FLYING COSTS IN FORESTRY PROJECTS

By

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INTRODUCTION

In forestry there is a distinct need for better knowledge of the fundamentals of flying costs. This need is felt by both public and private concerns, whether large or small. These concerns are potentially interested in flying as a new method of attaining their objectives in forestry, and as an adjunct to methods already in use.

Interest in flying has had a tremendous stimulus due to the war. This has come about through war publicity, technical developments, and wide use of aircraft. Wartime activity has added greatly to the supply of planes, pilots, knowledge, and adaptations which characterize the field today. Briefly, the kinetic nature of flying activity, and its dramatic use in war has created an intense public interest, as well as an increased public acceptance of the usefulness of aircraft.

Since the war, aircraft industries have sought to continue the high wartime volume of business by increasing peacetime use of aircraft. Hopes, promises, and general anticipation was too high for awhile. Two large lightplane manufacturers went into the hands of receivers in early 1947. There was a large amount of surplus military aircraft on sale at low prices, but the chief reason for the recession (1) was the attitude of the customers. Many of them were suddenly discovering that they couldn't afford to fly. Newspapers in search of dramatic news to maintain their wartime quota of "Headline Violence" gave widespread publication to the comparatively few tragedies which make up an average year's safety record in commercial flying. These are only a few of the factors that have entered into the consideration given by many concerns to the adaptation of flying to their particular business.
Flying has increased in the field of forestry both during and after the war. During the war much of it was supported or granted by the federal government as a national defense measure. The various instances of cooperation by the armed forces during wartime have added much to the forester's appreciation of the potentialities of flying. There are interesting reports on experimental work done by the Army with helicopters in Southern California. Some of these are contained in the 1946 "Fire Control Notes" published by the Forest Service. In spite of all the recent developments, flying has come far from reaching its expectations as a new expedient to the objectives of forestry and other peacetime operations.

THE PROBLEM

One of the main reasons for the shortcoming is the inability of the average man to get a clear picture of the costs incident to aircraft operation so that he can compare it with other methods of attaining his objectives. Military flying has distorted our picture of flying costs. During war the armed forces were more or less unlimited by money costs in their flying equipment and operations. This condition left a distorted impression on the mind of the public. People were not brought to realize that flights commonplace in wartime were costing prodigious sums of money, money being a secondary consideration to the objectives of war.

TOO MUCH HIRED FLYING

In view of the dilemma of forest agencies in acquiring the services they anticipated from aircraft, it is understandable that there has been an overbalance of hired flying as compared with flying done as a subsidiary operation of the forestry concerns. Except for
the recent program of the Forest Service in Region Six there have been only rare instances of airplane ownership by forestry agencies in Oregon. The State Board of Forestry is reported to have operated their own airplane for a time.

It is in this question — to hire, or to buy aircraft — that the knowledge of cost is of prime importance. Because plane owners have a better knowledge of the costs there have been many foresters who have foregone this study by adhering to a policy of hiring the services of aircraft owners. This condition is not conducive to further development of specialized services because the average commercial flyer is not so keenly interested in the foresters' work. An instance of illustrating this occurred recently when a large timber concern sought to add to their photographic survey which was being used in mapping part of their holdings. A local flyer was given the contract and proceeded to take pictures with a Piper Cub, flying at an altitude of ten thousand feet which is very near the maximum for this lightplane, carrying a reasonable load of equipment. The photographic specifications demanded an altitude somewhat higher, but were foregone because the plane could not attain this altitude. It is obvious that this work was being done very inefficiently because the range of efficiency of any aircraft does not extend to its absolute ceiling. It can be assumed that the contractor was being overpaid for the service he was performing, or that he was losing money on the operation. This situation called for an investigation of the type of aircraft which would deliver the cheapest photograph with the desired altitude requirements, as well as an investigation of the best method of obtaining the service — by hiring, or by purchasing an aircraft.
Aircraft salesmen often are the main source of information as to the costs of owning and operating aircraft in the newer fields of usage. The average buyer is not willing to rely on sales talk alone as the basis for judging an investment. He prefers unprejudiced information, or at least a diversified source of information for purposes of comparison. To that end some disinterested parties have made cost studies and reports on the more prominent developments in the recent expansion of airplane usage.

