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STUDY OF COMPETITIVE MISSIONS FOR AUTOGYROS

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ABSTRACT

Autogyro can be defined as a rotary wing aircraft that fly due to the presence of an engine. The whole disposable power is applied in a tractor propeller, which makes the aircraft to move ahead in the air, being this velocity the one that makes the rotor blades to rotate without being powered. In this work the possibilities of Autogyros, helicopters and aeroplanes are compared both from the point of view of performances and operation economy. Likewise, guidance is provided to allow aircraft users to choose the fleet combination for their requirements.

1. INTRODUCTION

The first aircraft used with commercial purposes was the dirigible. Its history begins well before the history of aviation, since in the nineteen-century the French balloons stated the basis to develop the dirigibles. These ones dominated the air transport at the beginning of the present century instead of the recently born airplanes until the first flight of Wright brothers in 1903. In this way, the dirigibles were the most important way for air transport until the fatal accident of Hindemburg in 1937. Their development was abandoned and the aeronautic industries choose other alternatives. Nowadays, some dirigibles have been manufactured for publishing missions due to his low operating costs in this kind of work compared to airplanes or helicopters.

Something similar happened to Autogyros. In this case, the premature death in 1936 of his inventor and precursor, D. Juan de la Cierva Codorniú, relegated this kind of aircraft in favour of helicopters. Although sometimes Autogyros have been erroneously considered as a first step in the development of helicopters, in fact they are a different kind of aircraft, being in the middle between airplanes and helicopters. On one hand, they do not need the ground infrastructure for take off and landing like airplanes but on the other hand, it is impossible for Autogyros to hover like helicopters. Instead Autogyro has not the problems related to stall as the airplanes do when flying at low velocities, and it is safer than helicopters in the case of powerplant failure because in Autogyros it is not necessary for the turn of the rotor.

Having in mind all the previously mentioned characteristics, it can be said that the Autogyro is an aircraft that can use very low cost ground infrastructures for take off and landing as helicopters, but at the same time it is capable to perform missions at low velocities (surveillance, observations, etc). Also Autogyro can fly at higher velocities than an equivalent helicopter and transport with a lower cost, being a rival for airplanes on low range missions. This fact can be possible because the centres for take off and landing for Autogyros can be nearer to the origin of traffic that the airplanes do, due to their ground performances.

2. HISTORICAL PERSPECTIVE

Autogyro* can be defined as a rotary wing aircraft that fly due to the presence of an engine. The whole disposable power is applied in a tractor propeller, which makes the aircraft to move ahead in the air, being this velocity the one that makes the rotor blades to rotate without being powered. This turn of the rotor produces the necessary lift to allow the autogyro to fly, being known this condition as autorrotation (1). D. Juan de la Cierva Codorniú granted the first patent of this invention in 1921. Some years after, in 1923, the first controlled flight of the Autogiro C-4 was achieved. To do this, it was necessary to solve the problems related with the aerodynamic asymmetry of the rotor in forward flight by including the flapping hinge (2).

Since that moment, D. Juan de la Cierva was devoted to improve his designs, resolving a lot of problems that were appearing in the new consecutive models. In this way the most famous Cierva's Autogiro, C-30, appeared. It was an Autogiro without fixed wings and with a rotor which plane of turn could be inclined by the pilot (direct control). Other revolutionary aspects of this model were the mechanical launching of the rotor and the direct or jump take off. By means of the mechanical launching of the rotor, the run on ground to achieve the necessary rotor speed of turn for take off was avoided. The jump take off was possible due to the autodynamic rotor, increasing the blade angle automatically on loosing the launching mechanism.

However all Cierva's Autogiros were of small size, for one or two persons, mainly due to the low power of the piston powerplants at that moment. The bigger of Autogiros built on that era was the Pitcairn PA-19, five-seater, with a maximum take off weight of 2100 kg and a power of 420 hp. The majority of the Autogyros built after Cierva's death has been employed for sports, being mainly single-seater although there is some two-seaters for instruction.

As an exception it must be pointed out that Fairey put in flight, in 1947, its model called Gyrodine (3). This aircraft was quite revolutionary due to its size, being five-seater and having a maximum take off weight of 2715 kg. In this model the rotor was only used to achieve lift but not thrust like helicopters do, but it needed some power. Later the Fairy Rotodyne was developed. It worked as an autogyro in forward flight, being powered by two 2800 hp Napier Eland turboprops. For vertical take off and landing, power from tip blade jets was applied to the rotor, avoiding the necessity of a tail rotor like in conventional helicopters. The first flight of this aircraft took place on 1954.

