Forestry use of the helicopter

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Abstract: *In this paper, the results of an evaluation concerning the possible applications of the helicopter in North West Italian forest and its hourly cost analysis are described. Furthermore, the results of an operating and economical comparison of wood transport with helicopter and cable crane are reported. To highlight the possible works that can be done by helicopter in the forestry sector the ship's log of an Italian helicopter's company with 30 helicopters have been considered. In detail, for this analysis, a period of activity of 5 years (2005 – 2010) for a total of 12.000 fly hours, has been considered.*
The economics evaluation has been carry out considering an helicopter of middle size with a nominal power of 624 kW, a useful load of 1076 kg and a cruising speed of 226 km h-1. The logging comparison between helicopter and cable crane has been made in a forestry of Picea Abies with a average slope of 40% located at an altitude ranking from 1.150 to 1.450 m. The average logs diameter was considered of about 400 mm with a total volume harvested of 750 m3. A cable crane of a length of 700 m and a nominal power of 104 kW with a motorized carriage has been considered for the comparison.
The study has pointed out that the helicopter in Italy is at present mostly employed for the barycentre hook transport (80%), but only 1% of barycentric hook transport is used for wood trasport. The helicopeter is mostly used for the transport of the material for building of mountain refuges and of the avalache shelters. The reason of this limited used in logging is manly related to its very high hourly cost (1.200 €/h). The logging comparison has underline a working time required by cable crane of 29 days, while with the use of the helicopter are necessary only 5 days. Forthermore, the manpower required for logging using the cable crane represent the 42% of the total manpower necessary for wood harvester, while using the helicopter its represent only 5% of the total. The use of helicopter seem, to be convenient only in situations where the priority is the quality of the work and the forestry safeguard.

Keywords: helicopter, cable crane, wood harvester, forestry

1 Introduction

The helicopter is an aircraft with rotating wings that allow vertical takeoff and landing and hovering (stable and fixed positioning at a suspended point) [1]. These unique capabilities have made this "machine" particularly useful for work and the delivery of emergency services in areas poorly- or under-served by roads.

Helicopters have been widely used in both the public and industrial service sectors of developed countries for fire-fighting, rescue, and material transport that utilizes a barycentric hook (logs, concrete, metal structures, and so forth). In Italy, log transport is generally not performed by helicopter because of the limited market value of woods that does not offset the high hourly cost of aircraft use. Consequently, flights performed in the Italian forestry sector are limited to material transport for camping/hiking hut construction/repair and infrastructure and engineering projects.

This study aims to analyze helicopter transport according to service sector type provided by a single Italian company. Additionally, helicopter skidding costs are examined and compared to those of a cable crane.

2 Material and methods

2.1 The company analyzed

The company analyzed is based in Italy and is operating since 1991, has a workshop certified for maintenance of its aircraft and it is one of the few firms that provides a variety of helicopter services (fire-fighting, barycentric hook transport, fungicide and Bacillus spp. spraying for control of mosquito proliferation in rice fields, photography, videography, and so forth).

In the study, the logbook that recorded data on every component of the helicopter fleet has been examined. The data reported in each of the two "Technical Notebooks" (TN) that contained aircraft engine and frame information as those of “Aircraft Technical Log” (ATL) have been evaluated [2,3]. In the TN maintenance and flight hour are recorded while the ATL contain the daily flight hours. The service type provided, takeoff and landing times, and refueling and inspection events,

The data recorded consider five years of activity and more than 12,000 flight hours. For a better analysis, have been divided into seven operative categories:

fire-fighting,
barycentric hook transport,
fungicide and Bacillus spp. spraying for biological control of mosquito in paddy fields,
photography and videography,
flight instruction;
passenger transport,
electricity line inspection and monitoring.

Helicopter skidding cost versus cable crane

The comparison between the two transport methods has been made using a “calculation model" and considering a scenario made by a conifer forest with an average slope of 40% at an altitude between 1150 and 1450 m. Trees were 0,40 m in diameter as measured at 1.30 m from the tree base and 26 m in height. Each cut volume was approximately 150 m^3ha^{-1} and was taken from a total crop volume of 4500 m^3ha^{-1}. A total of 750 m^3 of timber (Table 1) was harvested and moved over a downhill skidding with a length of 700 m.