This paper will attempt to show how methods of evaluating flying costs can be adapted to the forestry field. It recognizes the valuation commonly associated with hiring planes. These costs, on other than personal-type airplanes, run from $20.00 to $40.00 per hour (2), and the owners lack a necessary interest in improving the service available to forestry. Again, it is not uncommon for small commercial flying concerns to have a poor picture of their cost structure.
DEVELOPMENT OF COST STUDY METHODS

In the field of forestry particularly, it is true that the relationship between expense and utility is the determining factor in instigating any development. If there is an understanding of the elements that comprise operating costs, every major decision is made easier and more correct. The professional forester is continually in need of short formulae and rules of thumb which will permit him to make estimates on the various operations that contribute to his central occupation. It is possible that numerous officials of forestry organizations have passed up excellent opportunities for improving and economizing their operation simply because they did not know how much some new development or equipment would cost. Nearly all Forestry and Fire Protection organizations are aggressive in their search for new methods, because their work is far from the methodical stage. As regards the use of aircraft in forestry work there has been a limited amount of aggressiveness, and much of it because there was no generalised system of evaluating costs of flying operations. There is however a strong desire to know if flying can be incorporated into a variety of operations. Nearly every forester has his work spread out over a major land area, hence three of his major problems are: travel and freight distance; travel time, and visual coverage. All three of these problems are mitigated greatly with speeds and altitudes which can be achieved only by flying.

RECENT CONTRIBUTIONS IN COST STUDY

"A precise method of calculating operating costs for light aircraft is needed -- a method that will reduce the many variables to simple factors which will enable the
determination of costs under all possible circumstances. A suggested method has been developed which, while presented as an equation for determining costs of personally owned aircraft, is also applicable to company-owned planes with but a slight variation in the formula."

This statement appeared in the November, 1945 issue of Aviation in an article written by Berboth (3). The article itself will serve as a context for this paper, and the formula will be executed in sampling forestry flying costs.

Professor Skinner (4) of the School of Mechanical Engineering at Oregon State College, has made a similar study, in which he has incorporated the functions of the formulae into graphs from which the various cost factors can be assembled for lightplanes, and reduced to year, mile, and hour bases. By his permission this charted graph system is included herein, and a sample problem is worked thereby. These are the extent of the present local studies, and they are incorporated in the Ground School course for advanced pilot training at Oregon State.

The background for such studies is generally based on technical information which has been available since before the war. A detailed research report called "Tomorrow's Customers for Aviation" by the Crowell-Collier Publishing Company of New York (1) was put out in August, 1944. It does not deal with specialized use of aircraft, but it does relate the results of much research in public opinion to the research which is continually going on in the engineering phase of aircraft efficiency. This latter material is perhaps best represented by the efforts of the Civil Aeronautics Authority which has compiled vast amounts of technical information on nearly all types of aircraft, and in many flying projects.
METHOD AND PROCEDURE OF THIS WORK

An attempt has been made to secure data as to the need for cost information in the forestry organizations of the Willamette Valley. Since fairly complete information is available as to the expense of doing forestry work by hiring service of outside flying concerns, it was decided to check on organizations which are operating their own aircraft, or wish to operate their own planes. Conference with faculty members and others gave no clues to such organizations in the immediate vicinity. Inquiry was made at the hangar of Forest Service Region Six, Fire Control Division in Portland. A Mr. Soehler, in charge of aircraft maintenance and operations, was contacted. He indicated that there was no assembled and recorded information other than the records of expenditures for the two-year-old project.

This project is an outgrowth of Forest Service experimentation which resulted in aerial delivery of supplies and fire fighters in Region One during and prior to the 1940 fire season. A very good report on this work was made by Torrey A. Newton (2) in 1941 in his thesis "Aviation in Forestry". Previous to the aforementioned experiments, the Forest Service Records indicated they had owned only one plane.