When the rotorcraft division of Fairey joined to Westland Helicopters, a similar aircraft for 70 seats was designed. Two 5250 hp Rolls Royce Tyne turboprops powered this model. The level of noise generated by the operation when the tip blade jets were working was so great that this inconvenient obliged to cancel the project.

At the beginning of the eighties a Spanish aeronautical company, AISA, developed a five-seater autogyro powered by a 300 hp piston engine (4). An accident during the first flight as well as financial difficulties and the change of mind of the company stopped the project without reaching the production phase.

Recently, the interest for autogyros is increasing (5,6,7,8). In fact, there are a lot of light autogyros for leisure although, mainly because of its low developing and operating costs, there is some projects of autogyros with professional missions. Their weight values obliges them to be certified as rotorcraft JAR-27 (rotorcraft having a maximum take off weight non greater than

* "Autogiro" was registered first in Spain in 1923 and then in other countries as the Cierva Company's trademark. This word should therefore be spelt with capital when used for Cierva's products. The generic term "autogyro" or "gyroplane" is now widely used to describe all rotary-wing aircraft with unpowered rotors (1).

2718 kg; with no more than two occupants and a take off weight of no more than 600 kg can be classified as ultra-light rotorcraft). Among them there are some distinguished models as Hawk II (two-seater) and Hawk V (five-seater) developed by Groen Brothers Aviation (9), and CarterCopter (five-seater) from CarterCopter Inc.

3. AUTOGYRO MISSIONS

Having in mind the features of autogyros, it is possible for them to develop the same missions as airplanes. However, autogyros do not need airfields so long for take off and landing and, if they are equipped with autodynamic rotor, the vertical take off is almost possible. The cruising velocity is lower than the airplane and that fact limit the range to smaller values. On the other hand, autogyros are superior to airplanes in all low speed missions like agriculture works, photography, surveillance or publishing, due to the absence of problems related to stall.

In relation to helicopters, autogyros are capable to perform the same missions with the exception of those needed of hovering, or vertical take off and landing. This means that autogyros are inferior to helicopters in some rescue operations and also in those when access to remote zones full of obstacles is required. However, the cruising velocity of autogyros is greater than helicopters, and the operating costs are lower (there is no tail rotor and, as the main rotor is unpowered, the transmission is not so complex).

A relation of missions where autogyros can be competitive is presented below:

- Qualifying flight for pilots.
- Crew training.
- Police missions.
- Traffic control.
- Victim location in accidents and catastrophes.
- Civil protection.
- Fire detection and fighting.
- Transport of persons and cargo.
- Natural resources detection.
- Photography.
- Publishing.
- Agricultural and forest works.
- Ducts and electrical wiring surveillance.

Such a great diversity of missions makes that, nowadays, the potential advantages of autogyros must be compared against helicopters and airplanes.

4. OPERATING COSTS COMPARISON

First of all, a comparative study will be focused on the field of rotary wing aircraft by comparing autogyros and helicopters in the range of 500 and 1000 kg of payload. The autogyros are Hawk II and Hawk V, and the helicopters are Bell 206 and EC-135. The operating cost estimation has been made following the procedure recommended by the Helicopter Association International (HAI) (10,11) and data from the manufacturers (12).

Table 1 shows the main characteristics of the selected helicopters and autogyros. On the other hand, Table 2 depicts the same kind of data for the comparison between airplanes and autogyros. In this case, the selected airplanes have been the Cessna 182 and the King Air C90B, for the two categories of payload considered. The method chosen for the estimation of the operating costs has been the one developed by J. Roskam (13).