The comparison set-up consisted of a crane outfitted with a mobile station, 22 mm (diameter) cable, and a motorized carriage equipped with a 90 m long, 12 mm diameter rope and a payload capacity of 4000 kg (Table 2). The model assumed a four-person working team including one person each at the mobile station and landing site and two persons under the cable line. For the helicopter, two teams (one at the forest site and one at the landing site) were considered; each team has two persons (one expert and one assistant). "expert" manpower costs were included in the aircraft rental cost; all other workers cost was assumed to be of 12,50 $€h^{-1}$ (market value).

Table 1: Forest and topsoil characteristics used in the skidding system comparison

Altitude	1450 m.
Slop (%)e	40
Forestry Species	Picea abies
Average tree diameter (m)	0.40
Volume timber skidding (m^3)	750
Average skidding length (m)	700

Table 2: Main technical characteristics of the cable crane used

Engine power (kW)	Skyline		Mainline		Carriage type	Lifting cable	
	Cable length, (m)	Cable diameter, (mm)	Cable length, (m)	Cable diameter, (mm)		Cable length, (m)	Cable diameter, (mm)
104	850	22	850	12	Motorized	90	12

In the calculation of the skidding cost of the crane the equipment transport cost (600 €), plus the working time to assembly and disassembly cableway that take seven days has been included (Table 3-4). The equipment depreciation rate and cost were determined according to the methodology proposed by Ribaudo [4]. Furthermore, it has been estimated an average load of 2,5 m^3 (equivalent to 2,200 kg) and an average "carriage travel time" to span 20 minutes including log concentration and load hooking time.

Table 3: Operative costs considered in the cable crane skidding operation

Equipment transport (€)	600,00
Manpower (€h^{-1})	12,50
Fuel (€l^{-1})	0,65
Depreciation rate (€h^{-1})	15,00

Table 4: Operative characteristics in the cable crane skidding operation

Assembly/disassembly line (days)	7
Timber volume per travel (m^3)	2,5
Average travel time (min)	20

For the helicopter skidding it was assumed to use the aircraft Eurocopter AS 350 B3 "Ecureuil". Its manly technical characteristics are reported in table 5.

Table 5: Main technical characteristics of the Eurocopter AS 350 "Ecureuil" helicopter

Nominal engine power (kW)	Maximum Take-off weight (kg)	Maximum load (kg)	Cruising speed (km/h)	Maximum distance of work (km)
624	2,250	1,076	226	670

To determine the helicopter hourly costs both indirect costs (depreciation and maintenance) and direct costs (fuel and manpower) have been considered. For the indirect cost calculation, the aircraft was assumed to have a 12-year useful life; thereafter, the helicopter must undergo a detailed inspection and general overhaul costing as much as 75% of its original buying price. Maintenance, an important

component of the cost profile of a helicopter, depends on the model, accumulated flight hours, and age of the aircraft. Maintenance can be either routine or extraordinary. In this case study, both types were performed, and therefore considered, using the data of the helicopter use reported in TN and ATL.

Direct costs were calculated from several assumptions: 90,00 €h^{-1} for the crew including one pilot and one loading operation supervisor (area survey), 12,50 €h^{-1} for the worker who hooks/unhooks the load (market research), and 0,68 €l^{-1} for fuel. To determine the helicopter consumption the "topping-off system" has been used. This method involves filling the tank at the beginning and completion of work, and then calculating the amount of fuel used to perform the service to be that consumed between the two fills. The economic evaluation was made under the assumption that the helicopter was used 300 hours per year (average annual flight hours according to board documents). All inspections and component replacement costs that occurred during this period were also considered in the evaluation (Tables 6 and 7).

