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AVIACIÓN **C**IVIL

Report A-041/2005

Accident involving a Canadian SAFARI helicopter, no registration, in Cobreces (Cantabria), on 25 July 2005

MINISTERIO
DE FOMENTO

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SECRETARÍA GENERAL DE TRANSPORTES

COMISIÓN DE INVESTIGACIÓN DE ACCIDENTES E INCIDENTES DE AVIACIÓN CIVIL

Edita: Centro de Publicaciones
Secretaría General Técnica
Ministerio de Fomento ©

NIPO: 161-08-041-9
Depósito legal: M. 23.129-2003
Imprime: Diseño Gráfico AM2000

COMISIÓN DE INVESTIGACIÓN DE ACCIDENTES E INCIDENTES DE AVIACIÓN CIVIL

Tel.: +34 91 597 89 63
Fax: +34 91 463 55 35

E-mail: ciaiac@fomento.es
http://www.ciaiac.es

C/ Fruela, 6
28011 Madrid (España)

Foreword

This report is a technical document that reflects the point of view of the Civil Aviation Accident and Incident Investigation Commission (CIAIAC) regarding the circumstances of the accident and its causes and consequences.

In accordance with the provisions of Law 21/2003 and pursuant to Annex 13 of the International Civil Aviation Convention, the investigation is of exclusively a technical nature, and its objective is not the assignment of blame or liability. The investigation was carried out without having necessarily used legal evidence procedures and with no other basic aim than preventing future accidents.

Consequently, any use of this report for purposes other than that of preventing future accidents may lead to erroneous conclusions or interpretations.

This report was originally issued in Spanish. This English translation is provided for information purposes only.

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Abbreviations

00°	Degree(s)
CHR	Canadian Home Rotor
DGAC	Dirección General de Aviación Civil (Civil Aviation Authority)
UTC	Coordinated universal time
ft	Feet
h	Hour(s)
kg	Kilogram(s)
LH	Left hand
m	Meter(s)
MTOW	Maximum take-off weight
RH	Right hand
S/N	Serial number
ULM	Ultralight Aircraft

Synopsis

Owner and operator:	Private
Aircraft:	Canadian Safari, no registration
Date and time of accident:	25 July 2005; 19:00 h[1]
Place of accident:	Cóbreces (Cantabria)
People aboard and injuries:	Two, 1 fatal and 1 seriously injured
Type of flight:	General aviation. Private
Date of approval:	29 April 2008

Summary of accident

While on a local flight, the helicopter started to turn about its vertical axis and to the left, losing control and impacting the ground. The investigation revealed that the accident was caused by the fatigue failure of a delta pin that joins the driveshaft to the spindle to which the tail rotor blades are attached.

[1] All times in this report at local. Subtract two hours to obtain UTC.

1. FACTUAL INFORMATION

1.1. History of the flight

The owner and another person, the sole occupants of the aircraft, were making a short-duration flight in the vicinity of the ultralight field where the helicopter was based. The flight was being conducted for the purpose of adjusting the flight controls.

On their return to the field, while flying below 300 ft, the helicopter started a turn to the left about its vertical axis. The turn increased in intensity, making the aircraft uncontrollable.

The aircraft came down in a corn field with barely any lateral movement, coming to rest on its left side on the ground.

Figure 1. Final position of the helicopter

1.2. Injuries to persons

Injuries	Crew	Passengers	Total in the aircraft	Others
Fatal	1		1	
Serious	1		1	
Minor				Not applicable
None				Not applicable
TOTAL	2		2	

1.3. Damage to aircraft

The main structure housing the cabin and the engine showed extensive buckling to the lower and right sides. The front part of the skids broke. One of the tubes on the tubular tail boom adjacent to the main structure was broken in several places and bent in a downward direction.

The main rotor was detached from the mast. Its two blades had been bent by the impact. The tail rotor detached in two places, with one blade in one location, and the

Figure 2. Final position of the tail section

assembly consisting of the driveshaft, head and the other blade in another.

The aircraft was destroyed by the impact.

1.4. Other damage

The impact of the aircraft and the rescue efforts resulted in damage to a corn field.

1.5. Personnel information

There were two people aboard the helicopter, neither of whom held a helicopter pilot license, though according to available information, both had flying experience.