Further inquiry at the Fire Control Division's office in Portland failed to add to the information received at the airport. Since this time there has been a pre-season school at Roseburg in which some additional information was given as to the cost per pound of supplies delivered, along with other recent findings of the Forest Service. Forest Service findings will be dealt with later in this report.

VARIABLE COSTS

There are several types of specific costs which go to make up total operating expense. These are: fuel and oil, maintenance and
repair, hangar rentals, insurance, and depreciation.

To start building the formula it is necessary to reduce the fuel, oil and maintenance costs to a common denominator of dollars per horsepower-hour since these costs are the only ones that vary with the number of hours flown. In this way all that need be known is the horsepower of the ship, and how many hours it will be flown, to determine how much it will cost for gas, oil, and maintenance for a year's flying. Adding this sum to the more or less fixed costs of the other items will give the total cost.

The cost of 73 and 80 octane fuel varies generally from 24 to 33 cents per gallon throughout the nation, with the national average being 27 cents per gallon, or 0.5 cents per pound, according to a major oil company. The cost of oil also varies, with the national average being approximately $1.30 per gallon, or 17.33 cents per pound, according to the same source.

Fuel and oil consumption usually varies with the kind of engine and the horsepower used for cruising. Most lightplane engines have a fuel consumption of 0.52 pounds per horsepower-hour, and since most flying is done at cruising horsepower this figure is taken as representative of the average. Similarly the figure 0.0055 pounds per horsepower-hour has been taken as the figure for average oil consumption, further substantiated by the results of a survey of 518 light airplanes made by The Civil Aeronautics Authority in 1942.

If a plane cruised at 50 horsepower it costs about $1.21 for fuel and oil every hour flown, or approximately $181.00 per year for 150 hours flying.

The cost of maintenance and replacement parts can vary considerably, depending, among other things, upon CAA regulations, governing
inspection periods, and upon the care given the airplane. In developing
a cost factor it is assumed that reasonably good care will be given the
airplane under all conditions, that the airplane will be stored in a
hangar when not in use for long periods, and that ample insurance cover-
age will be maintained covering crash repairs and replacements.

Even though under the amended Civil Air Regulations the plane
owner is legally bound to have his aircraft inspected only once a year.
It can be assumed, for purposes of this study, that most owners will
consider their necks worth the few extra dollars necessary to have the
20 and 50 hour engine checks, 100 hour inspections, 500 hour engine
overhaul, and the major airframe overhaul after five years of operation.

Cost averages were taken for the above operations for aircraft,
ranging from 65 to 250 horsepower. In translating total cost for the
many operations over long periods of time into dollars per horsepower
hour, the effect of weight relationship to horsepower is considered,
since the cost factor includes airframe maintenance cost. Accordingly,
costs were considered for aircraft with varying power loadings and
varying useful load ratios. The effect of a major airframe overhaul
is not included in the maintenance cost factor for the first year of
operation of a new plane, but it is included in a sliding scale for the
second, third, fourth, and fifth years of operation. The result is an
increase in maintenance costs each year as the plane grows older.

Although the owner may not keep his airplane for a full five
years, and thus not incur the actual expense of a major airframe over-
haul, the airplane's resale value decreases with each year it gets
closer to the overhaul. Consequently this cost effect must be consider-
ed, either as an increasing maintenance cost or as a higher depreciation
cost factor. It is more technically correct to consider it as a mainte-
tenance cost factor.

The resulting cost factors for maintenance, repairs, and re-
placement parts are then:

<table>
<thead>
<tr>
<th>Year of Operation</th>
<th>Cost per horsepower-hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>$0.0134</td>
</tr>
<tr>
<td>2nd</td>
<td>0.0175</td>
</tr>
<tr>
<td>3rd</td>
<td>0.0216</td>
</tr>
<tr>
<td>4th</td>
<td>0.0257</td>
</tr>
<tr>
<td>5th</td>
<td>0.0298</td>
</tr>
</tbody>
</table>

Again, at 50 horsepower for cruising it would cost about 67¢ per
hour for maintenance, repairs, and parts, which is about $100.00 a year
for 150 hours of lying.