Table 6: Eurocopter AS350 Inspections costs

Inspection type	Total cumulative flight hours	Cost (€)
A	100	1,700
B	500	12,000
C	1,000	24,000

Table 7: Unit costs of different Eurocopter AS350 helicopter components changed during the five-year period considered

Component description	Component (n°)	Cumulative flight hours (n)	Unitary cost (€)
Starter	1	1,200	3,000
Primary rotor transmission	1	2,000	140,000
Primary rotor fixing screws	12	2,200	51
Primary rotor blade support	1		21,000
Other primary rotor support equipment		2,700	21,500
Tail rotor servocontrol	1	3,000	7,500
Primary rotor servocontrol	3		7,500
Tail rotor bearing	1		550
Pins (butee)	6		200
Engine	1		180,000
Primary rotor transmission bearing	5	3,600	250

The annual total operating cost of the aircraft considered was 360,000 € which corresponded to 1200 €h^{-1}. Of this cost, depreciation accounted for more than 40% and insurance represented 20% (Fig 1).

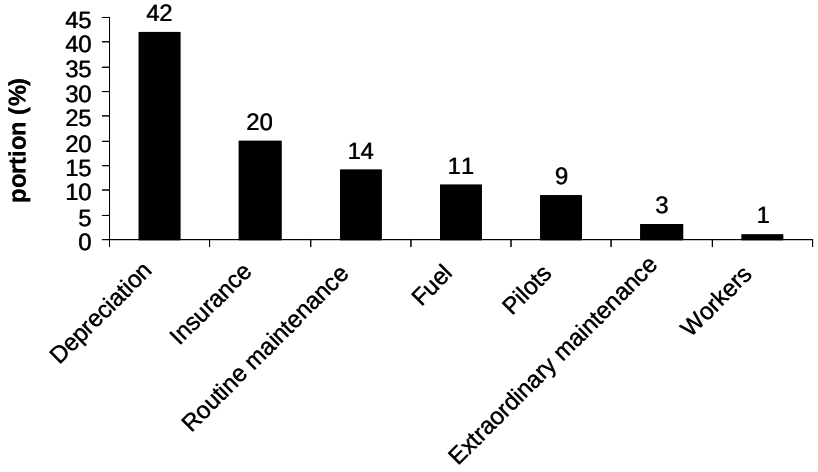

Figure. 1: Relative portion of different operating costs to total of the Eurocopter AS350 helicopter

Among the various cost categories, maintenance (routine and extraordinary) accounted for a sizeable portion of the total operating cost of the aircraft (approximately 17%). In this case, routine maintenance amounted to about 48,000 €year^{-1} or about 160 € per flight hour. The highest maintenance costs were recorded in the 7th and 11th years of the AS 350 related to two necessary and major replacements of the primary rotor transmission (2000 h) and the engine (3000 h) (Figure 2).

Periodic inspections (routine and extraordinary) totaled about 14,000 €year^{-1} or 46 € per flight hour while aircraft part replacement expenditures were 34,000 €year^{-1} or about 113 € per flight hour.

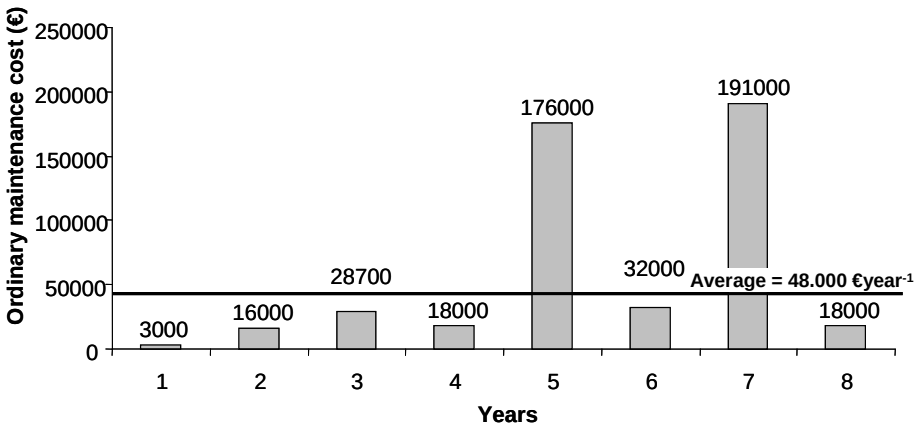

Figure 2: Maintenance costs of the Eurocopter AS350 helicopter

From this calculations, the final helicopter time cost has resulted of 25 €min^{-1}.