The person in the RH seat was the owner of the helicopter and, according to information provided by the other occupant, had acquired some 25 h of piloting experience, mainly in the ultralight field where it was flown. The person in the LH seat had some 250 h of piloting experience aboard Schweizer series 300 and 333 and Safari helicopters, as well as experience with ultralights, of both fixed-wing and helicopter designs, and in their assembly from kits.

1.6. Aircraft information

Canadian Home Rotor builds the kit for assembling the helicopter marketed under the SAFARI name.

Aircraft:	SAFARI
Kit manufacturer:	Canadian Home Rotor (hereinafter CHR)
Serial number:	BB2055
Engine:	Lycoming O-320B2C S/N L-16578-39A
MTOW:	680 kg
Number of seats:	Two
Registration:	None

The background of the helicopter's construction and ownership begins in Australia in 1999, where it was assembled and flown for 90 h under registration VH-HTB. In November of 2001, it was purchased through the Internet by someone in Argentina, where it was received in three pieces: cabin, rotor and tailboom. After being assembled, it flew 21 hours under registration LV-X273. In September of 2004, it was purchased by its current Spanish owner and shipped in four pieces: cabin, rotor, tailboom and main transmission. The information gathered indicates an estimated flying time of 20 h in Spain, which would put the total flying time of the helicopter at 131 h.

The aircraft did not have an Airworthiness Certificate and was not registered. There was also no application for an assembly permit for the helicopter filed with Spain's Civil Aviation Authority as required by regulations.

An examination of the helicopter's records revealed that the main and rotor transmissions had been replaced on 12 December 1999 after 10 h of flying time, and that on 13 May 2001, with 86 flying hours, the tail rotor head and blades were disassembled for adjustments.

The main rotor spins to the right, so the tail rotor produces thrust to the left to counteract the main rotor torque.

The fuel cutoff valve is on the left side of the cabin, near the LH seat above the backrest.

Tail rotor components

Figure 3 shows an exploded view of the tail rotor and is supplied with the assembly instructions by the manufacturer. The following components are of particular importance:

No. 3	Tail rotor spindle
No. 9	Delta Pin Bushing
No. 10	Tail rotor delta Pin
No. 25	Tail rotor Bump/Balance
No. 28	Bolt
No. 29	Pal nut

The tail rotor delta pin (10) is housed inside the spindle (3) and is held in place by the bolt (28). The spindle, in turn, is connected to the driveshaft by the delta pin.

The diagram in Figure 3 does not specify accurately how to assemble the spindle. The design of the component is such that if given half a turn about its longitudinal axis, it can be mounted in two different orientations, with the delta pin varying its position relative to the rest of the tail rotor head and blade assembly.

