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Comparison Between Helicopter and Cable Crane in Logging Operation

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In Italy, differently from others European Countries (Switzerland) where the use of helicopters is more diffuse, log transportation in slop land is generally performed by cable crane although its use is generally difficult and high time consuming for mounting/dismounting the line. With the aim to evaluate the possible use of the helicopter in North West Italian forest an overview of the present use of the helicopter in Italy followed by an operating and economical comparison of wood transport with helicopter and cable crane was made and reported in this paper.
The yarding comparison between helicopter and cable crane has been made in a forestry with an average slope of 40 % located at an altitude ranking from 1,150 to 1,450 m. The average tree diameter considered was about 400 mm with a total volume harvested of 750 m^3. In this study, the comparison was performed considering a helicopter with an engine power of 624 kW (useful load of 1,076 kg and a market price of 1,200,000 €) and a cable crane with a nominal power of 104 kW equipped with a motorized carriage.
The overview has pointed out that the helicopter in Italy is mostly employed for transport by the use of the barycentre hook (80 %), but only 1% of this transport system is used for wood due to its higher hourly cost (1,200 € h^{-1}). In the forestry situation examined, logging carried out using the cable crane required a working time of 20 days, while using the helicopter are necessary only 5 days. In contrast, logging performed with the helicopter has a cost of about 60 € m3 that is 4 times higher of the cable crane one (about 15 € m^3).

1. Introduction

The helicopter is an aircraft with rotating wings that allow vertical take-off and landing and hovering (stable and fixed positioning at a suspended point) (Spinelli, 2003). 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) (Akay et al, 2008; Satoh et al, 2000; Tomazin and Kovacs, 2003). In Italy, differently by others European Countries (Switzerland) (Stampfer et al, 2002; Heinimann, 1998), log transportation is generally not performed by helicopter because its high cost and the limited market value of woods. In forest with high slope (30-60%) is normally use the cable crane used although it require high mounting/dismounting times of the line. Consequently, flights performed in the Italian forestry sector are limited to material transport for camping/hiking hut construction/repair and infrastructure and engineering projects. Nevertheless, the use of helicopters, in comparison to other harvesting methods, allows the negative impact on soil and water to be minimized (Aust and Lea, 1992). They can also be used on sensitive sites (Jackson and Morris, 1986).
In Europe and north America numerous studies have already been conducted on the use of the helicopter in the forestry sector (Dykstra, 1975; Krag and Clark, 1996, Heinimann and Camminada, 1996, Sloan and Sherar, 1997), but in Italy, unfortunately, few studies were carried out until now.
This study aims to analyse helicopter transport according to service sector type provided by a single Italian company. Additionally, helicopter yarding costs are examined and compared to those of a cable crane.

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2. Material and methods

2.1 The company analyzed

The company analysed 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) with aircraft engine and frame information as those of “Aircraft Technical Log” (ATL) have been evaluated. In the TN maintenance and flight hour are recorded, as ATL daily flight hours (AA VV, 2009). The service type provide, take-off and landing times, and refueling and inspection events. The data of five years of activity (more than 12,000 flight hours) has been considered. For a better analysis, the aircraft operations have been divided into seven 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.

2.2 Helicopter yarding cost versus cable crane

The comparison between the two transportation methods was made using a “calculation model" and considering a scenario made by a conifer forest with an average slope of 40 % at an altitude between 1,150 and 1,450 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}. The two yarding systems were compared considering a timber volume of 750 m^3 each moved downhill for a length of 700 m.
The cable crane chosen for the comparison was a crane outfitted with a mobile station, 22 mm (diameter) cable, and a motorized carriage with a payload capacity of 4,000 kg (Table 1). The model assumed a four-person working team: one person at the mobile station, one on the landing site and two workers under the cable line.

Table 1: Main technical characteristics of the cable crane considered in the calculation model

Element	Dimension	
Power	Nominal power (kW)	104
Skyline cable	Length (m)	850
	Diameter (mm)	22
Mainline cable	Length (m)	850
	Diameter (mm)	12
Lifting cable	Length (m)	90
	Diameter (mm)	12

In the calculation of the yarding cost of the cable crane, an equipment transport cost of 600 € and a value of 18.50 € h^{-1} for manpower was assumed. The equipment depreciation rate and cost were determined according to the methodology proposed by Ribaudo [4] considering a fuel price of 0.65 € L^{-1} (fuel for agricultural use). Furthermore, it was considered an average load of 2.5 m^3 (equivalent to 2,200 kg) and an average “carriage travel time” to span 20 minutes including logs extraction and load hooking time.
For the helicopter logging, it was assumed to use the aircraft Eurocopter AS 350 B3 "Ecureuil". At the present, in Italy, this helicopter is the most used for timber transportation. Its manly technical characteristics are reported in Table 2.