Hangar rental is more nearly dependent upon the particular situa-
tion in which an aircraft is to be operated. For purposes of determining
costs of personal lightplane operation a study was made of the myriad
charging systems used in the United States. The most generally used
basis of charging for hangar rent was by size of aircraft, and this was
determined generally by the number of seats. The factor arrived at is
expressed:

\[
\text{Hangar rental in dollars per year} = \text{number of}
\text{passenger seats} \times \$90.00.
\]

This is the national average.

**DEPRECIATION**

Data supplied by the Civil Aeronautics Authority shows that the
average life of all non-military private aircraft at the close of 1938,
including destruction, was 7.4 years. Although on first thought this
may seem a little too long a period over which to depreciate an airplane,
considering obsolescence and an active new plane market, closer examina-
tion reveals that it may be accepted as a reasonably sound basis for
calculating depreciation.

The cost formula is based upon the first 5 years of operation, up to the estimated time of major airframe overhaul. Using 7.4 years as a reasonably good estimate of the active life of the average light airplane and allowing for a 32.5 percent residual value at the end of 5 years for the remaining 2.4 years of active life, the depreciation rate would be 13.5 percent of original selling price per year for 5 years. This can be expressed in the formula as:

Depreciation = original selling price \( (C) \times 0.135 \).

This means that a $2,000 lightplane would decrease in resale value at the rate of about $270.00 per year. The corresponding figure for a $10,000 utility cargo plane would be $1,350 per year.

**INSURANCE**

Insurance rates were reduced recently. It is probable that they will change from time to time in the future, depending upon accident rates and on how much the insurance companies have to pay out in damages per dollar of premium received. This means that figures used in the formula must be changed when necessary in order to yield accurate results. Rates included in these formulas are for hull insurance, public liability and property damage, and passenger liability.

As quoted by a major insurance company, costs for hull insurance are: Aircraft under 2,000 pounds empty weight, $12.50 per $100.00 of insured value, and aircraft of 2,000 pounds empty weight, $10.50 per $100.00 of insured value. It must be remembered that there are various types of hull insurance coverage at varying rates. The type for which prices are quoted specifies that the insured value for the first year is 100 percent of original price and for the second year 80 percent. For succeeding years, through the fifth year, the insured value is
15 percent less each year. This makes the hull insurance rate fit into the formula as:

\[
0.125 \times \text{selling price} \times \text{depreciation.}
\]

Public liability is quoted at $25.00 per year for $5,000 coverage, and property damage at $20.00 a year for the same coverage, making a combined total cost of $45.00. Passenger liability is quoted as follows:

- 2-Place Aircraft, one passenger -- $35 per year
- 3-Place Aircraft, two passengers -- $55 per year
- 4-Place Aircraft, three passengers -- $70 per year
- 5-Place Aircraft, four passengers -- $85 per year

For each additional passenger capacity over four: $15 per passenger per year

In order to simplify the application of the above figures for the formula, a rule of thumb was adopted whereby the rate was assumed as being $17.50 per year per passenger capacity.

**EXAMPLE USE OF COST FORMULA**

Many forestry operations call for an aircraft capable of carrying a pilot, and at least one passenger with some equipment. In order to provide some leeway in this respect, agencies often operate four-place aircraft. The Region Six Fire Control Division employs some Stinson "150" Voyagers. This economical four-place ship is taken as an example in the working of the formula. It cruises at 120 miles per hour at 105 horsepower, and the initial cost is around $6,000. Annual operating cost according to the formula would be approximately $2,720 for 200 hours annual utilization, as follows:

- **Fuel and oil cost** ............... $510.30
- **Maintenance, repair, and replacement parts cost** ............... 367.50
- **Hangar rental** ................. 270.00
- **Depreciation** ................. 810.00
- **Insurance** ................. 763.00

**Total Annual Cost (200 hours)** ...... $2,720.80
Total cost per hour . . . . . . . . . . $13.60
Total cost per passenger seat-mile. 0.0378

If the same airplane were operated 300 hours in a year, the hourly cost would be reduced considerably, clearly showing the important effect annual utilization has on hourly operating costs. This is because three of the heaviest costs — hangar rental, depreciation, and insurance — are fixed, regardless of the number of hours the airplane is used.