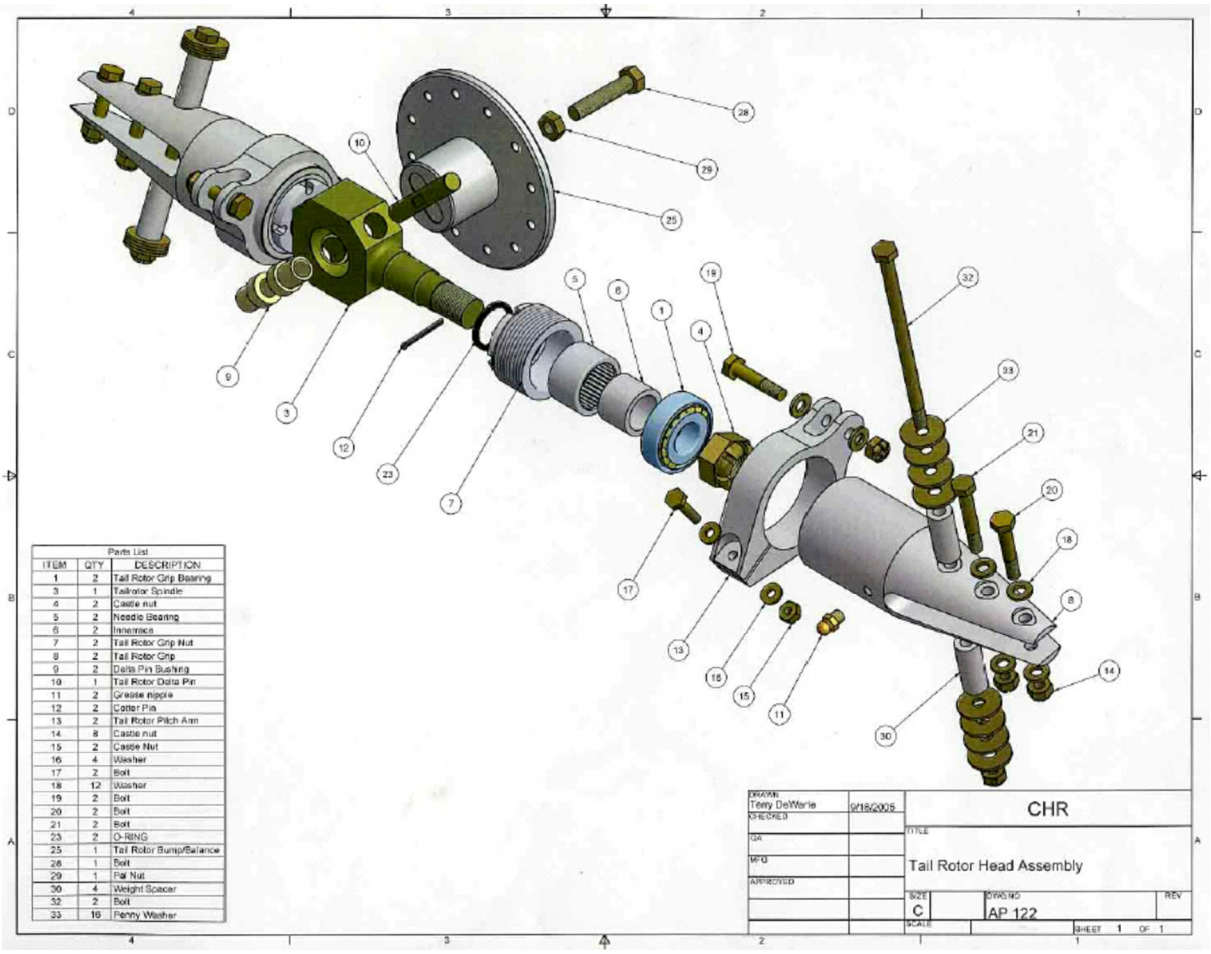


Figure 3. View of the tail rotor

1.7. Meteorological information

The wind was calm and it was a sunny day.

1.8. Aids to navigation

Not required for the flight.

1.9. Communications

There are no recordings of any communications.

1.10. Aerodrome information

The aircraft was based out of a privately-owned and unlicensed ultralight field. It has a 170 × 60 m grass runway with a 140°-320° orientation, and a gradient in excess of

4% over 50% of its length. There was a windsock on the roof of a building next to the runway and the runway had edge markers.

1.11. Flight recorders

Not applicable.

1.12. Wreckage and impact information

The main wreckage consisted of the cabin, engine, main and tail rotor transmissions, tailboom and tail rotor box. These components retained their integrity and were lying on the ground on the left side of the helicopter.

The main rotor head and blades had detached from the mast and were in the same general area as the main wreckage.

The front third of the helicopter's left skid was separate from the main wreckage but along the same likely path taken by the helicopter in the final moments of flight (see Figure 4).