Table 2: Main technical characteristics of the Eurocopter AS 350 "Ecureuil" helicopter

Element	
Nominal power (kW)	624
Max take-off weight (kg)	2,250
Max payload (kg)	1,076
Crusing speed (km h^{-1})	226
Max distance of work (km)	670

To determine the helicopter hourly costs both indirect costs (depreciation and maintenance) and direct costs (fuel and manpower) were 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. In this study case, the maintenance cost was calculated using the data reported in TN and ATL. From this calculations, the final helicopter 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 150 kg less than the maximum payload of the aircraft (at an altitude of 1,450 m). Yarding times were calculated based on six hours of work per day with two hours assumed for refueling and maintenance. Furthermore, 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 18.50 € h^{-1} (market value).

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 (Figure 1), respectively.

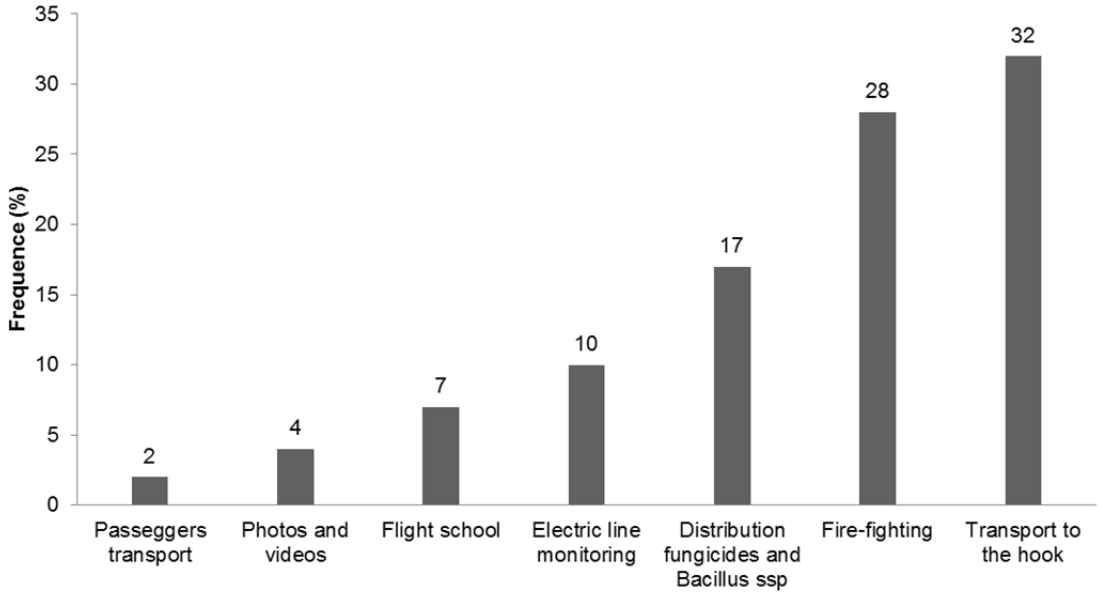

Figure 1: Service categories performed by the helicopter company analysed

Flight hours performed during the calendar year had an irregular distribution (Figure 2). 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.