When the pieces are fitted together the formula represents the simplest and most flexible method possible for determining operating costs under variable conditions. It isn't nearly so complicated as it looks. A pencil, paper, and 15 minutes are all that are necessary to find the cost of operating a given airplane, if the passenger capacity, cruising speed, cruising horsepower, and selling price are known.

To reduce the process to its simplest terms: Add fuel and oil costs per horsepower hour (.0243) and maintenance cost per horsepower hour, which varies with the age of the airplane. This sum is multiplied by the cruising horsepower of the airplane. Then the answer is multiplied by the number of hours flown per year. To this total is added the annual hangar rental cost, which is the number of passenger seats multiplied by $90.00 if there is not a specific cost; depreciation, which is the selling price of the airplane multiplied by .135; and the insurance cost. To get insurance cost add $45.00, the sum of the number of passenger seats multiplied by $17.50 and the sum of $.125 multiplied by the insured value of the airplane.

Someone may now ask what is to be done for those who are not interested in passenger hours, and seat-miles. Many forestry concerns would like to know just how much it might cost to deliver fire fighting supplies by air, or how much it will cost to map an area, or
spray insecticide over a given area. This formula will answer the question, in spite of the fact that it was designed to evaluate costs of conventional lightplanes which are generally rated as to the number of passengers they will carry. Due to a higher degree of production in the light personal-type class of planes they have been perfected to a point where it is often most economical to use them in business. The maintenance and repairs are much cheaper on these mass-produced planes, and quite often the initial cost is lower than it would be for a specially designed plane.

The Fire Control Division of the Forest Service in Portland, Oregon, uses at least four different lightplanes, all conventional models. One of these is the Stinson "Voyager". According to calculations by a group of students and two faculty members, this plane is outstanding in its class for economical travel of business men where more than one passenger is the rule. That is to say, it produces the cheapest passenger seat-mile for a concern employing men who are more or less constantly traveling in such a manner that more than one will be going on the average flight.(5).

An interesting comparison was made between passenger car travel and light passenger plane travel. A Portland banking concern wished to know if one of their representatives could travel more cheaply by air than by ordinary car at 5 cents per mile. It was found that the airplanes considered could not compete with the car unless the representative were to travel something over 20,000 miles per year. This is not entirely representative of forestry type problems, but it indicates a matter of prime importance. It is the relation of
operating cost to annual utilization. Only in special cases is it economical to own an airplane unless it is to be operated over 150 hours per year. Figures 1 and 2 on the following page indicate this relationship. It can be easily determined by graphs for most types of operations.
These graphs are taken from material presented to a class in advanced flying at Oregon State. The aircraft referred to are all conventional light-planes ranging from 79 to 165 horsepower.

**FIG. 1**
Operating Costs Per Plane-Mile vs. Annual Utilization
Airplane B
--- Total direct operating cost per plane-mile

(Key)
1. Insurance
2. Depreciation
3. Hangar rental
4. Maintenance
5. Fuel & oil

**FIG. 2**
Operating Cost Per Hour Flown vs. Annual Utilization
Three Exemplary Airplanes
THE CHART METHOD OF DETERMINING COSTS

In the graphic method of determining operating costs the many variables are brought into the summation by a system of line graphs and curves. Three separate charts are used, one for variable costs, one for fixed costs, and one to incorporate fixed and variable costs and to convert them to dollars per year, hour, and mile. Each curve or graph is arranged on its chart so as to be perpendicular of approach from the preceding one. The charts appearing on the following pages were prepared by Professor Skinner of the School of Mechanical Engineering at Oregon State College, in his Master's thesis on flying costs, May 1947.