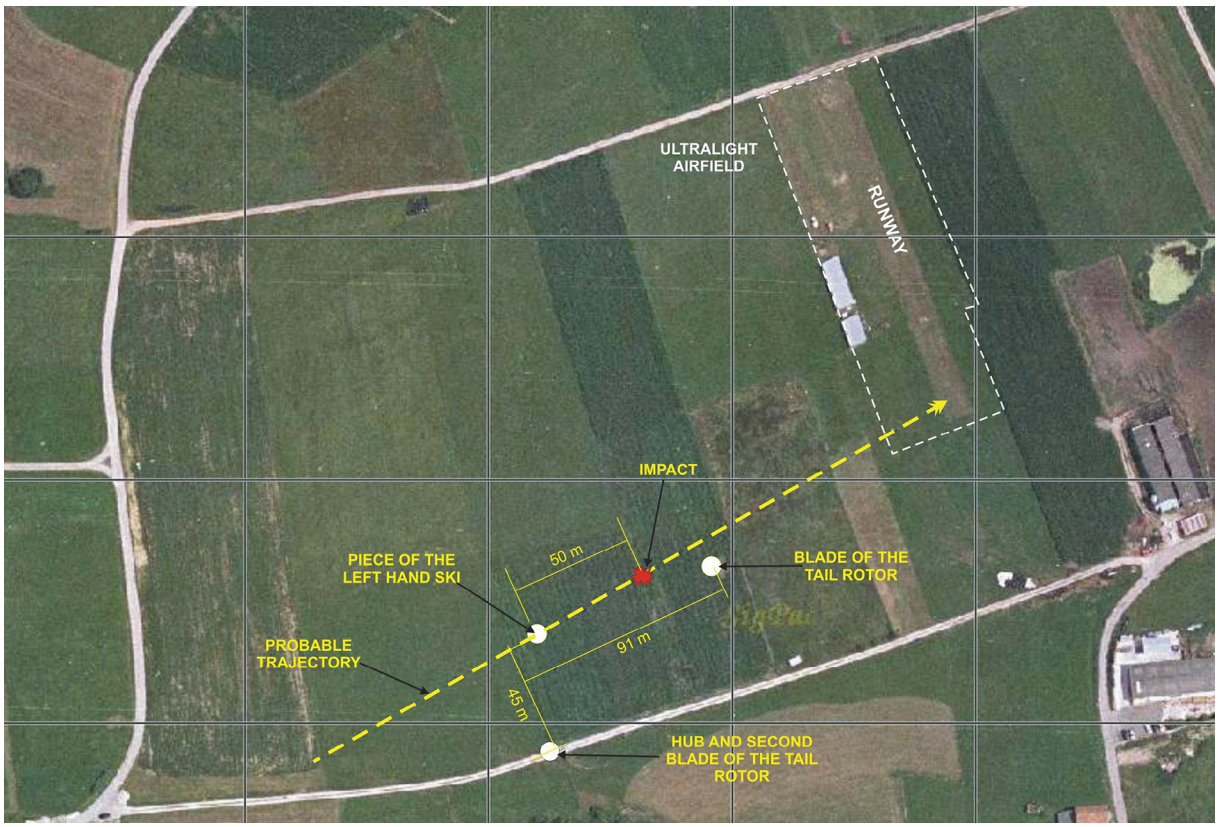


Figure 4. Overhead view showing the trajectory and wreckage distribution

The tail rotor remains were in two groups, separate from the helicopter:

1. The group comprising the rotor head, the right angle drive and one of the blades was found next to the skid fragment mentioned above. The last third of the tail rotor blade had received a severe impact.
2. The second tail rotor blade was found ahead of the main impact site.

Continuity was established for the cyclic and collective controls up to the swashplate. The linkages that go from the plate to the rotor head were cracked.

The anti-torque control cable linking the pedals to the tail rotor pitch control system was broken at the connection to the pedals and to the tail rotor.

1.13. Medical and pathological information

Not supplied to the investigation.

1.14. Fire

The accident did not result in a fire.

1.15. Survival aspects

The warping of the main helicopter structure suggests a high angle of impact with the ground on a nearly vertical trajectory with a right roll attitude. Consequently, the deceleration forces on impact were greater for the occupant in the RH seat, who died due to his injuries. The person in the LH seat was seriously injured but maintained consciousness. He was admitted to a hospital.

1.16. Tests and research

According to information provided by the surviving occupant and an eyewitness, the helicopter, while approaching the field and attempting to reduce its translational speed to zero, started spinning to the left about its vertical axis before spiraling erratically and falling vertically to the ground.

A detailed visual inspection of the tail rotor assembly revealed the following damage:

1. A broken and partially-coupled delta pin inside the spindle housing.
2. A broken spindle arm with the associated blade detached.

3. A broken driveshaft which coupled the tail rotor assembly to the right-angle drive.
4. Broken blade pitch control links and cable.

So as to understand the loading processes resulting from the above damage, the tail rotor was tested in a laboratory.

