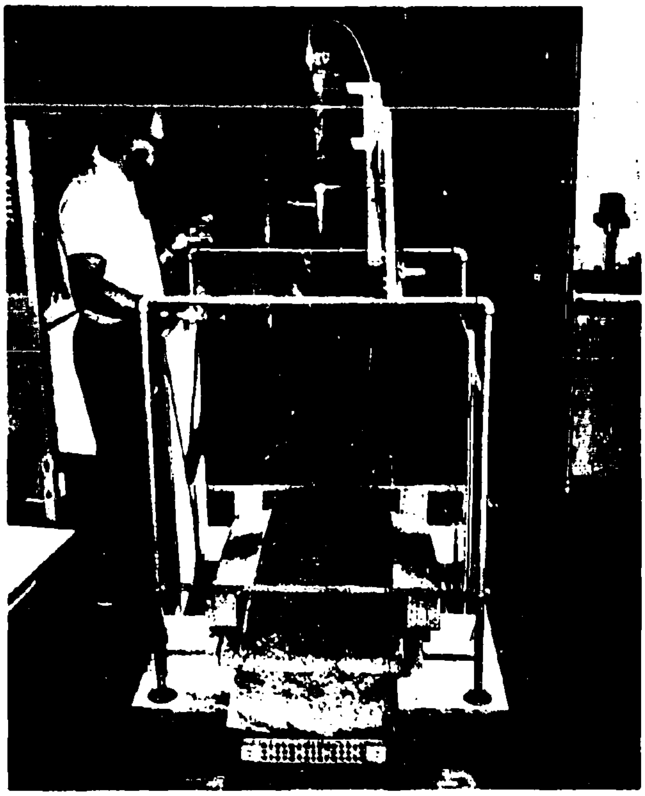

FIGURE 3. Retardants applied to forest fuels under laboratory conditions.

superior. The long-term retardants provide the greatest reduction in rate of fire spread after both one hour and three hours elapsed time following application.

We are learning how much salt content in long-term retardants is necessary to achieve various reductions in rate of spread, amount of fuel consumed per minute of burning time and radiation.

Field studies of fire retardants are an essential part of the research, development, and evaluation program. In 1970 we performed a field experiment at Porterville, California, to determine: (1) the effect of thickening agents on drop characteristics; (2) the effect of drop height, aircraft speed and wind on drop characteristics; (3) maximum effective drop heights as related to drop speed and crosswinds; (4) how the salt content of unthickened retardants can be adjusted to provide the same amount of active salt on the ground as provided by thickened retardants; (5) to provide data necessary for the correlation and development of an adequate model for studying drop characteristics as a function, known rheologic properties and types of gating and tank systems.

Cooperators in this field experiment included the Northern Forest Fire Laboratory, Division of Fire Control, San Dimas Equipment Development Center and five Forest Service Regions, the California Division of Forestry, and three retardant manufacturers.

The variables in the drop tests included four fire retardants, three drop heights, two aircraft speeds and three crosswind conditions. Standard conditions were established for the mix rates, viscosity, density, and salt content of each of the four retardants used in the tests.

The Porterville, California, airtanker base provided excellent support facilities including mixing equipment for Phos-Chek 202XA, a high shear and a batch-type mixer along with a 500 gallon portable tank truck for Fire-Trol 100, and separate 5,000 gallon tank trucks to handle the Fire-Trol liquid concentrate and mixed retardant.

In obtaining data on retardant drop patterns, a grid of 820 cups covering a four acre area was installed on the airfield. Special weather stations were installed to record temperature, windspeed and direction. High speed recorders with event markers were used to record fluctuations in windspeed and direction during each drop. Cameras and a theodolite filmed the drops and recorded aircraft height. An immediate average speed during the drop was obtained by a timing device.

All of the drops were made with a standard TBM airtanker, with a Fire-Trol 100 drop sequence, a Fire-Trol (LC), and finally a water drop.

The results of these tests are still being analyzed. A computer program has been developed to convert field data to gallons per 100 square feet and to assist in developing and testing an air drop model. We believe that this experiment and others planned for the near future will provide essential knowledge for the continued development of fire retardant technology.

Delivery Systems

One of the major aspects of fire retardant technology requiring increased attention is the matter of delivery systems. Many of the aircraft being used are of World War II vintage and need to be replaced. In the process of replacement we need to develop delivery systems - tanks, gates, release mechanisms, target selection, and aiming devices - that take advantage of our increasing knowledge of retardant requirements and performance. The design of these systems also must be based on the various principles of fluid mechanics and the aerodynamic factors that are critical elements in retardant patterns. These systems should fully capitalize on modern aerospace technology that can be transferred and adapted through cooperative research and development to fire control operations. Priority attention in these activities must be given to systems that will provide fast and powerful initial attack of threatening fires because this is the critical stage of fire fighting where the use of retardants can pay the biggest dividends.

Some of the important questions to be answered in the development of delivery systems are:

1. In the interest of safety and the use of larger, more efficient aircraft, can effective retardant delivery be made from higher flight altitudes?

2. Can technology be developed for safe and effective dropping of retardants in containers?

3. Can retardants be converted to frozen or semi-frozen form as one means of achieving target accuracy from larger and higher flying jet aircraft?

4. Can we expand and improve direct pickup systems for water from lakes and large rivers?

5. Can we develop electronic navigation and infrared target selection systems permitting nighttime aerial delivery of retardants or more effective delivery under conditions of dense smoke?

Helicopter Delivery Systems

Increasing use of helicopters is being made in the delivery of both water and chemicals to fires. The helicopter is an excellent machine for initial attack operations. It is also highly useful for attack of spot fires and for highly accurate drops of retardant to critical areas of a fire that may be difficult to attack with fixed-wing aircraft.

The principal method of fire retardant delivery with helicopters is to use buckets slung beneath the ship on cables. Chemicals are loaded from tanks at an airbase or water can be scooped into the buckets from lakes or rivers. One of the important limitations of helicopter delivery is the restricted fire retardant load capacity. With the advent of larger helicopters there will be greater opportunity to deliver larger amounts of retardant to critical sectors of a fire. In addition, with improved intelligence and aircraft control systems, massive attacks with several helicopters will be more feasible. The future possibility of using FLIR systems (forward looking infrared) may enable helicopters to be used safely and effectively at night. We believe that one of the most significant advances in fire attack with both helicopters and fixed-wing aircraft will come through development of total fire intelligence systems that aid in fire behavior evaluation, target selection, guidance and control of aircraft, and precision release of retardants. The major goal is to control potentially dangerous fires at small size and to reduce the occurrence of costly and damaging conflagrations.

Mr. Lowden: Our next speaker brings a very practical background to this discussion. One I think that you will appreciate and enjoy. He has spent about 25 years in the helicopter business and during that time he has accumulated a vast number of helicopters which have been operated on many different jobs. I am sure not only in his presentation but in our discussion he can bring a large contribution to this total program. It is with a great deal of pleasure I introduce Bob Suggs, who is owner and operator of Petroleum Helicopters, Inc. in New Orleans.

DIVERSIFIED HELICOPTER SERVICES

Robert L. Suggs

Petroleum Helicopters, Inc., New Orleans, Louisiana

I may be a little out-of-place here, because although we have done some fire fighting, we do many other things, too. I would like to talk about where and how we operate, the types of equipment we use and how we employ it, the fires we have fought, the ambulance services we offer, and how we are integrated with national and state fire-fighting agencies.

We have a worldwide area of operation, including banana spraying and remote region supply work in Ecuador and Colombia, spraying and transport of bananas in Central America. We provide air support for oil fields in Angola, and for both desert and off-shore operations in Arabia, where we have two Bell Jet Rangers (206's), and a 205. A most interesting venture is our work in New Guinea where we are working on the opening of a new nickel mine for Freeport Industries, using six 204's - a vehicle with higher reliability and performance at the mine site, which is atop a 11,000-foot mountain.

Domestically, our operations are mainly in Texas and Louisiana, with a venture by invitation of the Bureau of Land Management to work on fire suppression in Alaska. We do, however, perform other missions in all other states in the Union, such as power line construction work, in which we move workmen to and from work sites daily. In just one such task, we fly 50 helicopters daily from the 46 pads on just one heliport.

Our fleet of equipment numbers 184 helicopters and three airplanes - and constitutes the biggest air taxi operation in the world. Of course, it is not comparable to the thousands of aircraft in the U.S. Army or Air Force, but it is a truly big commercial operation, in which we use the "47-type" helicopter, Bell's 204/205's, 206, and a 212, besides six of the Hughes' 500's. Our three airplanes are used for movement of people, as well as transport of maintenance parts to our equipment in Honduras and Costa Rica.

Personnel-wise, we employ 330 pilots - mostly ex-military - and recently we have been recruiting what we call "pilot-mechanics," whom we hire whenever available. For maintenance and repair, we employ 300 mechanics to cover the specialized categories such as engine overhaul, structural work, stripping and painting, and so forth.

In the area of safety, we have a Supervisor who conducts safety briefings, flies with all the pilots, reports on all accidents and incidents, of which there were 131 last month in 15,000 total flying hours. Thirty-one of the incidents were substantial. We employ two instructor pilots to teach our new men, to give proficiency checks, to upgrade pilots to bigger equipment, and to run proficiency flight checks for all pilots on our air taxi certificates. Lastly, we carry three "production" test pilots for test flight of all helicopters coming out of maintenance.

As for fires and rescue work, I am sure that you are aware of some of the terrible fires that we have experienced in the Gulf of Mexico. Because an oil rig gas explosion is so violent and destructive, there have been incidents in which 30 or 40 people were killed, and we just recently managed to extinguish a fire that had been burning for about six months.

For routine operations and for quick response to fire and accident, we have a fleet of 120 helicopters operating between Galveston and the mouth of the Mississippi River. Our communications consist of three VHF networks, in addition to a point-to-point HF system to keep in contact with our 15 bases. A base immediately is informed of any fire or accident, and often within two or three minutes we can have 40 or 50 helicopters in the target area. More often than not, there is little that we can do immediately because one cannot usually fly into a burning rig - although one of our pilots received a Carnegie aware two years ago by picking a trapped worker off a burning platform.

In the area of other oil rig accidents, we continually perform rescue and evacuation work - in fact we have up to 50 cases a month, from rigs located as much as 130 miles offshore. Even in electrocution cases, we find that if we can get the patient to a shore hospital quickly he often can be saved.

Louisiana, next to Alaska, is the largest fur-trapping area in the Country, and trappers set marsh fires to catch the rats that come in to feed on the ensuing growth of new grass. Often such marsh fires threaten compression stations or pipeline outlets and we are called upon for fire suppression.

In the Gulf area we are frequently engaged in massive evacuation operations in the hurricane season, in which we must hurriedly get the workers in from rigs and other installations and get them back when the storm has passed.