Cost factors used in Professor Skinner's thesis compare closely with those used by Mr. Berboth in the formula method previously explained. The following charts are relatively self-explanatory, and are probably the quickest and easiest method, so far, of arriving at accurate summation of the many factors in flying costs. In the form presented here the charts apply to a limited class of planes, but they can, with proper care, be extended to include any desired size of plane. So long as a plane is 150 horsepower or lower, and does not cost more than $7,000, the charts are fully applicable.

APPLICATION OF THE CHART SYSTEM

Perhaps the best way to get acquainted with the chart system is to work a sample problem with it. A few figures must be known before a calculation can be made. These figures are readily attainable, and include: Sale price of the airplane, cruising horsepower (2/3 rated horsepower), cruising speed, oil cost (average 35 cents per quart), fuel cost (average 26 cents per gallon), and hangar rental (average $90 per passenger-seat, per year). These figures can be quickly arrived at by consultation with airplane salesmen and airport
CHART I. VARIABLE OPERATING COSTS

1. The chart is entered at the oil cost scale (top left) and followed as indicated by the dashed lined example.

2. Maintenance costs include 20 and 50 hour engine checks, 100 hour inspections, 500 hour engine and 5 year airframe overhauls (applied on sliding scale).

3. The maintenance costs per horsepower-hour corresponding to the year of operation lines are listed under basic assumptions. If maintenance costs are known use them to select the proper year of operation line.

BASIC ASSUMPTIONS

<table>
<thead>
<tr>
<th>Year</th>
<th>Maintenance Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.01 lb per hp-hr</td>
</tr>
<tr>
<td>2</td>
<td>2.62</td>
</tr>
<tr>
<td>3</td>
<td>3.24</td>
</tr>
<tr>
<td>4</td>
<td>3.85</td>
</tr>
<tr>
<td>5</td>
<td>4.47</td>
</tr>
</tbody>
</table>

0.52 lb fuel per hp-hr.
0.0055 lb oil per hp-hr.
CHART 2. FIXED OPERATING COSTS

1. The chart is entered at the top left and is continued to scale A. It also
   is entered at the top right and is continued to scale B. A straight line
   drawn between the A scale and the B scale values will intersect the T scale
   at the value representing the total yearly fixed cost. An example is
   indicated by the dashed line.

2. Liability insurance is estimated on the assumption that approximately equal
   limits will be obtained on each of the three types.

3. Hull insurance is the comprehensive (ground and in flight) type.

4. Depreciated value is assumed to be 80% of that for the previous year.
CHART 3. TOTAL OPERATING COST

1. The chart is entered at the top left and is followed as indicated by the dashed lined example.

2. Annual, hourly and per-mile costs are determined by the intersection of their respective scales and your plotted line.
managers. If the plane is to be used locally, it is a good idea to make
inquiries rather than to use the average figures indicated, since they
are subject to changes and local differences. Suppose, for instance, it
is intended to employ the airplane in several phases of forest manage-
ment in Southeastern Alaska. The buyer will be interested in an
amphibious plane because much of the forest area is on islands where it
is generally uneconomical to build airstrips. The work will undoubtedly
call for some transportation of personnel and some cargo. The Republic
Seabee incorporates most of the features desired, and its design leans
toward lightplane economy. It is a four-place amphibian monoplane with
a pusher type propeller. Its cruising speed is 103 miles per hour, and
the cruising horsepower is 150. By questioning a sales agency it may
be learned that the initial cost is $7,000. Now to determine what
liability coverage is desired by insurance. Since population is low
in Alaska it might be assumed that a liability limit of $10,000 will
be sufficient. This done, it is time to investigate and get an estimate
of fuel and oil costs. These may run above the national average, so
40 cents per quart for oil, and 28 cents per gallon for aviation
gasoline are reasonable assumptions. Perhaps a project engineer
can give an estimate on the annual expense of owning a hangar large
enough to house the plane. Since considerations would not be involved
with demand competition, it may be possible to store the plane cheaply
by building a hangar from local materials. In the end it may be
decided that hangar expense will amount to $150 per year. The plane
is to be operated in connection with a long term project, and is
expected to be used until it becomes worn out or obsolescent, hence
it is decided that the second year will be the average year of operation,
and of maintenance costs, since after the second year maintenance costs will begin to increase toward the major airframe overhaul, thus offsetting the decreasing depreciation which is a factor incorporated in the charts. The next step is to carry our information thus arrived at over to the charts.