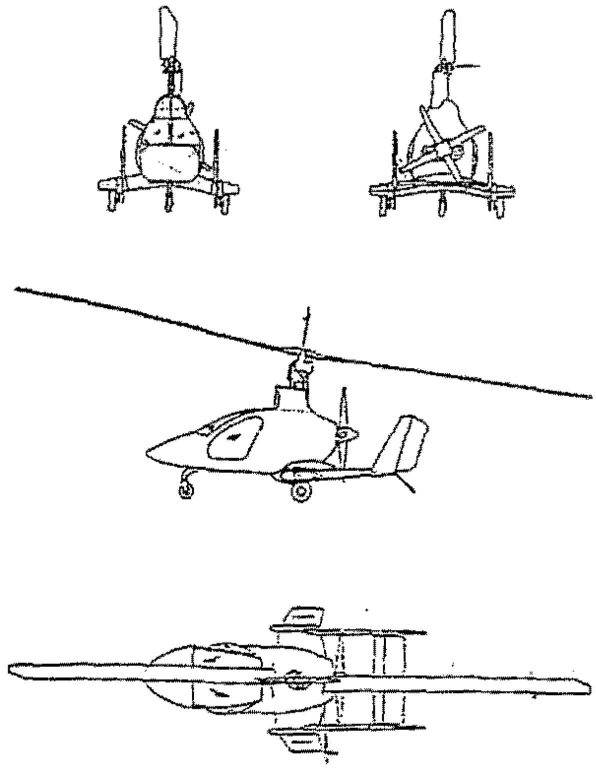

Figure 1. Hawk II autogyro drawing

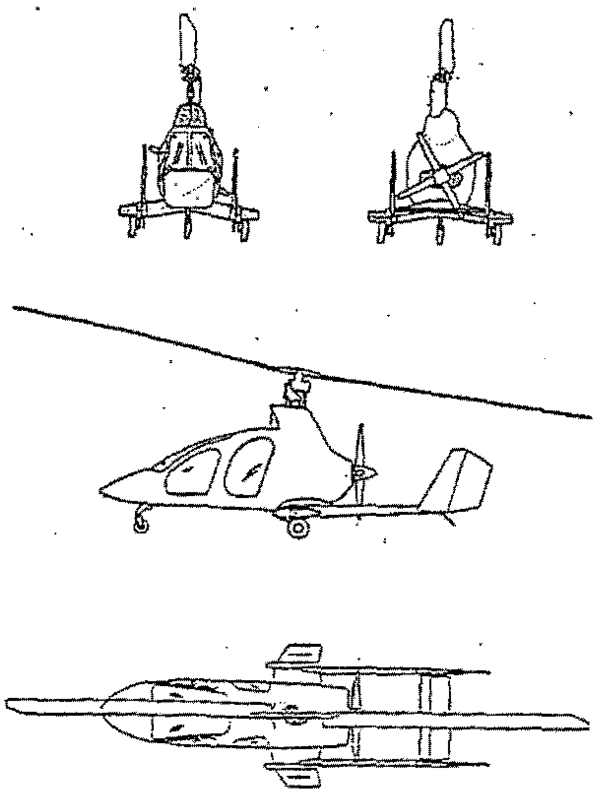

Figure 2. Hawk V autogyro drawing

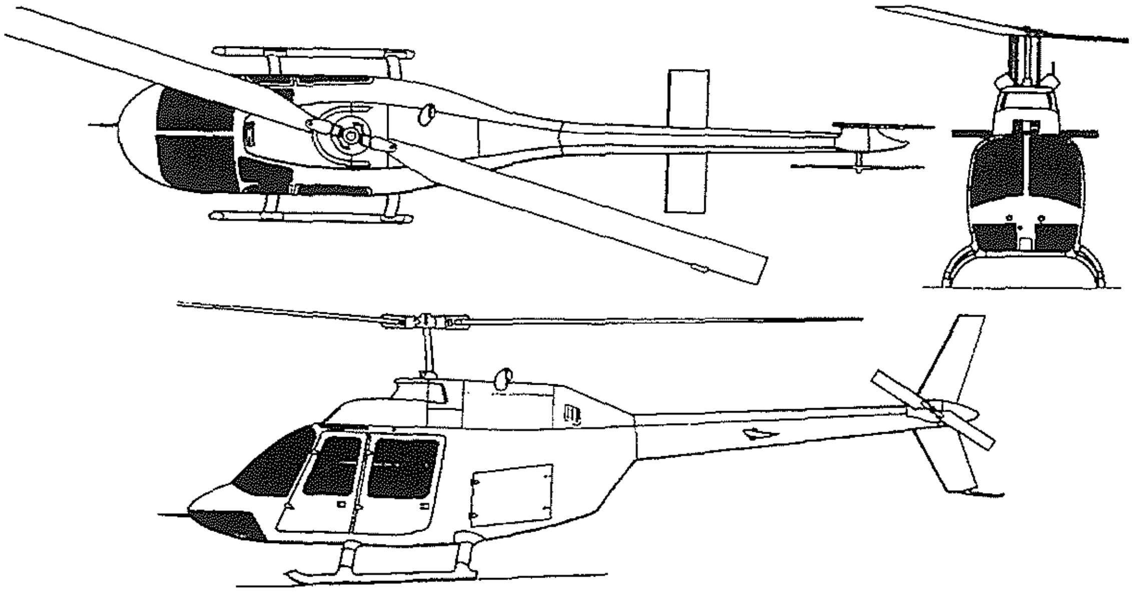

Figure 3. Bell 206B JetRanger III light utility helicopter

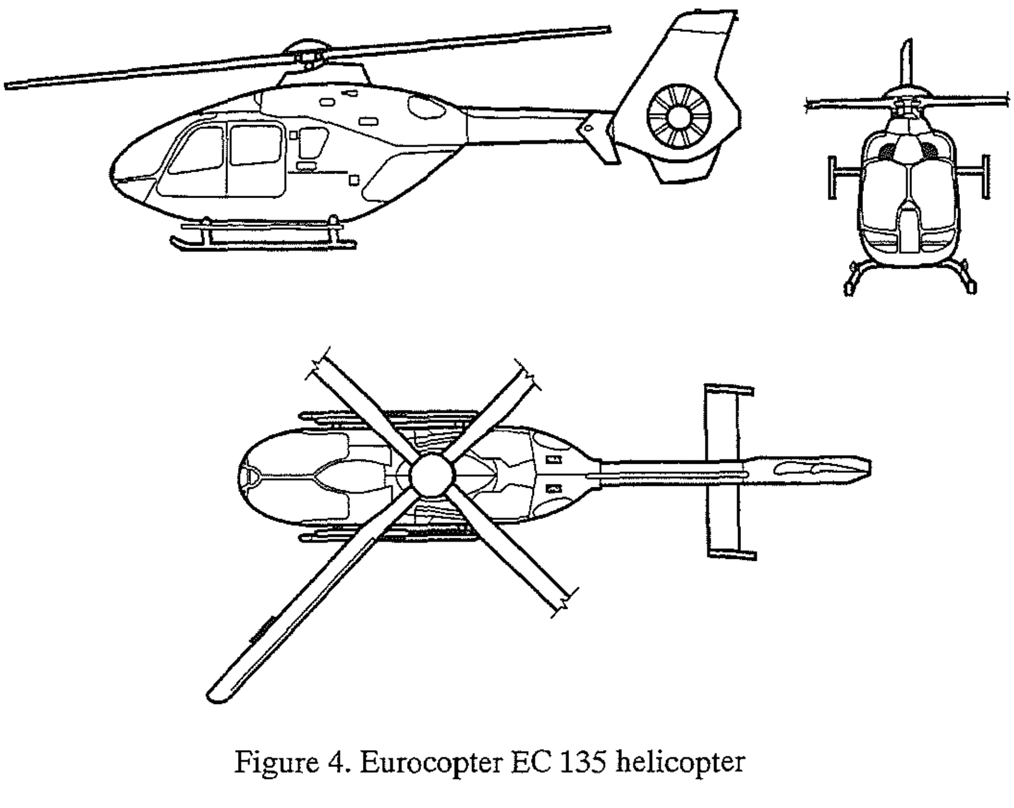

Figure 4. Eurocopter EC 135 helicopter

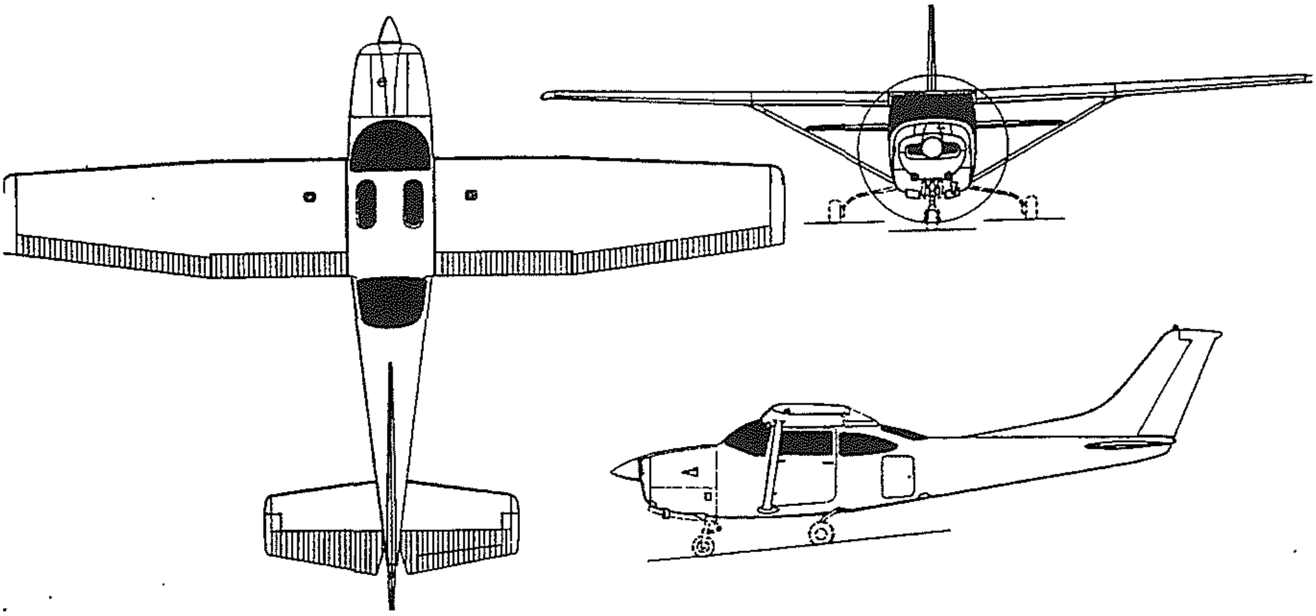

Figure 5. Cessna Skylane RG airplane

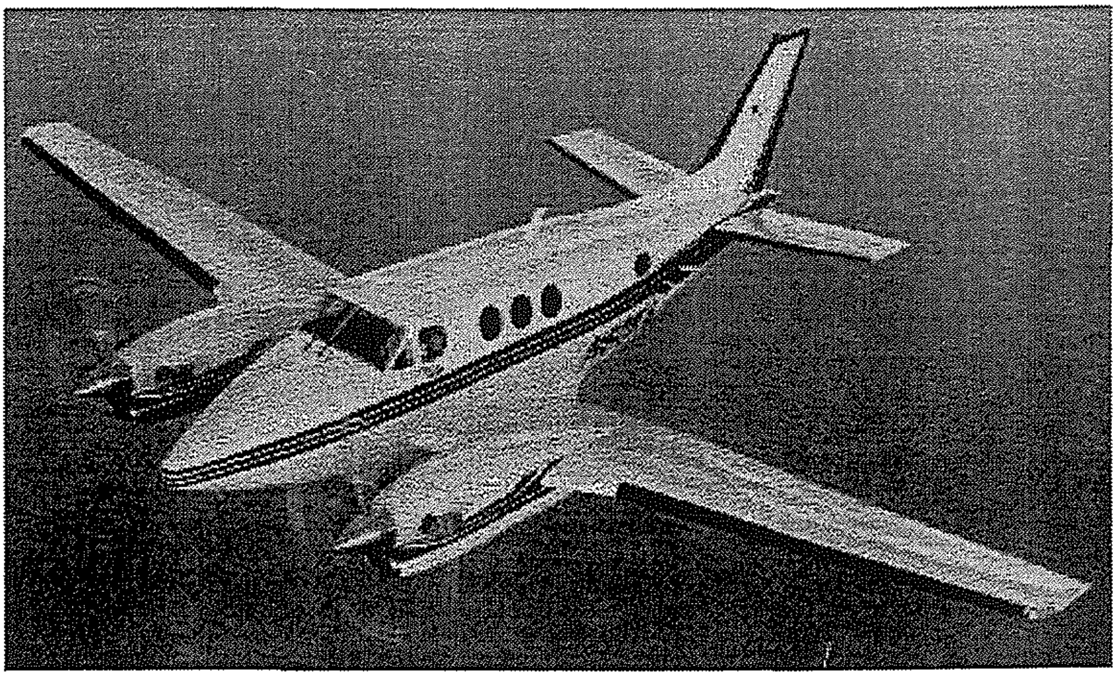

Figure 6. Beech King Air C90B airplane

Table 1. Characteristics of helicopters and autogyros

	Rotorcraft MTOW<1500 kg		Rotorcraft MTOW>1500 kg	
	autogyro	helicopter	autogyro	helicopter
	Hawk II	*Bell 206*	*Hawk V*	*EC-135*
	Fig. 1	*Fig. 3*	*Fig. 2*	*Fig. 4*
MTOW (kg)	1270	1189	1672	2630
MPL (kg)	410	452	712	1210
Power Plant	TSIOL 550	Allison 250	Walter	Arrius 2B
(No engines and kW)	(1x261)	(1x485)	(1x559)	(2x435)
Take off distance (m)	38	---	46	---
Stall speed (km/h)	28	---	65	---
Cruise speed (km/h)	259	185	259	245
Range (km)	725	463	769	598
Endurance (h)	5,3	2,8	2,97	2,4
Acquisition cost (M$)	0,235	0,7	0,230	2,44
Operating cost ($/h)	71	222	87	292