As for local municipal or county requests for fire, rescue, or police assistance from our company, the authorities have shown little or no interest - even when we offered all the helicopter service free. In 23 years, we have never been visited or called on for help by the New Orleans Fire Department. The State of Louisiana has never once asked for a helicopter for fire observation. Only once has a Federal agency asked for help (Alaska, about two years ago) and we had two 204's up there in about four days. I do believe that we can help; that fire-suppression people should use the newer, bigger equipment. I do not understand why we should not build something as good as the big Russian equipment - which I saw at the Paris Air Show - which can carry 40 tons or more, and would be so valuable in the suppression of forest fires. Meanwhile, we are willing and able to contribute our help at any time.

Mr. Lowden: The next speaker is assigned to the headquarters of the U.S. Air Force as an air-operation staff officer with the search and rescue branch of the Director of Operations. He has 13 years of flying experience with 2,600 hours in helicopters. He spent two and one-half years instructing in fire suppression techniques and procedures during which time he accumulated 1,500 hours in the H43 helicopter. I am very happy to present to you, Major Scarff.

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CURRENT TECHNIQUES EMPLOYED BY USAF HELICOPTERS IN CRASH FIRE OPERATIONS

Major James P. Scarff, Jr.

Headquarters, USAF, Washington, D.C.

An examination of military aircraft accidents reveals that approximately 75 percent of all crashes occur within 10 nautical miles of an airdrome, with about 45 percent impacting on or in immediate proximity to the installation.

It has long been recognized that an appreciable number of the victims of these crashes survive initial impact, only to perish in the ensuing fires which occur in roughly 45 percent of the crashes. Many of these victims perished because surface rescue units could not reach them in time, due to unfavorable terrain. And because they were unable to extricate themselves due to aircraft structural damage, physical incapacitation, or the confusion and disorientation associated with the trauma of a post-crash fire.

With these somber facts in mind, we logically arrive at the question - what can be done to reduce the injuries and loss of life resulting from post-crash fires? Obviously, something new was needed. Something capable of overcoming the obstacles of terrain, time, and distance. A rescue team with the capability to suppress post-crash fires and extricate victims; to administer to their immediate medical needs; and to rapidly evacuate them to sophisticated medical facilities. The solution seemed to lie in the vertical take-off and landing capabilities of the helicopter.

This was the philosophy which led to the development of the USAF integrated airborne fire suppression system which came into being in 1957 with the adoption of the H-43 "HUSKIE" helicopter and air transportable fire suppression kit. Prior to discussing the procedures and techniques of employing the H-43 fire suppression system, let's first look at the equipment and personnel required to operate it. The single-engine H-43 is a turbine powered helicopter, capable of speeds up to 105 knots. It can fly at a maximum gross weight of 9,150 pounds, but normally operates at a mission weight of approximately 8,000 pounds in the fire suppression configuration (Figure 1). The fire suppression capability is provided by one of two types of fire suppression kits (FSK) which are suspended beneath the H-43. The first type of FSK is a "soft hose" kit weighing approximately 1,000 pounds (Figure 2). This kit has 150 feet of collapsible dacron and cotton hose which is deployed from a basket attached to the kit frame. The second type kit is the "hard hose" kit which has a reel-mounted, 150 foot rubber hose (Figure 3). This kit weighs approximately 1,200 pounds.

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FIGURE 1. USAF Series - HH-43B Helicopter.

Both FSKs contain 78 gallons of water and five gallons of mechanical foam concentrate which is mixed and delivered by a 3,000 psi air supply. This provides approximately 690 gallons of foam which can be delivered at a rate up to 800 gallons per minute. With the foam nozzle full open, a constant flow of foam can be sustained for 55 seconds.

In discussing the fire suppression kit and its relatively limited supply of agent, one must bear in mind that the primary objective of this system is, as the name implies, to suppress fires. Although the equipment is capable of extinguishing some fires, its design purpose is to open a rescue path to facilitate the recovery of crash survivors (Figure 4).

Operating this integrated airborne fire suppression system are four highly trained specialists who must exercise perfect crew coordination and sound judgment, not only for the sake of potential rescuees, but to insure their own safety. These individuals are the pilot (Rescue Crew Commander); two fire fighters (Nozzleman and Rescueman); and a Medical Technician. These individuals train together constantly to maintain the precise skills and timing which are essential to success and survival.

Putting these elements together, we have a Local Base Rescue (LBR) unit which possesses a highly responsive and mobile crash fire suppression capability. In their "immediate alert" posture, with the aircraft "cocked," and the crew on standby, the H-43 can be airborne within 2 to 5 minutes after notification of an actual or impending emergency.

Although the typical LBR unit has a 75 nautical mile radius of rescue responsibility, the effective radius for fire suppression operations is ten miles. This limitation is a function of speed and distance, since the H-43 is limited to 85 knots airspeed when carrying the Fire Suppression Kit.

Operational experience has shown that, from engine start through the approach to the crash site, the H-43 is capable of an average closure rate of approximately one mile per minute. Applying this rule of thumb, we see that ten minutes will elapse in reaching a crash site ten miles distant. Therefore, since the essence of successful fire suppression operations is being able to employ the suppression system before the fire spreads or becomes too intense, we consider ten miles to be the effective range for this system. This of course is not an absolute. Each situation must be evaluated in light of its particular circumstances. For example, if the H-43 is alerted and enroute to intercept an aircraft before it crashes, the effective range is extended considerably. Conversely, if a mountain range lies between the H-43 and the crash site, the effective range is substantially reduced. In either event, every reasonable effort is made to reach the crash site with the FSK.

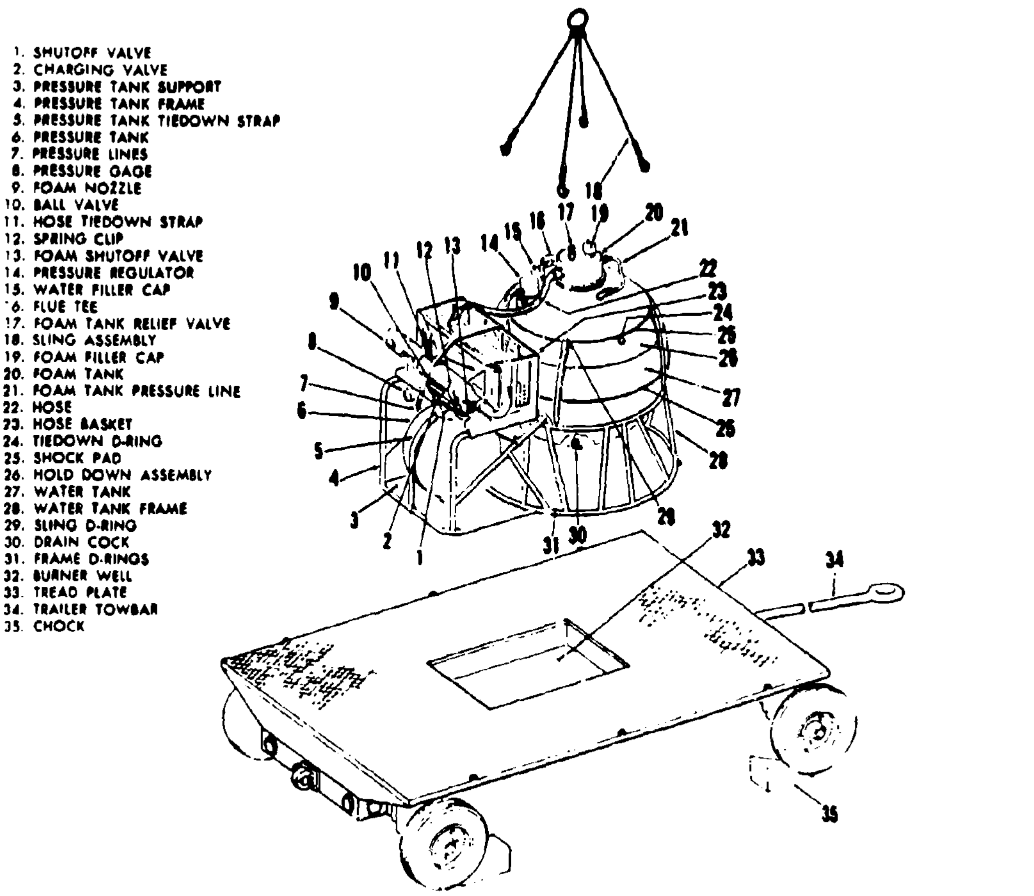

FIGURE 2. Fire suppression equipment (soft hose kit).

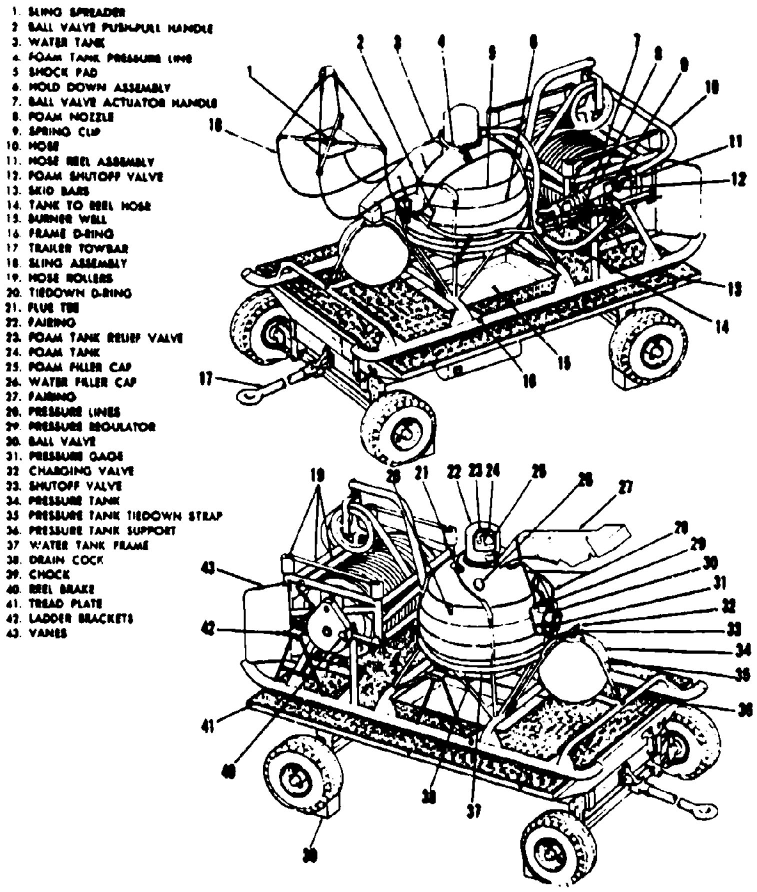

FIGURE 3. Fire suppression equipment (hard hose kit).

Perhaps the best approach in discussing the specific techniques and procedures of the H-43 fire suppression system, would be to look at a hypothetical mission. Let us assume that a single-engine jet aircraft has declared an emergency twenty-five miles from our base. The pilot has stated his intention to attempt a landing at the base as soon as possible. The control tower operator immediately activates the crash alert network which notifies all appropriate agencies, one of which is the Local Base Rescue unit.