Instructions are included at the bottom of each chart, and the charts are used in the order in which they are numbered. Starting at the figure "40" on the oil cost scale, and proceeding directly to the line "2" representing the year of operation, the path turns perpendicularly from this point of intersection downward until it intersects with fuel cost line "28". Again turning perpendicularly from this point of intersection to the next graph — cruising horsepower, and repeating the process the imaginary line followed will arrive at a scale marked "total variable cost—dollars per hour." In the "cruising horsepower" graph it was necessary to interpolate between 100 and 110 horsepower to find the point of intersection for this ship which cruises at 103 horsepower. A straight-edge or ruler is handy for aligning the path through the charts. A dash-line with arrows all through the charts indicates the direction to follow. The line followed in this problem crossed the dollars per hour scale at a point two divisions past the five. Interpolating, this indicates that the variable cost will be $5.20.

Next comes Chart 2. Here again, the dash-line indicates the direction to take, except that on this page the dotted line enters from two different places. The two lines of approach will come to two scales set opposite each other near the center of the page. Drawing a straight line between the two places intersected on these
scales will bring about a point of intersection on the vertical scale set between the scales indicated. This latter scale is labeled "Total Fixed Cost-In Dollars Per Year." The point arrived at on the last scale is, for this problem, $2,300, which is the total fixed cost per year. Proceedings so far have resulted in two new figures which are highly usable: variable cost ($5.20 per hour), and fixed costs ($2,300 per year).

By carrying these two figures to Chart No. 3, much more valuable information can be had. In the third chart the line proceeds in the same manner as in the first chart. On the scale at the center of the chart it will be found that the total cost per year is to be $3,900. Proceeding to the right and upward will give the total cost in dollars per hour, which in this case is $13.00, this figure being inexact due to rough interpolation in using the graphs, but for most purposes it will be accurate enough to influence a business decision.

On Chart No. 3 there are two graphs reflecting the effect of annual utilization. If it is not already determined how many hours the airplane will be flown per year it is possible to substitute a variety of figures, noting the results on the dollars per hour scale. This will lend emphasis to a crucial matter, and that is the relationship between annual utilization and costs per unit of use. Under ordinary circumstances this is the best way to determine whether to hire flying done, or to buy a plane.

Just above the "dollars per hour scale" on Chart 3 is a graph of various cruising speeds. Since the plane in question has land gear, and water gear, as well as other characteristics, it can be said that these features have been part of the cause for the low
cruising speed of the small amphibious plane. Speed is the feature which has been sacrificed along with range, and payload. Were this plane to make long flights regularly it might have been more desirable to choose a plane that "travelled light". From the point on the "cruising speed" graph the line proceeds to a scale marked "Total Cost-Cents Per Mile". On this the point of intersection is very slightly over 12 cents.

A sales agent could give information on the cargo capacity of the plane. If the information provided indicated that by removing the seats the plane could be loaded to 1,000 pounds with equipment and supplies, there would be little difficulty in computing the cost per ton-mile of cargo. In this case it would be 24 cents which may or may not fit in well with the budget concerned and may not compare with other available forms of transportation, except in speed. At any rate, decisions forthcoming will have been arrived at by a sound and practical method which is very convincing as to the correctness of the decision.