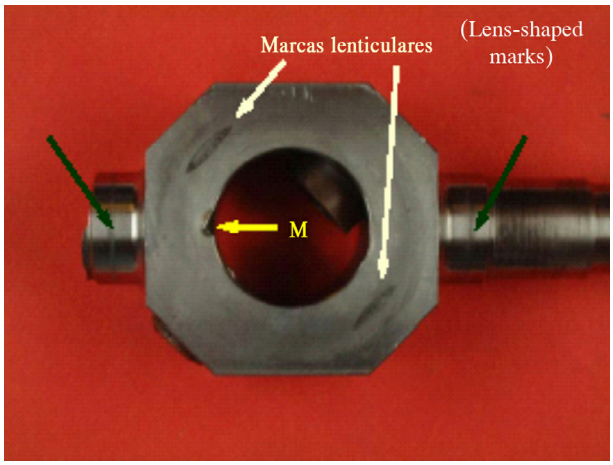


Figure 5. Spindle as seen from the driveshaft side at the time of the event

The tests revealed that the spindle was mounted in a different position from that specified in the manufacturer's assembly instructions (see Section 1.18.1). This resulted in a delta pin that was 90° out of alignment.

The spindle was made from a titanium alloy that complied with the manufacturer's specifications concerning the type of alloy, chemical composition, mechanical properties, hardness and microstructure. The delta pin was also made of a titanium alloy with characteristics similar to those of the spindle.

The fracture of the spindle arm resulted from fatigue and developed at a point situated on the tail rotor's rotational plane, on the leading edge side. No cracks were found on the corresponding section of the other spindle arm.

There were lens-shaped marks on both sides of the spindle, situated symmetrically about and perpendicular to the delta pin, apparently due to contact with the edges of the tail rotor bump/balance and resulting from excessive clearance in the assembly.

The driveshaft experienced ductile failure due to instantaneous overloading.

The delta pin also fractured as the result of fatigue originating on the external surface opposite an existing notch. The fracture surface did not exhibit any obvious signs of static failure, leading to the conclusion that the crack propagation mechanism was fatigue-induced.

On the opposite side, in a position corresponding to that of the crack propagation point, there was another crack, indicative of a second fatigue process analogous to that which caused the failure of the component.

A third crack was found propagating lengthwise along the surface at the base of the notch, apparently resulting from a slight bending moment experienced by the delta pin

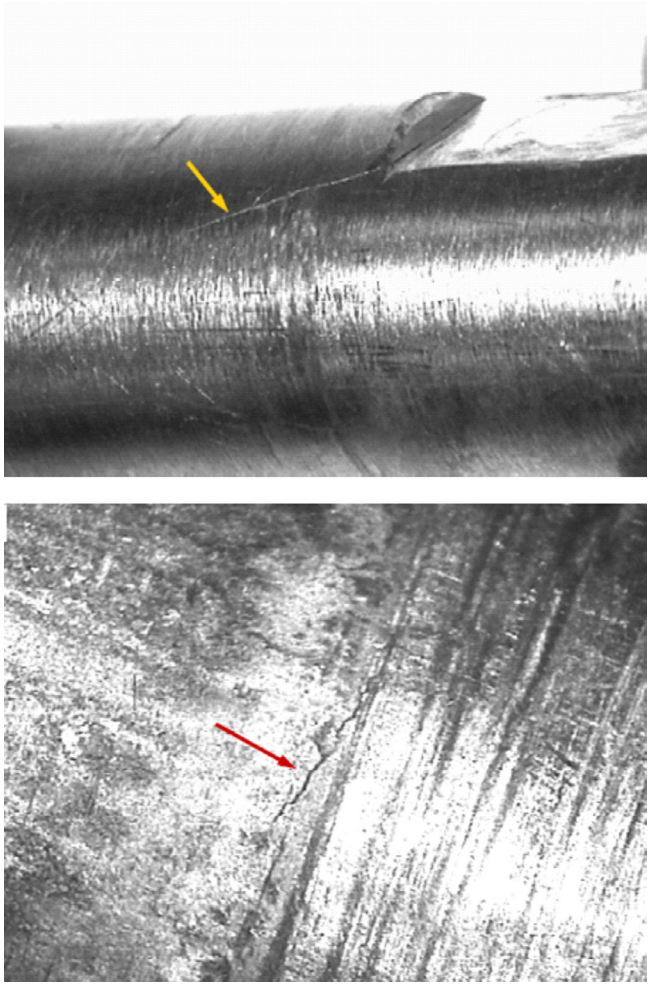


Figure 6. Delta pin showing the crack and a third crack (top picture); and the crack symmetrical to that of the failure (bottom)

and therefore associated with a different loading mechanism from that which affected the other two.