At the first sound of the alert, the waiting H-43 crew "scrambles," reaching the "cocked" helicopter in a matter of seconds (Figure 5). As the firemen put on their aluminized bunker suits, which are positioned in the aircraft for quick donning, the pilot starts the engine and engages the rotor system. Meanwhile the medical technician is assisting the firemen and readying his emergency

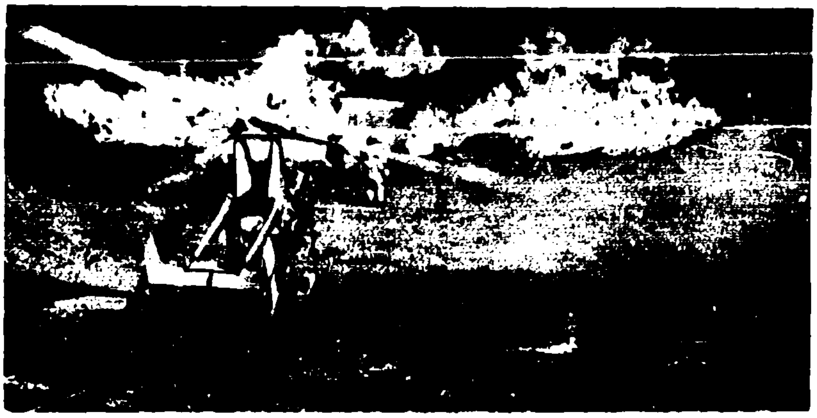

FIGURE 4. The "synchropter" rotors produce large volumes of low velocity air which have a longitudinal forward thrust at ground level producing a "cooling corridor" when the helicopter is properly positioned.

equipment. Three minutes after being alerted we are airborne, hovering over the FSK which is positioned on a trailer in front of the helicopter (Figure 6). Fifteen seconds later, with the FSK attached, we are enroute to intercept the distressed aircraft. Throughout the launch phase, our pilot has been receiving a steady stream of mission information over the radio - type of aircraft, number of personnel on board, fuel load, position, nature of the emergency, etc. Our objective is an F-100 with one pilot on board. He has 2,000 pounds of fuel remaining, and is

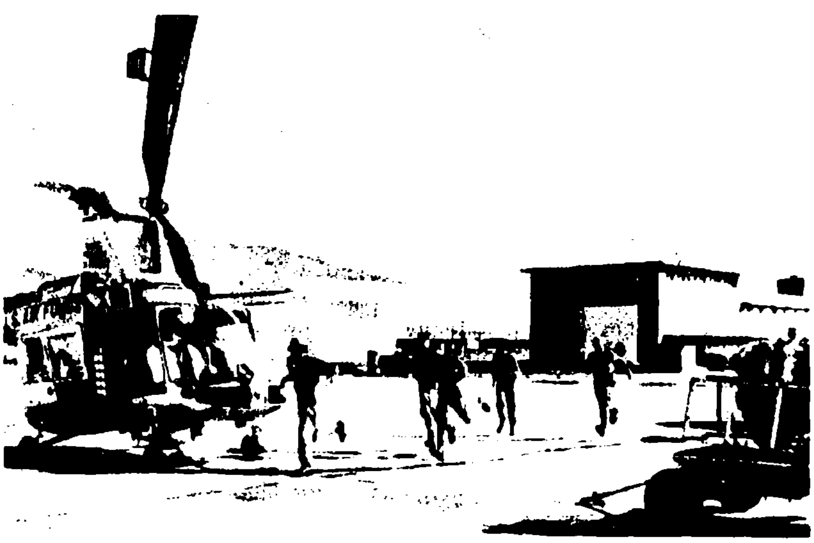

FIGURE 5. Crew answers an alert.

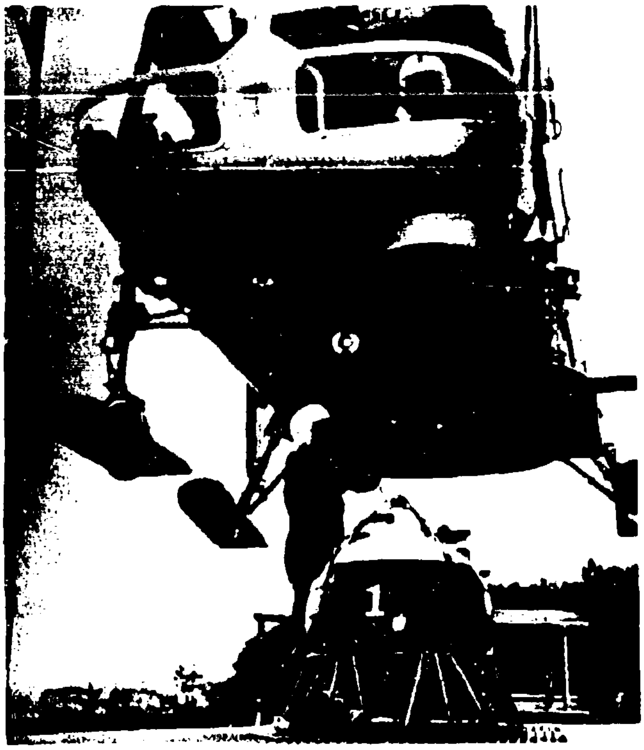

FIGURE 6. Nozzleman laying down fan-shaped foam discharge pattern in arc approximately ten feet wide.

experiencing hydraulic trouble. Now we see him - four miles out on final approach. His flight path appears erratic. Suddenly, the F-100 enters a shallow right descending turn - a crash is inevitable.

As we continue to close on the crippled jet, it impacts in an open field two and one-half miles from the approach end of the runway. The F-100 hits in a relatively level attitude and careens along the ground for nearly 1,500 feet before coming to rest. We are relieved to see that the aircraft remains upright and is relatively intact - then we see it! That first telltale flicker of fire. A fuel tank has ruptured and the seeping fuel has been ignited. The fire is in the left wing root area and is inching its way toward the cockpit where the unconscious pilot sits, still strapped in the seat. As we near the crash site in a fast shallow approach our pilot ascertains that the wind is from the South at about eight knots. It is blowing across the F-100's nose toward the fire just back of the cockpit. We quickly adjust our heading to ensure that our approach route is within 45 degrees of the prevailing wind. As we reach an altitude of 100 feet, the pilot executes a gentle flare (nose up) to reduce our airspeed. At 30 knots he levels the helicopter and brings it to a 15 foot hover at a point 75 feet upwind from the fire. Rapidly but smoothly he lowers the helicopter until the fire suppression kit touches the ground.

As it touches, an automatic mechanism opens the cargo hook of H-43, releasing the FSK. We receive confirmation of this event from a small green light which illuminates on the instrument panel. Instantaneously the pilot backs the helicopter away from the FSK and quickly lands, with the nose pointed at the kit, to off-load the fire fighters. The Nozzleman is first out, followed closely by the Rescueman and Medical Technician. The Nozzleman moves quickly forward until clear of the rotor blades - then straight to the FSK. We have a "soft hose" kit, so he releases the host securing strap, grasps the nozzle and runs directly toward the perimeter of the fire, in line with the helicopter.

The H-43, now airborne, has established a ten foot hover between the FSK and the perimeter of the fire, with the tail directly into the wind (Figure 4). The Nozzleman passes under the helicopter and begins dispensing foam, being careful that the rotor wash does not knock him off balance. The rescue path is now being formed.

Meanwhile, the Rescueman had exited the helicopter with the crash entry kit. He opened the foam valve on the FSK, pulled the remaining hose from the basket and spread it out to prevent kinking, then proceeded to the fire perimeter. At this point he selects the appropriate crash entry tools, and joins the Nozzleman in the rescue path.

The Nozzleman is laying down a fan-shaped foam discharge pattern in an arc approximately ten feet wide. The rotor wash from the H-43 rolls the arc of foam forward, widening the path as it goes (Figure 4). The fire fighters are careful to keep the hose in the center of the rescue path so it won't come into contact with flame. This process continues until the desired entry path is opened to the burning aircraft.

Throughout the fire suppression operation, our helicopter pilot maintains a steady hover with the nose of the H-43 pointing directly down the rescue path. He is alert for any sign that the rescue path might close from either side. If he detects this or if the Nozzleman so directs, he will move toward the non-closing side and turn slightly toward the closing side. This directs maximum rotor wash velocity toward the encroaching flames, forcing them away from the center of the path. In doing this the pilot must not allow the rotor blades to penetrate the fire perimeter. This could easily cause smoke to begin recirculating through the blades, thereby causing a total loss of reference with the ground and the fire fighters. Once the Nozzleman is satisfied that the rescue path is well established, he lays down the nozzle and assists the Rescueman in removing the F-100 pilot from the wreckage. The survivor is carried a safe distance from the fire, where the Medical Technician is waiting to receive him (Figure 7). Once the rescue is completed and the Nozzleman gives the signal, then and only then, our H-43 withdraws from the rescue path.

Our survivor is placed on a litter and checked over by the highly trained Medical Technician. He is suffering from shock, possible back injuries and a couple of minor burns on exposed parts of his body. The Medical Technician is now busy administering fluids and comforting the F-100 pilot (Figure 8).

He is one of the lucky ones - we got to him before the flames did. Now, just eighteen minutes after impact, he is aboard our H-43 enroute to a medical facility.

Again the system paid for itself! The skillful employment of foam and the cooling rotor wash of the H-43 combined to create a tolerable rescue environement.

This is the USAF integrated airborne fire suppression system, operated by Local Base Rescue units at 67 Air Force bases throughout the world. It certainly isn't the ultimate system, but it's a start.

FIGURE 7. Medical Technician waiting to receive pilot after crash landing.

FIGURE 8. Medical Technician administering fluids and comforting F-100 pilot.

Mr. Lowden: We have had many references during the meeting to fire intelligence. Certainly there have been some wonderful developments in obtaining the use of fire intelligence in the last few years. I do not think we could have done better in getting a person to talk about this subject than a man who has been ten years with the Forest Service at the Missoula Laboratory working on various intelligence systems and is a real pioneer and developer in that line. I am very happy to present to you Stan Hirsch of the Missoula Laboratory of the Forest Service.

FIRE INTELLIGENCE

Stanley N. Hirsch

Northern Forest Fire Laboratory, U.S. Forest Service, Missoula, Montana

Although the title of my talk is "Fire Intelligence" I am going to limit it to airborne infrared (IR) forest fire mapping and detection. The field of remote sensing has been actively pursued since about 1960. There have been fantastic promises of techniques to provide all of the intelligence required in fire suppression. Very few of these promises have been realized. There has been some work done in determining fuel moisture, but it is of a very preliminary nature and has really not progressed far enough to determine feasibility.

What can we do remotely to assist in supplying the needed intelligence for forest fire control?

1. We can detect small latent forest fires either by day or night and under conditions when smoke or other atmospheric pollutants prohibit visual detection.

2. We can map the perimeter of large forest fires, determine the relative intensity along various portions of the fire front, detect spot fires outside of the main front, and determine the size and extent of unburned areas within the fire perimeter. We can determine the location of the fire front with respect to towns and villages. We can map escape routes, roads, streets, and trails that are not shown on outdated maps. We can do these things from aircraft or helicopters during either day or night and under conditions when very heavy smoke palls obscure the area to view; and we can do them without exposing personnel to the hazards of ground scouting in dangerous fire situations.