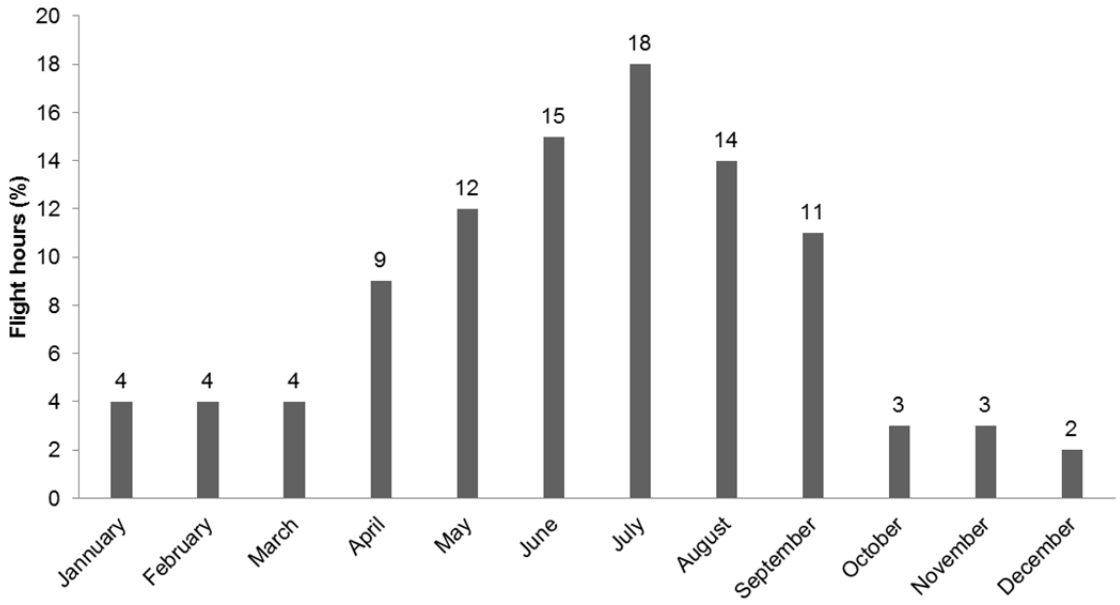

Figure 2: Helicopter company flight activity performed by month

Services that required a barycentric hook represented approximately 80 % of the transport service category and was used for transport of dam building materials and shelter/hut construction. Use of the barycentric hook for timber skidding was merely 1 % of the total services rendered (Figure 3).

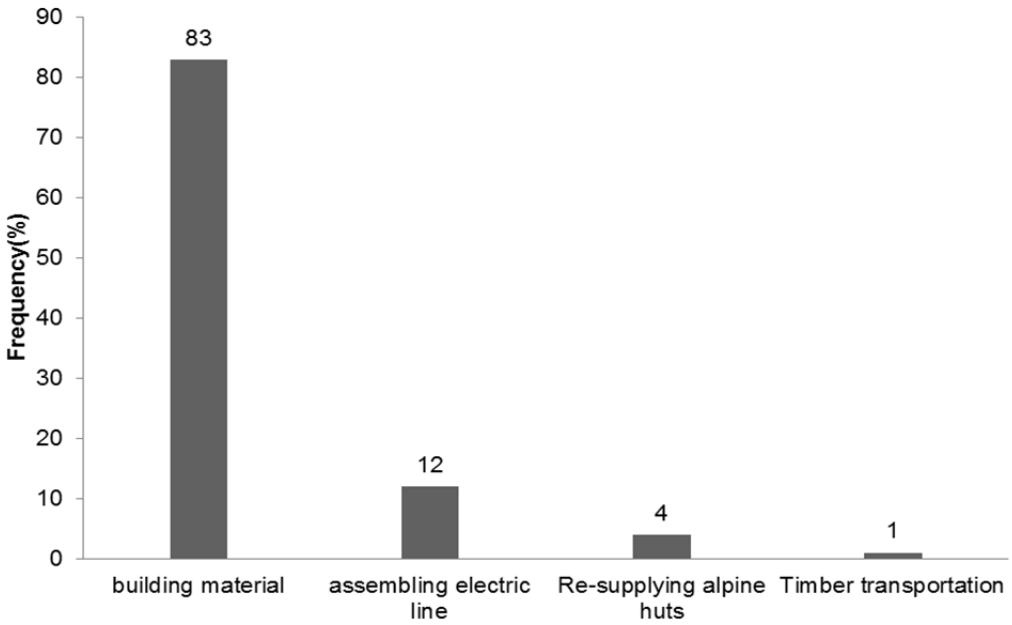

Figure 3: Composition of transport services provided by the helicopter company analysed

3.2 Comparison of cable crane and helicopter yarding

This study showed an undeniable economic advantage to use a cable crane for yarding. Cable crane yarding cost is 14,3 € m^{-3}, four times lower of the helicopter one. However, differences existed in the work hours of the

two systems. The yarding 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 3).

Table 3: Operating characteristics and costs of the two skidding systems analysed

	Cable crane	Helicopter
Workers (n°)	4	2+2
Assembly/disassembly line (days)	7	0
Yarding (days)	13	5
Work Period (days)	20	5
Timber volume (m3 h-1)	7,5	19,0
Equipment hire cost (€)	2.700	45.000
Manpower cost (€)	8.000	2.000
Total cost (€)	10.700	47.000
Yarding cost (€ m-3)	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. In the yarding 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 yarding 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 (25 € min^{-1}) that cannot overcome the economics associated with market forces. Nevertheless, helicopter use might be preferable such as when yarding must be performed, but land conservation is considered a priority.

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