The average helicopter load was assumed to be 900 kg or 1 m^3 of timber which was about 50 kg less than the maximum payload of the aircraft (at an altitude of 1450 m) (Fig. 3).

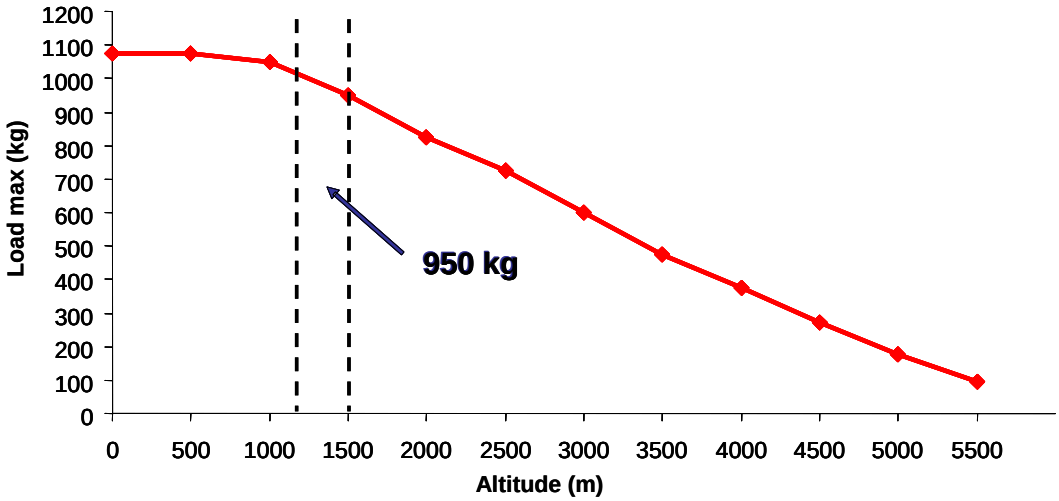

Figure 3: Graph of the maximum load of the Eurocopter AS 350 helicopter

Skidding times were calculated based on six hours of work per day with two hours assumed for refueling and maintenance (Table 8).

Table 8: Operating characteristics and costs assumed in Eurocopter AS 350 helicopter skidding work

Helicopter hire cost (€m^{-1})	25,00
Manpower cost (€h^{-1})	12,50
Workers (n°)	2+2
Timber volume per transport (m^3)	1
Average transport time (min)	2,5

3 Results

3.1 Company services analysis

Among the various services offered by the company, transport to the hook and fire-fighting were the two largest services provided and represented 32% and 28% of the total hours flown (Fig. 4), respectively.

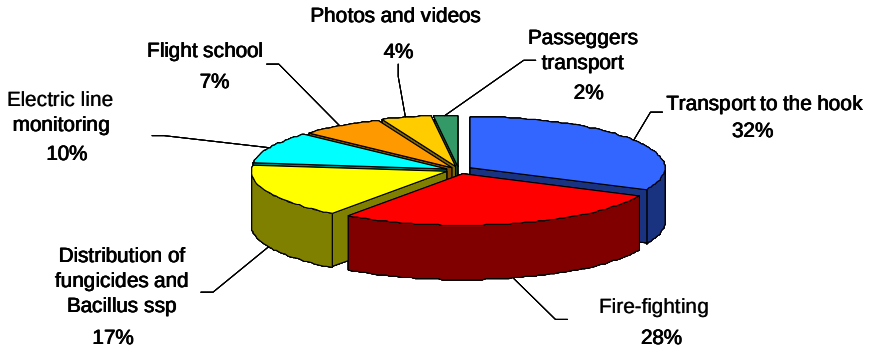

Figure 4: Service categories performed by the helicopter company analyzed

Flight hours performed during the calendar year had an irregular distribution (Fig. 5). Most of the flights occurred during the spring and summer months for pesticide spraying, transport by hook, and fire-fighting services. Flight school and photographic services were performed primarily during the winter months due to greater visibility (Fig. 6).