In 1961 we began to develop airborne IR line scanners for the detection of small latent forest fires. One of the first offshoots of that program was that we learned smoke is transparent in the thermal IR, and we began demonstrating that fires can be mapped with IR line scanners. In 1965 the first IR scanner became operational in the Forest Service. The effectiveness of that tool has been well documented and I am sure its performance is familiar to all of you."[1]

That mapping system has several shortcomings:

1. It is sometimes quite difficult to differentiate between fire targets and rocks heated by the sun.

2. The imagery it produces is panoramic and interpretation requires a rather high degree of training and skill.

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3. The imagery is produced on small Polaroid prints that have to be spliced together to form a mosaic.

Performance of that equipment has been very good and it was the best we were able to do in 1965. Since that time we have devoted a great deal of effort to designing equipment capable of performing the fire detection task while keeping in mind the needs for large fire mapping.

In 1969 we put together a bispectral, IR fire surveillance system. This system has many features that are completely unique. It will out-perform any other IR system in existence in the specific task of detecting small, hot targets in the presence of contrasty thermal backgrounds. It will detect 1-square-foot, 600°C targets against background thermal anomalies of up to 50°C at 15,000 feet above terrain or lower. Small hot targets are automatically marked so that the operator need only scan down the edge of the film until a target mark is observed. He can then look at the imagery and determine the exact location of the fire. A block diagram of this system is shown in Figure 1, and a detailed description of the equipment appears in

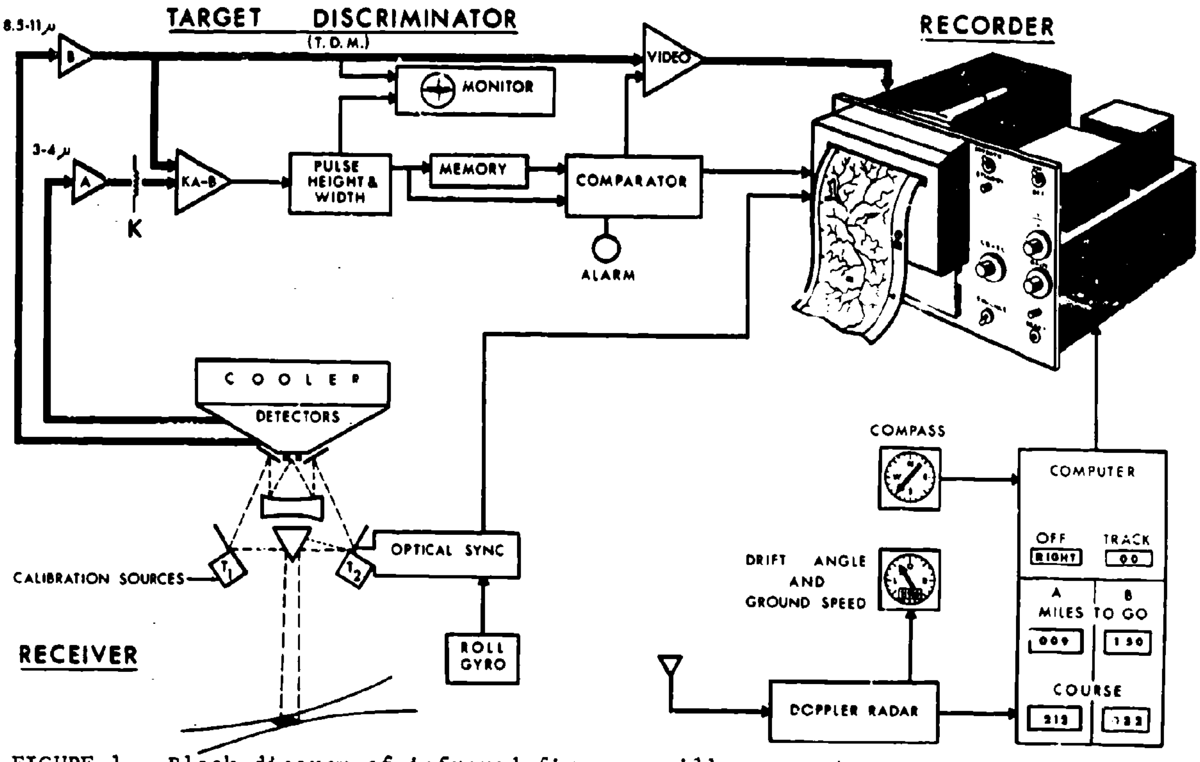

FIGURE 1. Block diagram of infrared fire surveillance system.

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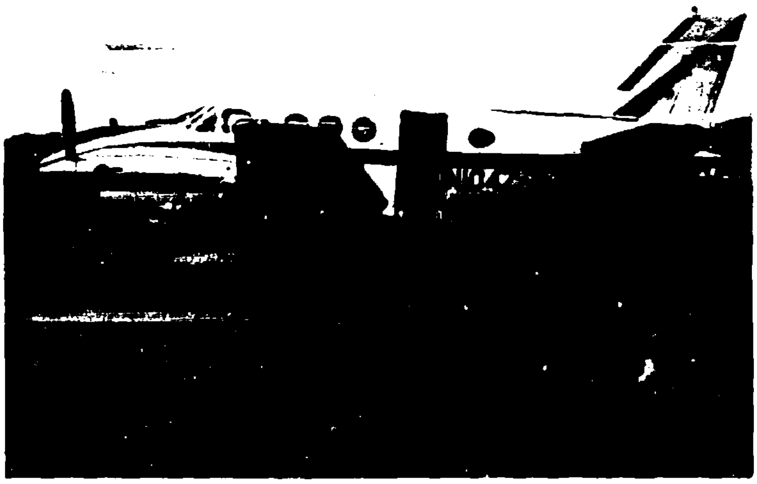

FIGURE 2. Beechcraft B90 King Air. Scanner port is visible aft of stairway on the right side.

Appendix I. Figure 2 shows the Beechcraft King Air in which the system was installed. This aircraft contains a Doppler radar navigation system that permits precisely flying predetermined tracks and accurately measures true ground speed so that the IR equipment can be adjusted to provide truly distortion-free imagery. Figure 3 shows the scanner installation and Figure 4 the IR console with the 5-inch film processor.

To determine the performance of the bispectral system we performed a flight test using thermal anomalies in Yellowstone National Park to provide a high contrast background. The targets we used for this test were buckets of glowing charcoal with surface areas of 1 and 2 square feet. Figure 5 shows a comparison of the results obtained with a single channel system using 3μm to 4μm signals as compared to the bispectral system.

All imagery (Figure 5) was recorded using the 8.5μm to 11μm B channel. In the left-hand image of Figure 5, the 3μm to 4μm (A) signal was used as input to the target discrimination module (TDM). The 2-square-foot targets were marked by the TDM, but the 1-square-foot targets were missed. The system false alarmed on geothermal activity in the area.

The right-hand image of Figure 5 is a similar pass with the KA - B signal as input to the TDM. K was adjusted for a background range of 0^{o} to $50^{o}C$. Both the 2-square-foot and the 1-square-foot targets were marked. The only nonfire alarms were on geysers whose temperatures were known to be about $90^{o}C$. Notice that the actual targets do not show up in either image.

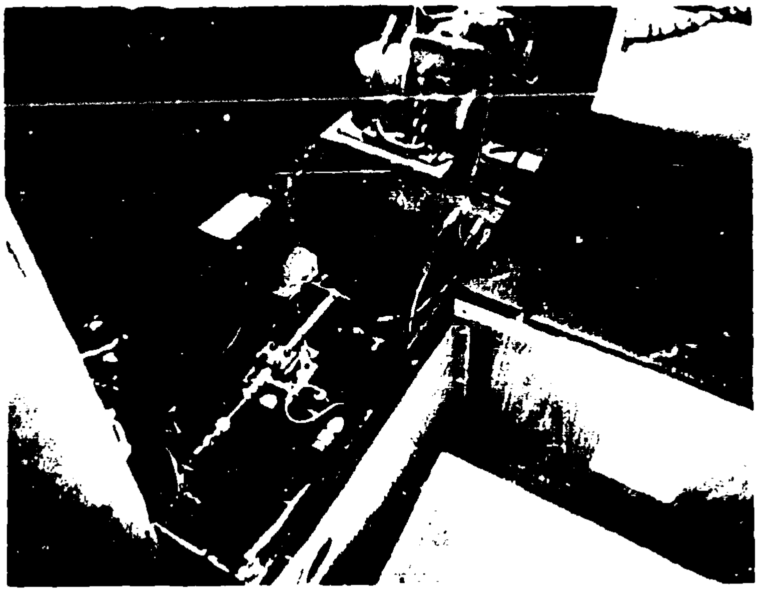

FIGURE 3. Looking aft, scanner mounted in specially constructed hatch. IR scanner required a modification of the fuselage by the factory. When closed, the cover for the hatch forms a pressure seal. Helium refrigerator shown provides detector cooling.

Evaluation of the System During the 1970 Fire Season

IR Fire Detection

After completing the Yellowstone Park test, we were convinced that the bispectral IR system had met all of our expectations in its ability to detect small hot targets. We then began the much more difficult task of determining its suitability for detecting latent forest fires. The strategy for employing this new tool in an overall fire detection system must consider fuel flammability, lightning storm occurrence, cloud cover, and the as yet unknown relationship between the radiant output from a fire and the smoke output used by the visual detection system.

To compare the performance of the IR system with visual fire detection, we selected a forested area containing 8,200 square miles (5.2 million acres) in the Bitterroot, Clearwater, Lolo, and Nezperce National Forests in western Montana and northeastern Idaho. Elevations in the area range from less than 1,300 feet near Kooskia, Idaho, on the Middlefork of the Clearwater River to 10,211 feet at Trapper Peak near Darby, Montana. Average elevation is 5,400 feet. The area was selected because of high lightning fire occurrence (average 250 fires per year) and relatively little habitation.

Detection in the area is normally accomplished by 59 lookout towers, supplemented by seven light aircraft flying low altitude visual patrol. The test we conducted in 1970 did not attempt to replace the existing detection system - IR flights were superimposed on the visual system.

Four IR patrol routes were established in an attempt to maximize detection probability. Two north-south routes, each containing eight strips were laid out (Figure 6). By alternating successive patrols, we assured that areas of low detection probability near the edge of the patrol route on one strip were given high detection probability by being near the center on the next patrol. These north-south flights were flown on the night patrols.

Two additional routes (Routes 3 and 4) on east-west headings were established for daytime patrols to minimize the effects of specular reflectance.

The flight crew consisted of a pilot and an equipment operator-interpreter. The operator continuously compared imagery to maps on which the desired flight tracks were marked. He immediately noted any deviations from the desired flight track and informed the pilot who updated the navigation computer and returned the aircraft to track.

The location of fires detected was recorded by the interpreter to the nearest 40-acre block (1/4 mile) and the information radioed to the forests concerned during the turn around at the end of the run. Radio frequency interference prohibited transmitting fire locations during runs.