Table 2. Comparison between airplanes and autogyros.

	Aircraft MTOW <1500 kg		Aircraft MTOW >1500 kg	
	autogyro	airplane	autogyro	airplane
	Hawk II	*Cessna 182*	*Hawk V*	*C90 B*
	Fig. 1	*Fig. 5*	*Fig. 2*	*Fig. 6*
MTOW (kg)	1270	1340	1672	4581
MPL (kg)	410	590	712	1383
Power Plant	TSIOL 550	Cnt-460	Walter	PT6A21
(kW)	(1x261)		(1x559)	(2x410)
Take off distance (m)	38	411	46	768
Stall speed (km/h)	28	106	65	
Cruise speed (km/h)	259	296	259	536
Range (km)	725	1275	769	2200
Endurance (h)	5,3		2,97	3,2
Acquisition cost (M$)	0,235	0,165	0,230	2,5
Operating cost ($/h)	71	48	87	220

For the aircraft having a MTOW<1500 kg, it can be seen that autogyro has an operating cost much lower that helicopter, almost three times lower, although it is a bit superior than airplanes. However, the minimum flight velocity is much lower, as well as the requirements for ground infrastructures, due to the fact that the airplane needs a 411 m long field whilst the autogyro can use any heliport. In relation to the acquisition costs, the autogyro is better than the corresponding helicopter; and in relation to the performances, having all aircraft similar weight, the cruising velocity, range and endurance are greater for autogyros than for helicopters.