There was considerable wear on the plastic bushings mounted on the ends of the delta pin and housed inside the spindle. The wear had resulted from rubbing against the ends of the driveshaft, most likely following the breakage of the delta pin. The bushing mounted on the attached section of the delta pin had extruded through the housing, leaving circular marks on the driveshaft surface.

1.17. Organizational and management information

Not relevant.

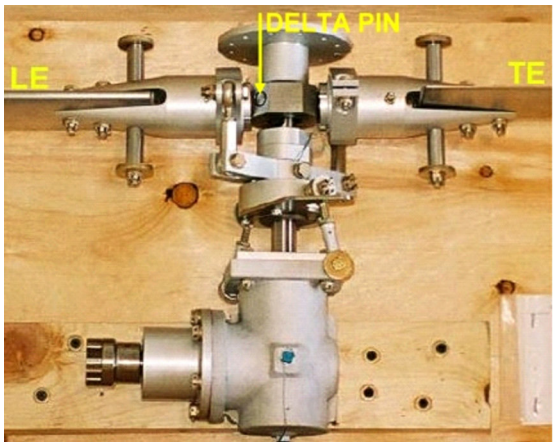
1.18. Additional information

1.18.1. *Spindle assembly*

Information on the correct assembly of the spindle is provided to registered users by the kit manufacturer through its website. According to the data collected, the owner had not registered with the kit manufacturer as the owner of the helicopter and never requested assistance from the manufacturer.

The instructions supplied by the kit manufacturer specify that the spindle must be assembled such that the mounting hole for the delta pin faces towards the leading edge of the blades. However, the diagram also provided by the manufacturer which shows the components of the tail rotor assembly is ambiguous, admitting the possibility of two different ways to assemble the spindle (see Section 1.6).

The spindle was installed on the helicopter such that the drill hole housing the delta pin was not facing the leading edge of the blades (see Figure 7), but faced the trailing edge instead, that is, it was 90° out of alignment with respect to the manufacturer's instructions as appear for the customers in the internet site.



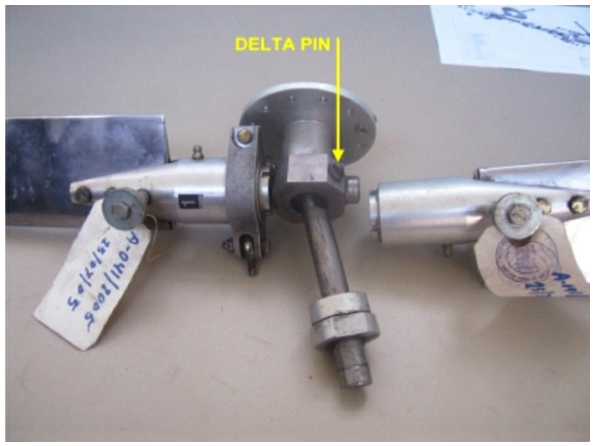


Figure 7. Spindle assembly according to CHR's Compliance Procedure (left); asfound assemble of the tail rotor (right)

It is CHR's considered opinion that a faulty installation of the spindle will result in increased gyroscopic forces on the component when wide pedal movements are applied or when wind gusts impinge on the tail rotor.

It was not possible to ascertain with certainty when the tail rotor head section was last assembled.

1.18.2. *Statement from an eyewitness on the ground*

The helicopter was flying toward the ultralight field when an eyewitness saw a component detach from the rear of the helicopter, directly followed by a turn to the left and the aircraft crashing to the ground.

1.18.3. *Statement from the occupant*

According to information provided by the survivor, the helicopter had been in an accident on 30 September 2004 during which the main rotor blades had impacted the ground. The resulting damage led to the replacement of both main rotor blades, one fuel tank and various main transmission components. The helicopter cabin was also changed out a few days before this event due to damage sustained during transport.