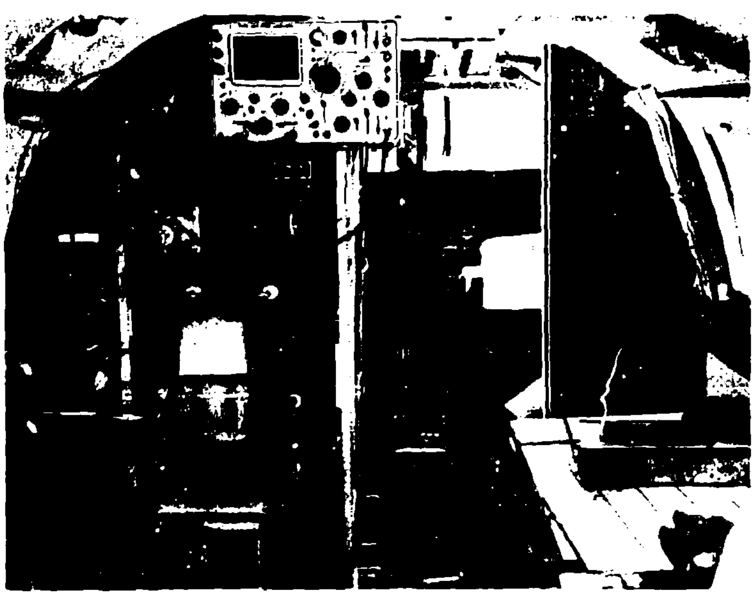

FIGURE 4. Scanner control console (looking forward), including the 5-inch film (left foreground) near real time film processor.

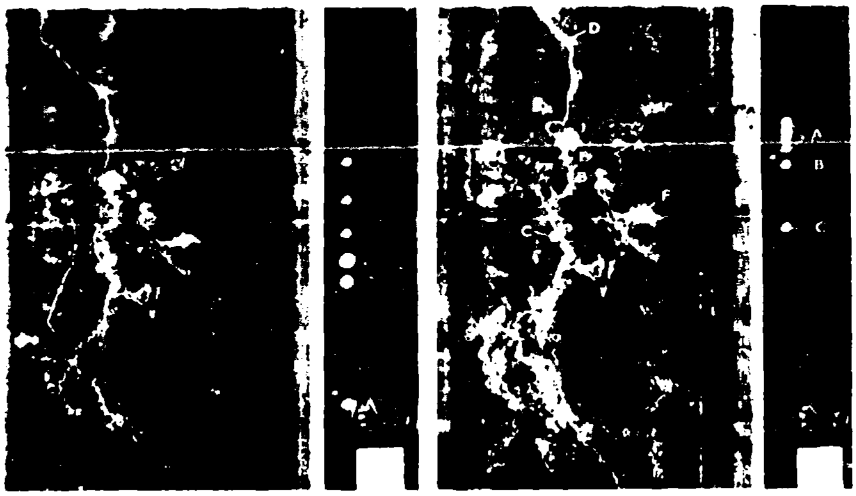

FIGURE 5. Imagery from the Yellowstone Park test in April 1970. The left-hand image is A channel with TDM input. The right-hand image is KA - B channel with TDM input, and is annotated as follows: A, TDM trips on test targets (600°C); B, Kaleidoscope Geyser; C, Excelsior Geyser; D, Fire Hole River (10°C); E, snowfield (-13.6°C); F, Hot Lake (52°C); and G, asphalt road (-9°C).

Results of the IR Fire Detection Tests

From July 7 to September 3, we flew 41 patrol missions of approximately 5-1/2 hours' duration each. Patrols were flown nightly at 23,000 feet m.s.l. (or 18,000 feet above terrain), with supplemental daylight patrols added when high fire occurrence was probable.

During this period, there were 418 forest fires in the test area that required suppression action; 12 of these fires were detected and extinguished during times when the aircraft was out for periodic inspection or involved in forest fire mapping missions. Two hundred and three of the fires were detected, manned, and extinguished before the IR aircraft had an opportunity to look at them, leaving 203 fires known to be burning when the IR aircraft passed over them. We detected 103 (approximately 50 percent) of the fires we flew over, or 25 percent of the total fires burning in the area.

Sixty-two of the 100 fires missed were only flown over once before they were seen visually, manned, and extinguished. A description of fires by detection category, size class, and elapsed time from visual to IR or IR to visual discovery is shown in Figure 7.

During the 41 patrol flights, the TDM marked 804 hot targets. While in flight, the interpreter identified these hot targets as: 169 wildfires and 635 miscellaneous targets (campfires, burners, etc.). Although these numbers do not agree exactly with those in Figure 7, they do indicate the interpreter's ability to sort out most wildfire targets from other TDM marks.

In the few cases where the location provided by the IR interpreter was different from that recorded on the fire suppression report, the IR location was the more accurate of the two.

From July 7 to September 25, over 265 flight hours were logged and nearly 500,000 square miles of terrain imaged with no equipment failures.

No firm conclusions about the relative effectiveness of IR vs. visual detection can be made from the 1970 data. There were no large fires in the test area and no serious suppression problems were encountered. None of the fires missed by the IR system became larger than 1 acre. IR detection could not be credited with substantial savings on the fires that were detected early.

We attempted to find criteria to determine which fires might have caused serious suppression problems if they had not been detected and manned when they were - we found none. We interviewed fire staff men, dispatchers, and fire control officers - all qualified and experienced men from the forests. They all felt any attempt at a subjective analysis would be meaningless. Conditions of fuel, weather,

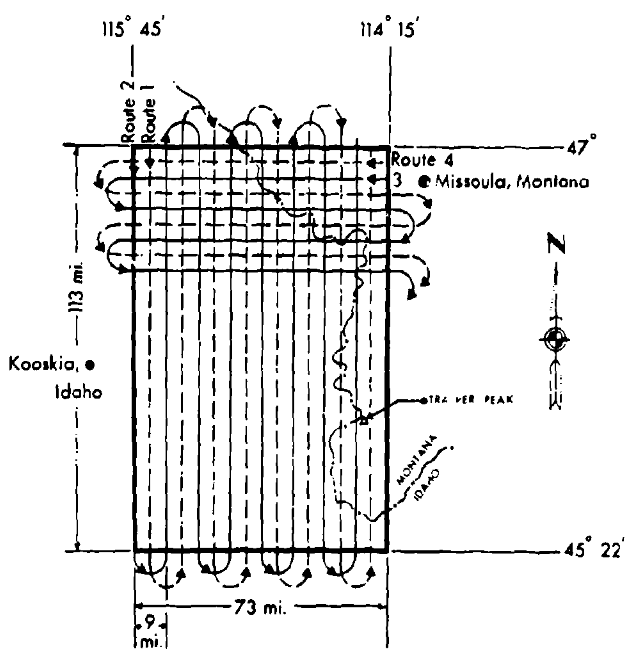

FIGURE 6. Layout of the 1970 patrol routes.

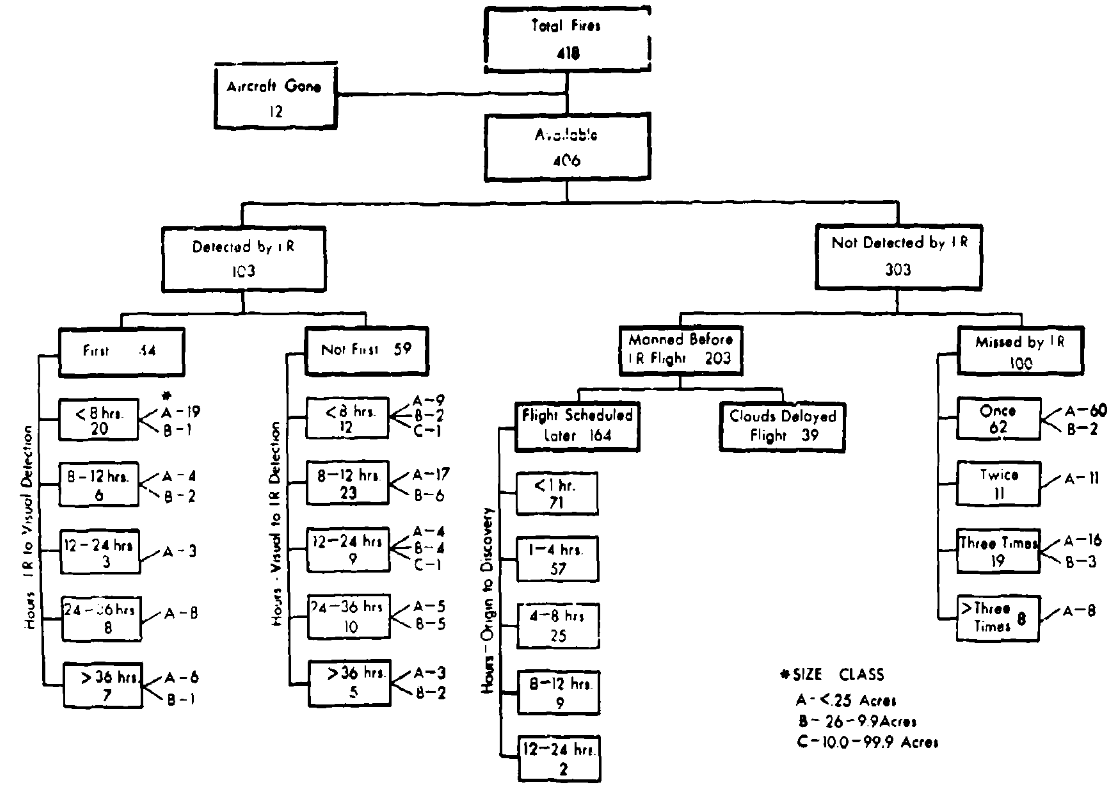

FIGURE 7. Summary of 1970 patrol test results.

and topography were just too variable.

Our limited experience has shown that the IR equipment can find fires before they become visible, but many fires become visible quite rapidly - before a planned flight. Table 1 shows the number of fires occurring during each day of the fire season. From these data, it becomes readily apparent that the effectiveness of the fire detection system is determined by its performance on a very limited number of days. If the operational strategy is in error and flights are not made at the critical times, a large percentage of the total season's fires can be missed. We need to continue IR system tests under operational conditions in combination with strategically located lookouts and well-planned visual air patrols.

We did not fly the airplane over more than 50 percent of the fires that were burning in the test area. We made a nightly flight covering the entire patrol area. If we had reason to believe that two or more undetected fires remained, we scheduled another flight within the next six hours. Cloud cover over all or part of the area delayed some flights and even caused us to cancel a few. By the time we did fly, many fires had smoked up, were seen, manned, and extinguished.

TABLE 1

Fires originating by day* in the patrol area during 1970 fire detection flights

July	No. fires	August	No. fires	September	No. fires
11	2	1	17	1	5
12	12	2	6	2	3
13	8	20	1		
16	54	23	1		
17	7	24	16		
18	3	28	1		
19	2	31	227		
20	8				
21	15				
22	2				
25	1				
27	15				
28	11				
29	1				
Total	141		269		8

Total fires in project area from July 7 to September 3 = 418

*No fires reported on days not shown.