Comparing the airplane and the autogyro, the operation and acquisition costs are similar but, as has been stated before, the autogyro does not need so high inversion on infrastructures and, in the case of missions in which the low velocity is important, autogyros are clearly superior. It is important to point out that in the case of setting up new flight units, the ground requirements are of capital importance to evaluate the operation costs.

For heavier aircraft, the advantage in costs of the autogyro is evident compared to the other aircraft types. The likeness in cruising velocity and endurance make the helicopter and autogyro to be comparable, but the acquisition cost is multiplied by seven. In this level of weights, the airplane needs an important ground infrastructure (900m field length at least). It is seven times more expensive than the autogyro and, every hour of flight is two times and a half more expensive. For low velocity missions, autogyro can fly at half the airplane speed.

All these advantages make autogyros to be very interesting when compared to other aircraft for all the missions presented at section 3.

5. CONCLUSIONS

Although it can be thought that autogyros are only a step in the history of rotary wing towards the helicopter, the present study shows how this statement is not completely true. The analysis carried out in this work demonstrates that autogyro is a type of rotary wing aircraft with special characteristics that make them very competitive in relation to airplanes and helicopters.

The main advantages can be resumed in the ability for flying at very low velocities with safety, the absence of problems with the failure of the powerplant (because the autorrotation of the rotor), the very simple infrastructures required, and the low operating and acquisition costs.

Therefore, having in mind these ideas, it seems possible from the economic point of view, to develop an autogyro and to put it into the aeronautical market with a relevant reduction of acquisition costs compared to other type of aircraft.

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