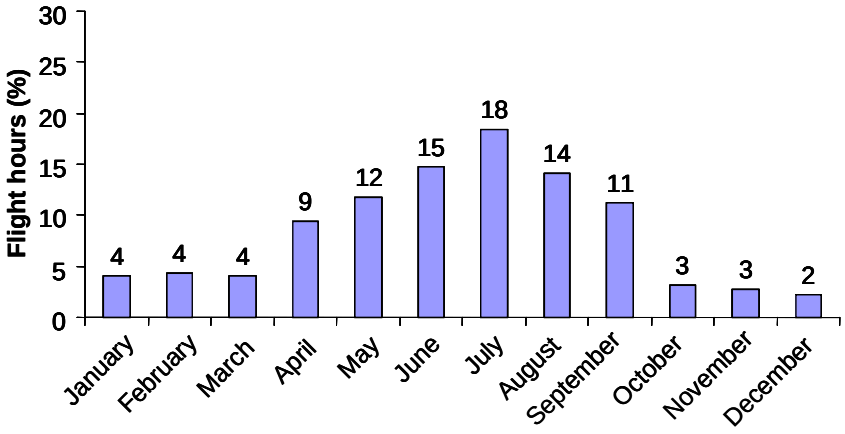

Figure 5: Helicopter company flight activity performed by month

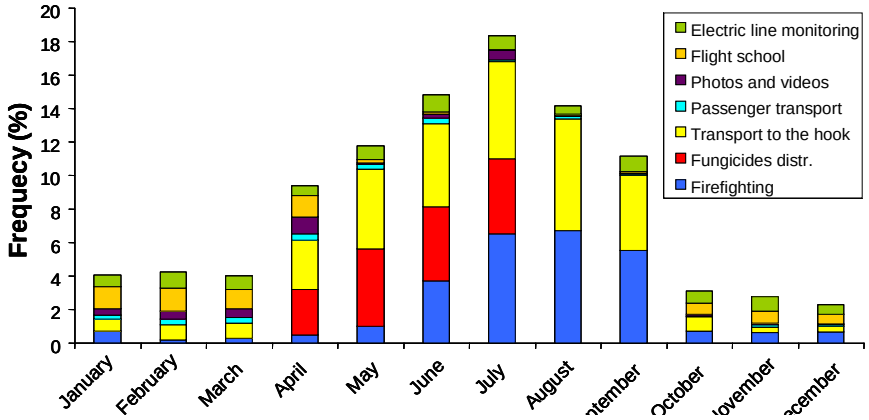

Figure 6: Helicopter company flight activity by service category

Services that required a barycentric hook represented approximately 80% of the transport service category and was used for trasnport of dam building materials and shelter/hut construction. Use of the barycentric hook for timber skidding was merely 1% of the total services rendered (Fig. 7).

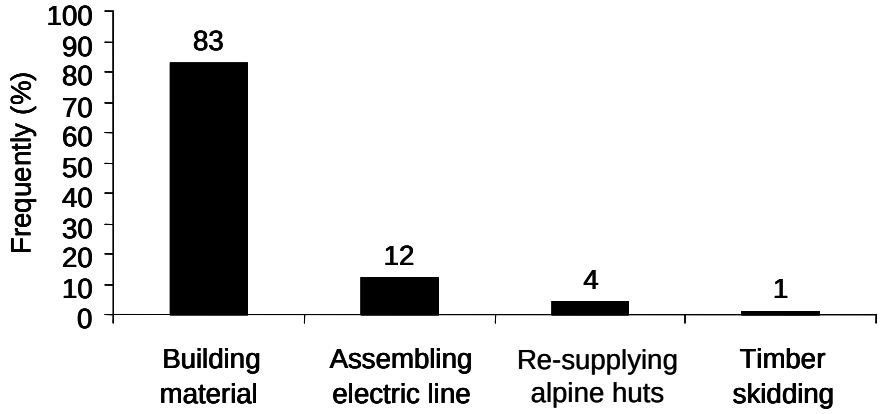

Figure 7: Composition of transport services provided by the helicopter company analized

Maximums payload are linearly related to the engine nominal power of different helicopter models. About 1kg of material can be carried per 0,5 kW of helicopter engine power (Fig. 8). This same ratio fell to 0,35 $kWkg^{-1}$ when the helicopter had more than 2000 kW engine nominal power.