Daily fire occurrence patterns for the past season show that flying the entire area was not the optimal strategy. Lightning storms usually followed paths that included only small portions of the area. By waiting until conditions were right for a full flight, we lost the opportunity for early detection.

Forest dispatchers can provide up-to-the-minute weather data and storm pattern information. Areas of prime concern can be delineated prior to flight time and routes planned to provide overlapping coverage and high detection probability. Flights can be made at reduced altitude, below cloud cover, when the intent is to cover a specific part rather than the entire test area.

IR Fire Mapping

The bispectral equipment was used to map 13 large forest fires in Montana and Idaho during all phases of fire suppression; five large fires burning in the State of Washington were mapped shortly after control. Prints of the imagery were made as soon as the airplane returned to base, and delivered at dawn to the fire camps by light aircraft or helicopters.

Interpretation of the imagery at the fire camp was simple and anyone with even a minimal background in aerial photography was able to do a good job with little additional training.

The ability of the equipment to mark the small, hot target is invaluable during the final cleanup work. Fires too small to print on the image can be identified and located by ground crews. This provided the fire boss with information never before available to aid in making decisions on manpower needs and placement (Figure 8).

Fire Spotter

During the summer of 1968 we became aware of the need for a device to pinpoint small fires that had previously put up enough smoke to be detected visually. The smoke output often dies down after initial detection and suppression forces are unable to locate fires from the descriptions given by the lookout or air patrol who first saw them. We felt that a simple, inexpensive, airborne, IR line scanner would be useful on light aircraft or helicopters to assist in locating these fires.

We built a feasibility model during the winter of 1968. It had a resolution of 10 mrds, scanned 120°, and used an uncooled PbSe detector filtered for the 3µm to 4µm region. This airborne "Fire Spotter" detected 1-square-foot, 600°C targets at altitudes up to 2,000 feet above terrain against daytime thermal and solar backgrounds. After preliminary flight tests, we improved the design and produced 10 prototypes for evaluation during 1970 (Figure 9). A commercial

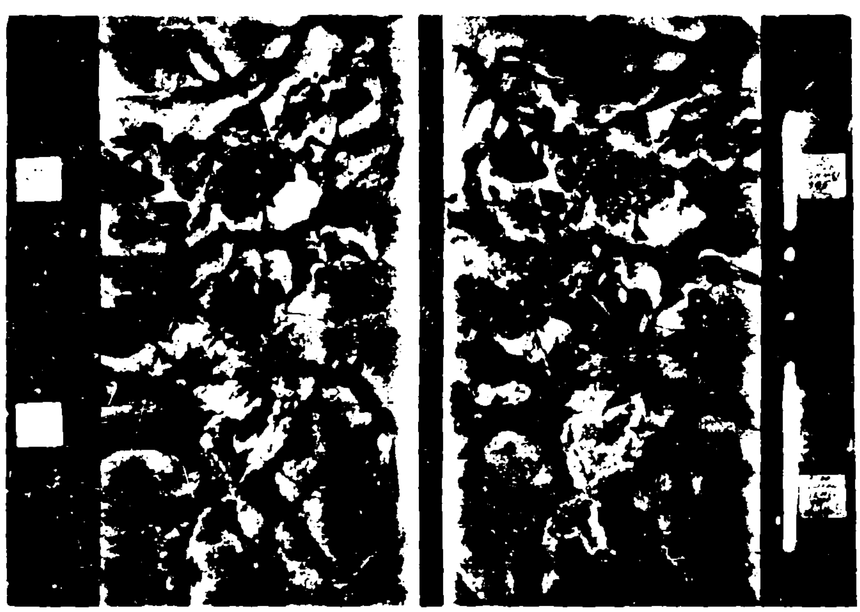

FIGURE 8. Imagery from fire mapping mission, August 30, 1970

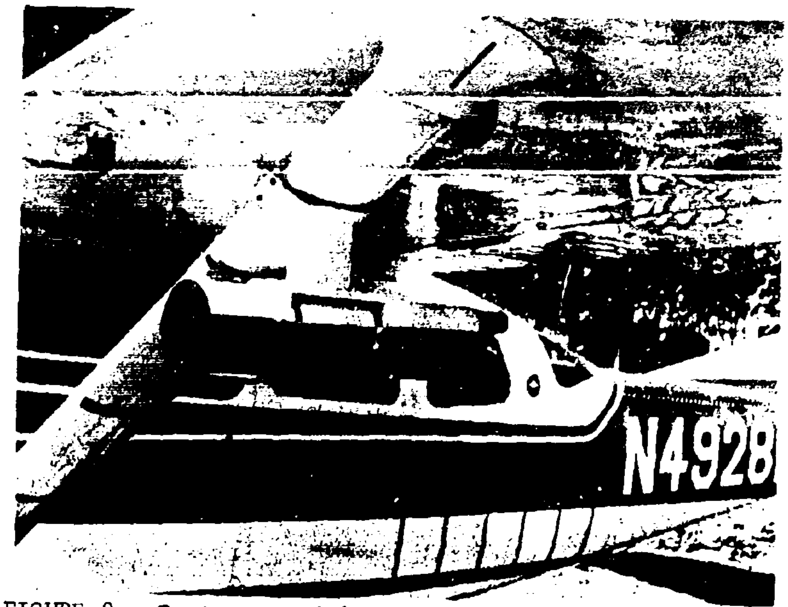

FIGURE 9. Prototype airborne fire spotter.

version, produced by Barnes Engineering Company, became available during 1970 (Figure 10).

These scanners employ a simple threshold detector to discriminate fire targets from background. The output from the threshold detector activates a horn and one of five lights to indicate which 24° segment of the total 120° scan contains the target. The spotters were mounted on forest air patrol planes for testing. An excellent example of the usefulness of these devices in conjunction with the high altitude IR patrols occurred on July 16, 1970.

The Granite Creek Fire in the Nezperce National Forest started from a lightning storm on either July 10, 11, or 12. High altitude IR patrols were flown on July 14 and 15 (patrol terminated at 0400 hours on 7/16). The fire was missed on the July 14 patrol but detected on the night of July 15. The IR image shows two fire targets - one of them a camp fire at Twin Lakes and the other the latent fire (Figure 11).

We flew over the fire at about 1000 hours on July 16 with the commercial fire spotter mounted on a Cessna 182. There was no smoke visible. The fire was missed on the first pass but picked up on each successive pass. After four or five passes, we were able to locate the fire. On one very low altitude pass looking into the sun, we did see a small wisp of smoke. Smokejumpers from Missoula were unable to jump on the fire because they could not find it visually.

One of our project people walked into the fire, leaving Missoula late on the afternoon of July 16. At about 2200 hours that

FIGURE 10. Commercial version of fire spotter.

evening he camped about two miles from the fire. During a very heavy rain shower he saw a tree burst into flame at the fire location. He arrived at the fire on the morning of July 17 and reported that the fire was not producing enough smoke to be visible from the air. He measured approximately five square feet of burning material at a temperature between 600° to 700°C. He extinguished the fire late in the afternoon of July 17 when a burning log began to roll downslope toward heavy fuel where it could have started a major fire.

Results of the 1970 fire spotter testing were very encouraging.[2] Fires that had been previously reported were located and manned even though not smoking. Others were found in areas where none were supposed to be, such as in controlled burns that had been extinguished and outside the control lines of large fires.

The equipment if properly used can perform a real service as part of the total IR detection system.

Future Plans

During 1971, an updated bispectral fire detection system will be operated by National Forest personnel rather than our research group in the same test area flown during 1970. Twenty-five of the 59 lookouts in the area will be left unmanned. The IR aircraft will become part of the operational fire detection system. The equipment has been improved by replacing much of the electronics used in 1970 with integrated circuits. The recorder has been replaced with a unit employing a fiber optics CRT and heat-processed, 9-1/2-inch-wide dry silver recording paper. The recorder will produce 8-inch-wide, rectilinearized imagery with over 4,000-line resolution and 12 gray shades. Our major effort will be concentrated on developing strategies to effectively integrate this new tool into the overall fire suppression system.

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2. Kruckeberg, Robert F.: "No Smoke Needed," USDA Forest Service Fire Control Notes. (In preparation for publication)

APPENDIX I

The radiant energy from a forest fire (600°C) peaks in the 3µm to 6µm region. If a 600°C target fills less than 2×10^{-2} of the field of view of the scanner, the target's signal-to-background ratio

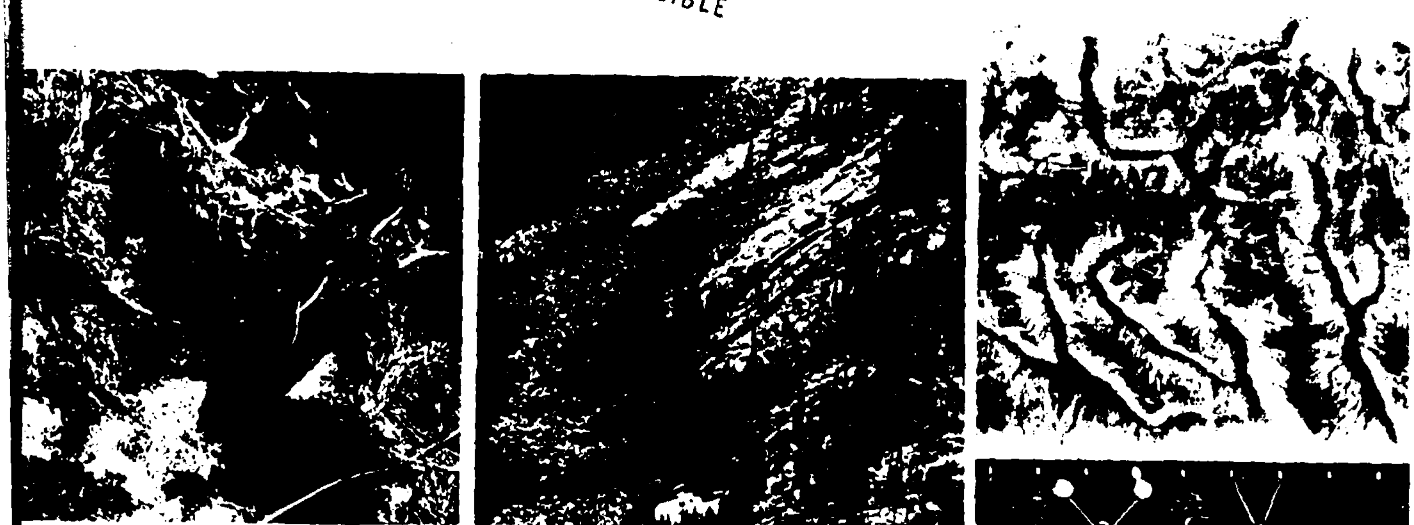

FIGURE 11. Granite Creek Fire, Nezperce National Forest. This lightning-caused, latent or incipient fire (A) occurring in one tree in this area (B) was first spotted in this imagery (C) which was recorded at 0005 hours on July 16, 1970, in an aircraft flying at 21,000 feet. The fire was still burning when photo B was taken. The imagery is annotated as follows: (1) Target is a campfire at Twin Lakes; (2) TDM marks (double marks at latent fire are due to aircraft pitching during the run); (3) actual fire; and (4) navigation marks at 1-mile intervals.

in the 3µm to 6µm region is insufficient to distinguish fire targets from background thermal anomalies. In the 8µm to 14µm region, the target's signal-to-background ratio is less than it is in the 3µm to 6µm region. Because the background signal is coherent between these two spectral regions, we wondered if we could algebraically sum the signals to improve the signal-to-noise ratio.