SUMMARY

The United States Forest Service Region Six Fire Control Division held school at Roseburg, Oregon, in May, 1947. The objective of this school was cargo dropping training, and mimeographed procedural instructions were issued. These instructions are quite comprehensive as to the details of up to date cargo operations in forestry. They propose to fly in all materials for the construction of two lookouts, and they have successfully proven this type of venture. Other new aircraft uses include the supplying of lookouts, and trail crews by air.

It was stated at the time of this school that it cost between seven and ten cents per pound to deliver cargo by their methods. It was not learned what they considered to be their average length of haul, but this would have to be considered in using the cost figure given.
Conversation with Mr. Soehler, the man in charge of piloting and maintenance prior to May 1947, revealed some pertinent facts. The primary cargo aircraft in use were Noordyne "Norsemen", and they have been modified in the Forest Service shop so that there is a bottom hatch just behind the cargo doors in the floor. This feature alone illustrates greatly the advantages to be gained where a forestry concern can afford to own its own planes. The hatch is not obstructable by cargo in the cargo space just forward, and it is a very fast way to discharge either cargo or smoke-jumpers. Speedy discharge is an essential to accurate dropping in mountainous forest areas. A few seconds spacing or delay in releasing an object can mean just as many hundred feet in distance on the ground. This innovation appears to be safer for the cargo crew, and it gives them an opportunity to look directly at their target. The aircraft above mentioned falls just between medium and large in the Forest Service classification of their cargo planes. They use a variety of planes ranging from the 65-horsepower "Cub-Cruiser" up to the 2000-horsepower C-47.

Referring to their costs Mr. Soehler said that they were not yet ready to break down the costs, and that there had been no distinct breakdown previously because of the experimental nature of the project. Some of the planes had been purchased from war surplus, and of these the "Norsemen" had cost $10,000 each. Hangar cost was in a state of flux, because the hangar had been rent-free on the Portland Army Air Base until such time as the base would be transferred to the Port of Portland. After that time it was expected that the hangar would rent for $1,500 per month. During the non-fire season there were ten or eleven planes stored in the hangar, which also housed the central maintenance shop still being developed for this project. During the
fire season the planes are dispersed to four summer fields at strategically located places in the Oregon and Washington part of the region. Mr. Soehler estimated that the lightplanes were used on the average about 100 hours per year, while the primary cargo planes had an annual utilization slightly higher, or about 130 hours.

The above information indicates an excellent opportunity for cooperation between the Regional Headquarters and all other forestry organizations in the region. The annual utilization is low under the present arrangement, and this could be easily bolstered by hiring them at, or near cost to agencies desiring forestry-specialized flying service.

By such cooperation and centralization of ownership it is possible to shed some of our most damaging costs. Hangar rent, insurance, maintenance costs, and initial costs are all subjects for economizing. Initial costs are somewhat better where it is possible to buy war-surplus planes, but this is usually out of the picture for small agencies. These planes cannot be insured against damage to a higher valuation than they cost. Yet major repairs, such as a wing, propeller or landing gear will cost more than the original price of the surplus plane unless repairs can be made by the agency itself through buying of war-surplus parts and the operation of a complete maintenance and repair shop, which represents a heavy investment.

Hangar cost as used in the foregoing studies represents a nationwide average wherein the planes travel from one commercialized airport to another, and are stored in rented hangar space or tied to the ground with a substantial charge for parking outdoors on the busier airports. The average in this case should be greatly improved upon by an organization capable of renting whole hangars, or of buying
or building its own.

Since the war there has been a tremendous return of trained military pilots to the forestry profession. These men are often in a position to hold steady jobs with an organization, and yet be on constant call to serve as pilots in any project within the organization. This is another of the many advantages of the present opportune situation for progress in flying forestry.

Success with these opportunities will be largely determined by how efficiently costs may be determined. The next step would be a sliding scale device which might be called a cost computer, and which would be designed especially to include the most representative factors and limits applicable to the field of forestry.
BIBLIOGRAPHY