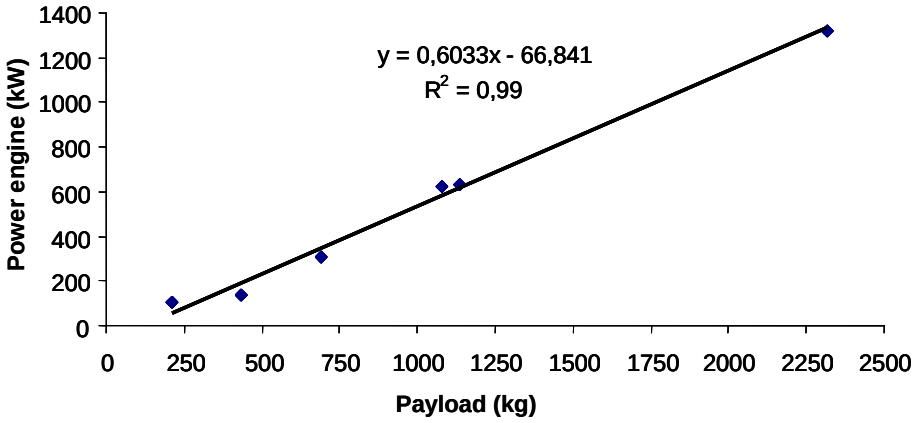

Figure 8:Correlation between helicopter engine nominal power and payload

3.2 Comparison of cable crane and helicopter skidding

This study showed an undeniable economic advantage to use a cable crane for skidding. Cable crane skidding cost is 14,3 $€m^{3-1}$, four times lower of the helicopter one. However, differences existed in the work hours of the two systems. The skidding performed by the cable crane spanned 20 days, seven of which were used exclusively for line assembly and disassembly while the same work performed by helicopter took just five days. Moreover, the two methods had very different cost structures; manpower represented 25% of the total cost when using a cable crane and only 5% of the total cost when a helicopter was used (Table 9).

Table 9: Operating characteristics and costs of the two skidding systems analyzed

	Cable crane	**Helicopter**
Workers (n°)	4	2+2
Assembly/disassembly line (days)	7	0
Skidding (days)	13	5
Work Period (days)	20	5
Timber volume (m^3h^{-1})	7,5	19,0
Equipment hire cost (€)	2.700	45.000
Manpower cost (€)	8.000	2.000
Total cost (€)	10.700	47.000
Skidding cost ($€m^{3-1}$)	14,30	62,30
Manpower incidence (%)	25	5

4 Conclusions

The investigation made in the helicopter service showed that the helicopter is mainly used for transport by barycentric hook (32%) and firefighting (28% of total). More than 80% of barycentric hook activity is performed for building material transport and merely 1% for timber transport. The Eurocopter AS350 hourly helicopter cost (1,200 $€h^{-1}$) is high and principally driven by indirect costs that comprise about 80% of the total one. Depreciation and insurance costs accounted for more than 60% of the total cost while maintenance expenses (routine and extraordinary), required to ensure helicopter proper and safe use, accounted for another 15%. In the skidding activity, when the helicopter is compared with cable crane, the first one has a number of advantages: short working times (a characteristic not to be underestimated because of weather condition, transport of log with higher length and the possibility to work on a large scale without assembly/disassembly structures). By contrast, helicopter skidding has a cost (about 60 $€m^3$ of timber) 4 times higher than the cable crane (about 15 $€m^3$ of timber).

In summary, in Italy the helicopter, although typically characterized to be of advantage, is a poor fit for forest work due to its high operating costs (about 20 $€minute^{-1}$) that cannot overcome the economics associated with market forces. Situations do, however, appear in which helicopter use might be preferable such as when skidding must be performed and land conservation is considered a priority.

5 References

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