Figure 12 shows the 3µm to 4µm (A) and 8.5µm to 11µm (B) signals from both terrain background and fire targets, as seen by a 2-mrd system from 15,000 feet, plotted in two-dimensional vector space. The lower curve contains all background temperatures from 0° to $60^{\circ}C$.* The area above the curve (shaded area) contains target signatures from fires ranging in temperatures from 600° to 800° C, areas ranging from 1 to 10 square feet, angles of view from 0° to 60°, and obscuration ranging from 0 to 95 percent. Amplitude discrimination in the A channel (horizontal line) would not provide effective separation of targets from background, nor would amplitude discrimination in the B channel (vertical line).

A sloping, straight line separating the lower curve from the target points does provide discrimination for most targets. The equation of that line is:

$$A = KB + C$$

where:

$$A = \int_{3}^{4} W_{\lambda} T_{A} T_{F_A} R_{D_A} d\lambda$$

$$B = \int_{8.5}^{11} W_{\lambda} T_{A} T_{F_B} R_{D_B} d\lambda$$

K = slope of discrimination line

C = displacement from origin

W = Planck function

T_A = transmission of atmosphere

T_{F_A} = transmission of A channel filter

T_{F_B} = transmission of B channel filter

R_{D_A} = responsivity of A channel detector

R_{D_B} = responsivity of B channel detector

or, rewriting and redefining K

$$K'A - B - C = 0$$

* Variations in spectral emissivity will spread the background points, forming a band rather than the discrete curve shown in Figure 12.

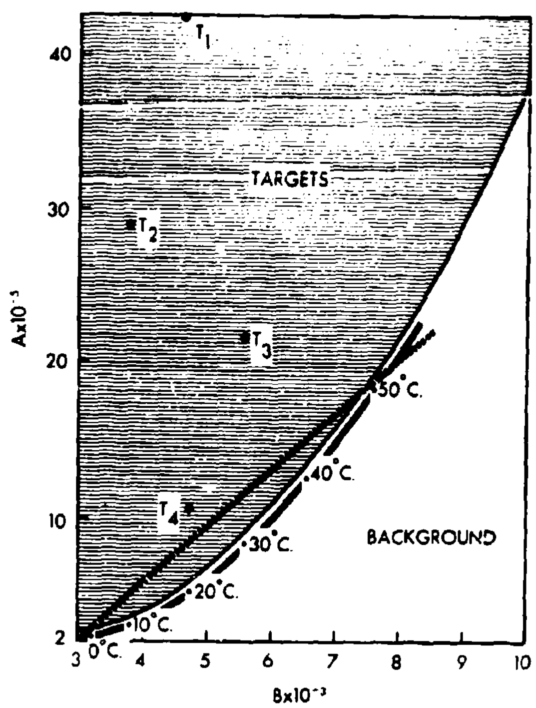

FIGURE 12. The signals for both targets and background, as seen by the 2-mrd IR detection system from 15,000 feet, are plotted in two-dimensional vector space, where A is the 3μm to 4μm and B is the 8.5μm to 11μm vector. Annotation of the target and background temperatures, areas, and angles of view for targets is as follows: T_1 - 1 ft.^{2}, 600°C, 20° background, 0° angle; T_2 = 1 ft.^{2}, 600°C, 10° background, 30° angle; T_3 = 1 ft.^{2}, 800°C, 30° background, 60° angle; and T_4 = 1 ft.^{2}, 600°C, 20° background, 60° angle.

K is the slope of the discrimination line. It is determined by the range of background temperatures we expect to encounter. If the background temperature range can be predicted for a given flight, an optimum K can be selected. An effective decision rule and one that is easy to implement in an analog system is: A target exists if the signal is greater than KA - B. A nonlinear function that more closely matched the lower curve would be an even more efficient rule, but it would be more difficult to implement. We employed the KA - B function and found it quite effective.

To minimize the effects of changes in atmospheric moisture, we selected the 3μm to 4μm and 8.5μm to 11μm bands rather than the total 3μm to 6μm and 8μm to 14μm windows. We empirically selected spectral regions centered around 3μm and 8μm , where the ratio of the power is relatively insensitive to changes in atmospheric moisture.

The Bispectral System

The 8.5μm to 11μm channel produces high quality IR imagery from which the position of targets can be accurately determined with respect to terrain features.

The KA - B signal is pulse-height/pulse-width discriminated. A pulse above a preset threshold and within the pulse-width* limits produces a logic pulse that is stored in a digital memory for one scan line. To eliminate false alarms caused by electrical noise, we made use of the overscan available to do scan-to-scan comparison. If a logic pulse is produced at the same point in two successive scan lines, an output pulse is generated. The output pulse produces a mark on the edge of the film and reinserts a pulse in the video, which cues the operator (Figure 13).

The curvature of the function shown in Figure 14 permits selection of two temperatures where the KA - B signal amplitude is equal. To calibrate the system we select a pair of temperatures that will produce equal signals in the difference channel for the desired K value. We set the internal calibration sources at these temperatures,** and then adjust the gain of the 8.5μm to 11μm channel until the signal from the two sources is equal. This simple procedure assures that the ratio of total gain (amplifier, detector, and optics) in both channels is optimum for differentiating between targets and any preselected background range.

The receiver is a modified Texas Instruments, RS-7 line scanner.*** The two detectors (Ge:Hg and InSb) are mounted side by side in the focal plane along a line perpendicular to the rotational axis of the scanning mirror. The signals from the two detectors are put in register by time delaying the InSb signal.

The Ge:Hg preamplifier is direct coupled and contains an automatic bias loop to maintain the detector at optimum bias. The 3-db

* Pulse-width limit is set to equal the dwell time for one resolution element.

** Atmospheric transmission is not included in the integration for A and B in Figure 14 since the path between the detector and calibration sources is short.

*** The use of trade and corporation names in this publication is for the information of the reader. Such use does not constitute an official endorsement by the U.S. Department of Agriculture of any product to the exclusion of others which may be suitable.

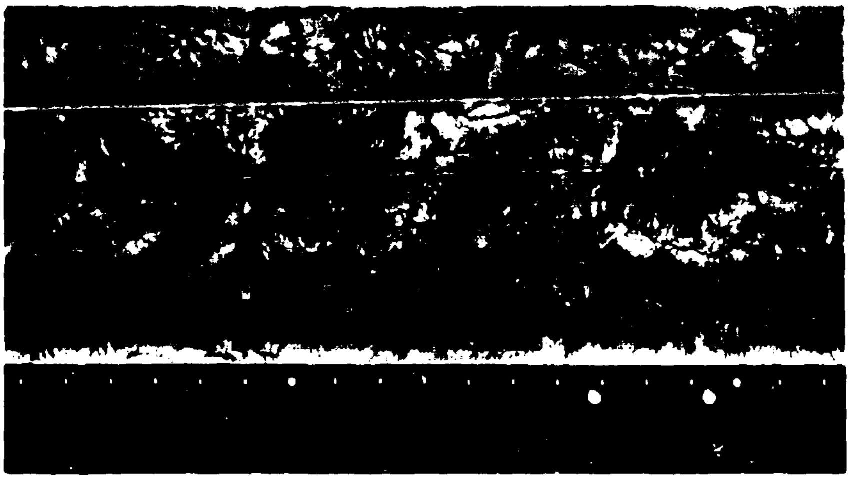

FIGURE 13. Imagery from 1970 patrol flight, August 19, 1970, at flight altitude 23,000 feet m.s.l. Mileage marks, spaced 1-nautical-mile with large mark every 10 miles, are recorded from Doppler navigation system. Target 81906 is believed to be a campfire located at the junction of a trail and target 81907 is a campfire at Mud Lake.

bandwidth is 0 to 300 kHz. The InSb preamplifier* is ac coupled to 250 kHz. Extreme care was taken in the design of the $3 \mu m$ to $4 \mu m$ preamplifier to provide the best signal-to-noise ratio for the very low signal amplitudes available from the filtered InSb detector.

A synchronous clamp after one ac coupling in the printing video dc circut maintains the dc reference required to eliminate overshoot, undershoot, and ringing that would otherwise obscure terrain detail when high amplitude signals from large fires are encountered.

The IR equipment was installed in a pressurized turboprop aircraft (Beechcraft B90 King Air), with a range of approximately 1,200 miles, average groundspeed of 200 knots, and a service ceiling of 28,000 feet. In addition to the IR equipment a Doppler radar and navigation computer were installed to permit accurately flying predetermined tracks.

* The InSb preamplifier was designed and built by Texas Instruments, Incorporated.

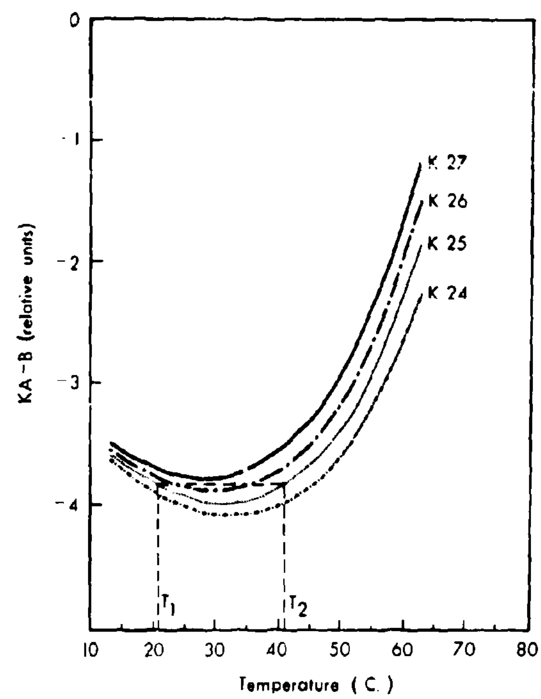

FIGURE 14. KA - B signal plotted against temperatures for several values of K. To calibrate the system, T_1 and T_2 are selected to produce equal signals in the difference channel for the desired K value.

DISCUSSION

Dr. Fristrom: I would like to ask Major Scarff whether there is a considerable loss of time in hooking the fire suppression device onto the bottom of the helicopter and whether the sling-type would improve this. Has this been looked into?

Major Scarff: There is a slight loss of time, 15 seconds under normal wind conditions; the stronger the wind is blowing, the harder the helicopter is to control. The hook has been redesigned over the years. It now has a forward opening hook, a forward spacing opening, and the ground crewman who is under there with the ring attached to the cables of the kit has this aligned with a hook in it and the instant the airplane comes within range he simply hits it, slams it in, and it is on just that fast. It costs us 15 to 20 seconds per hookup.

Captain Prichard (National Aeronautics and Space Administration): First, I would like to say how much I have enjoyed this symposium. There was comment about the Russians; possibly some in the audience have seen the film of the 50th Anniversary of Russian Aviation. If any of you have not seen it, I wish you would because it is documented proof of how far behind we are, particularly in the field of heavy-lift helicopters. I think this is an area in which we need to go forward; to date the military has been trying to do this, but there are many other needs for heavy lift helicopters and some of them have been discussed here. We should explore some of these mutual agreement concepts about the use of helicopters. If we had heavy-lift helicopters for fighting forest fires, ones that could take in heavy equipment, these would also be of benefit to police departments in clearing road blocks for riot control and things like that. There are mutual support agreements with the military who turn out for natural disasters such as hurricanes, but calls to the military seem limited when it comes to fire fighting in large major disasters.

Mr. Lowden: I would like to give the military a real boost for helping on fires; there has been a lot done by the military but there has not been enough publicity about it and that is something that the various agencies are trying to cure. There have been negotiations on how the military can help more and I am sure this will get more attention in the future.

Major Scarff: I would like to respond to that. We appreciate your comments. We agree that we need to look at heavy-lift helicopters. We are thinking of their use in lifting logs out of forest areas, and we are very much interested in doing this from an environmental standpoint. Some of our conventional logging methods are rather tough on the environment; if we can get heavy-lift helicopters, we may be able to change some of these systems in a very beneficial way. The same helicopters can be adapted both to lifting logs and fighting fires. I would like to express our appreciation to the Aerospace Industry for the interest which they have developed over the last several months. Not only are helicopters useful, but we can also utilize modern aircraft if we develop specific systems for the use of aircraft.

Question from the audience: What do you think the chances would be of exploring an International Conference? Maybe getting together with the Russians on forest fire fighting?

Answer: I think probably there would be some possibilities. I wonder if you are familiar with the international agriculture aviation conference group that holds world-wide conferences. Their last meeting two years ago was held in Canada (first time in North America), and there was a considerable part of the program devoted to this very thing. The Russians were strongly represented there. I believe they had five or six people and they brought one of their reciprocal helicopters with them and demonstrated so that everybody had a chance to see. In fact, there were many representatives from various countries behind the Iron Curtain - as well as Cubans, Chinese, and many others. That international group continues with headquarters in the Netherlands, a permanent organization. They are devoted to agriculture and the forest fires are related but as a result of the last meeting, I think they are going to give more attention to this international aspect.

Mr. Lowden: We have representatives here from Canada. We would like to hear from them. Dr. Williams, I wonder if you would like to speak.

Dr. Williams (Canadian Forestry Service): We certainly appreciate being here. As you may know, our Prime Minister has recently returned from a trip to Russia at which time he expressed an interest for a greater exchange of developments (recent equipment developments, this sort of thing) with the Russian people and, as you mentioned, the international conference at Kingston a few years ago had a number of Russian forestry people over on a tour. One of our research coordinators, Mr. J. C. Macleod, spent some time over in Russia not too long ago where he saw quite a bit of their fire control equipment.

Much of it was very, very similar to what we have but other pieces were quite different. They use helicopters quite a bit. They use large helicopters to haul in water for fire retardants. One thing that they have that I do not think any other country has, is a sort of a helitack crew that rides in these larger helicopters and slides down ropes. It is not exactly a rope, it is a tape which is in a container on the fire fighter's belt and he simply hooks that on and slides down and fixes equipment and then the helicopter goes out and picks up water retardant and comes back to help him out. I do not know how widespread that system is, but we have some pictures of it and there is no doubt at all in my mind that they have the same problems we have, and they are working on them and we should be exchanging some ideas with them. I wish this could be extended. We have occasional exchange of correspondence with them, but sometimes we have difficulty in getting letters back and forth. Maybe our Prime Minister could do a little more to clear up this problem for us.

We have listened with very great interest to all the speakers here and we are in pretty close contact with most of the fire service people. We try to keep in touch with what is going on and we have gained a tremendous amount from this and we hope to contribute something from time-to-time. We are a small organization and cannot contribute as much as we would like, but we certainly hope to do more in the future. We will try to keep our people coming down to conferences such as this and to have individual contacts with your people.

Mr. Lowden: We appreciate your remarks and your participation in the symposium. We have had a number of opportunities in recent years to take advantage of your hospitality.

Dr. Emmons: I want to make a general comment. As I have listened over the last couple of days to these various developments that have been described and the successes that you have had. I have been impressed with the ingenuity that has been applied to developing all of the gadgets and the pack methods and it seems to me that there is probably considerable room for improvement in the direction of the manufacturer, representatives of the forest service and urban representatives getting together with manufacturers to see what the best possible compromise would be. It is clear that there are many things that the helicopter has that were not designed for fire purposes and it is clear that the techniques of the firemen as they adapt them do not quite fit on the helicopter, but they do the best they can.

What would you like to do if you could ignore the money entirely? What would be the best possible compromise of all the potentialities of the aircraft and all the potentialities of the fire-fighting techniques? I think more of the urban area where there has been least exploration of this. It seems to me it would be possible to come up with a much better design, or much better utility and flexibility. You would not, of course, come up with a design which could then be financed; it undoubtedly would be too expensive, but at least you could get the right compromise, whereas at the moment it is a case of fiddling a little here and fiddling a little there. I wonder if the Air Force, which is a coherent organization that has a budget, has even gotten together with the manufacturers on this kind of a basis.

What would we really like to do and what approximation to it can we reach?

Similarly, in the urban area, I do not think we as yet have any coherent organization with enough money to do this job at all. The Fire Research and Safety Center, which, in principle, has the possibilities of doing this does not have enough money. Eventually, in the urban area, it seems to me that a lot can be done with designing a hover package to be delivered to a location in spite of traffic. If you have to move it from one place to another, you do not move it on it's own wheels, you come pick it up and put it in the new location. Has this a real potential or hasn't it? Seems to me a fairly general study on these questions might result in considerable long-range improvement.

Dr. Rockett (Office of Fire Research and Safety, National Bureau of Standards): I think there is a good deal of merit to our getting together. I think that if we did, it could most practically be done jointly with the Air Force, and Forest Service, because it seems obvious that there could be multiple uses for this helicopter even if it were optimized for any one of the uses. Chief Houts has all of the problems you have now and he has all the problems Ray Hill has in the same operation. What is needed is a helicopter that can do a variety of tasks. I have talked with a number of people several times about the strictly urban applications of the helicopter. We have spoken about the day and night operations and I gather that Chicago does routinely, within the urban area, operate at night because of good landmarks well-illuminated. There is considerable interest in the techniques of landing equipment on top of buildings, the extent to which this has actually been done, and the extent that is still experimental. I think we need to use as much imagination as we can in adapting this device for urban operations. At the present time (this is my impression from this meeting), we have only scratched the surface and mainly are using the helicopter as a rescue device. Can we land on roofs of high-rise buildings that have not been designed and built for that purpose? Can we land on present structures without having them prepared? Can we land at night safely in a city where we have streets well-illuminated for landmarks? To what extent have we done the things that we have heard about, or are they experiments?

Mr. Hill: We do not land on roofs of buildings that do not have heliports on them. However, we use the same technique that we have seen here in many slides showing hover jumpers. We go up and get down within two or three feet of the roof and a man can literally make a short jump from the skids out to the roof. We have done this many times in practice sessions. It is primarily experimental only because we have not had too many fires in the high-rise buildings. We only recently started building high-rise buildings in Los Angeles. However, in that one fire that I referred to in the 21 or 22 story building, we did lift men and equipment to the roof of this particular building and it did not have a heliport on it, so this technique can be used. When you have a greater alarm fire it has been our experience locally that, when you call additional companies, you need them for manpower and not necessarily for the equipment that they bring with them. They ride on equipment, so the equipment is there but it usually stands idle. If you had high concentrations of men in two or three locations and could airlift men in very rapidly to the scene of a fire, I think you would be getting down to the meat of the problem. We have a tendency in the fire service to try to improve on what we did yesterday; make it a little smoother, a little bigger, or a little wetter. I think we need to stand back and look at our operations and decide what we really are trying to do instead of looking at what we did yesterday and try to improve on it a little. It is like the man who is trying to improve a water well. He digs it a little deeper, puts in a little better pump, and so on, but maybe the well was dug in the wrong place and he ought to dig it somewhere else.

Mr. Lowden: I think we have had a fine discussion. I wish we could go on with it, but we do want to get to the general summary. I think this discussion that we have had has brought something into focus that has been bothering me. Those of us in the forest fire business have been telling you about so many things that I began to think that you might wonder if our presentation has any application to you, or is all this a forest fire meeting. I am sure it was not planned that way at all. We are hopeful that the applications will be made. I know that the ideas that have been suggested can be applied. There is a great future for aerial operations in urban and structural fires and also in the increased use of chemicals. I recall speaking to one fire chief of a very large department in the U.S. and asking him if they use any helicopters, and he said, "No, we've got no place for those machines." I think he will rue the day that he talked like that.

GENERAL SUMMARY AND DEVELOPMENT

R. Keith Arnold

Because we have had four summaries of the meeting, I am not going to give a complete summary here. Let me briefly read you what we have heard: from Chief Houts - the helicopter is the most significant advance in fire control in the past 50 years; Chief Volkamer - 180 lives saved in the first year of helicopter operations; Mr. Pierce - 26,000 hours of helicopter use by the Forest Service; Mr. Chandler - helicopters useful as a fire truck on urban fires in some special situations. Mr. Shields gave something quite significant, that helicopters are all basically designed for carrying people and we need some types designed for fire suppression. We learned from our manufacturing panel that there are continuing developments and I hope we were able to impress them with some of our needs. Mr. Thorsell showed us a number of problems that the FAA faces, and that we also face in the utilization of helicopters. Chief McCullom's paper on communications pointed obviously to the need for systems and operations research. Mr. Fergusson made us think about how we can really operate helicopters with the tremendous cost and the safety factors, etc. Mr. Hastings made this point, that obviously an air attack on fire without coordinated ground attack may be in large measure worthless; on the other hand, with proper integration it is an extremely valuable tool. Mr. Barrows again brought up and emphasized the systems viewpoint and that the selection of a chemical to add to the effectiveness of water cannot be done unless it is integrated and tested and evaluated into the entire system. Mr. Suggs showed what could be and is being done, and suggested that we have capabilities that many of us do not realize. Major Scarff showed us a completely operational fire and rescue system.

I have three conclusions. The first is that there is a new technology, a new tool, rapidly becoming available for the fire services, but it is being used by only a relatively few of the more innovative services in the country today. Is there anyone here who would disagree with that conclusion? The second conclusion is that we are not going to get very far just by adding a helicopter to the transportation devices we already have. We will need a highly integrated, sophisticated fire service system and systems research which will deal with personnel, maintenance, operations, and tactics. The third conclusion is that the fire services in the U.S. do need the planned development of an aircraft fire vehicle. Those are the three conclusions that I come up with. In the absence of any dissenting opinions, I think that the Proceedings will show that the symposium was in complete agreement with these conclusions.

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