The rotor and then the main rotor blades were aligned and balanced two days before the accident. According to the statement, the appropriate tools were used for the task. They were having problems with vibrations originating presumably in the tail rotor. Though they were considered normal, they repeated the balancing operation three times.

Following the repair, the biggest problems encountered on the test flights, which were usually made by both occupants, involved an adjustment of the pedals and the control of the aircraft under hovering and low translational speed conditions. They attributed the problems to a lower than expected tail rotor thrust, made noticeable by the large motion that had to be applied to the pedals when more tail rotor thrust was required during the transition from normal to stationary flight.

The owner of the helicopter was at the controls during the accident flight. When they were preparing to land, they felt a shudder in the tail rotor. According to the statement of the survivor, he responded immediately, taking over the controls and applying right pedal to try to stop the left turn. The helicopter continued turning and shaking rapidly until they impacted the ground.

The occupant stated that the tail rotor section had been received already assembled and that they had not replaced any components. They were not familiar with CHR's compliance procedure.

1.18.4. *Information supplied by the manufacturer to the owners of aircrafts Canadian Safari helicopter type*

The aircraft's manufacturer has communicated that in their website there is a section for owners where, besides assembling instructions, there are collected recommendations for performing tests in stationary hovering position and at low height during 20 h after the aircraft's assembly and before performing flights at higher heights.

1.18.5. *Measures adopted by the manufacturer*

The manufacturer has communicated his intention of including in their website, in the section for owners, some details of this incident as safety improvement according to their politics of keeping informed to owners and manufacturers.

On the other side, and in order to avoid future mistakes in the tail rotor spindle assembly, the manufacturer will proceed to engrave this piece, indicating which side is situated in the outside area.

2. ANALYSIS

2.1. General

The owner of the helicopter, accompanied by another person, were doing test flights following the replacement of important components which had been damaged in an accident involving the helicopter a little over a year before. Neither occupant had a pilot's license. The pilot's flying experience was very limited, while the other occupant had somewhat more experience aboard small helicopters and ultralights.

The tests were being carried out so as to adjust the flight controls, mainly the pedals, which control tail rotor pitch, and to eliminate vibrations. They had noticed some control difficulties during hovering and low translational speed maneuvers, which require considerable anti-torque from the tail rotor. Aware of these circumstances, they planned a short-duration flight, with the events leading up to the accident occurring on the way back to the field. When they were some 300 m away from the field, they felt "the tail shudder", in the words of the survivor, and from there an uncontrolled yaw to the left which increased rapidly until the impact with the ground.

In this helicopter, an uncontrolled turn of the helicopter nose to the left is consistent with a loss of tail rotor thrust, which counteracts the torque induced by the main rotor. The location of the two separate tail rotor remains (one rotor blade in one place and the head, the other blade and the shaft in another) confirm their detachment from the helicopter while in flight.

It was the in-flight breakage and detachment of the tail rotor, therefore, which led to the loss of control. The crew had obvious difficulties in controlling the resulting condition, which made an accident under those circumstances practically impossible to avoid.

2.2. Loss of the tail rotor

A mechanical and metallographic analysis of the detached rotor components place the origin of the detachment on the fatigue failure of the delta pin which attaches the spindle to the rotor driveshaft. After the failure, it is likely that fatigue also led to the failure of the spindle arm, to which the blades are mounted. This fatigue probably resulted from the new load distribution following the failure of the delta pin.

It has not been possible to determine the flying time that elapsed between the failures of the delta pin and the spindle. It was the breakage of the latter which resulted in the detachment of the blades just before the accident. Nevertheless, given the difficulties present during the test flights involving pedal adjustments and vibrations, and that no changes were made to the tail rotor assembly during the helicopter's assembly, the

damage to the delta pin may well date back to the year 2001, the last time that component was disassembled.

2.3. Tail rotor assembly

The inspections and tests on the spindle and the delta pin used to attach the spindle to the driveshaft revealed that the arrangement of these components on the helicopter matched that shown on a diagram for the tail rotor head included with the manufacturer's documentation. Said information differed from that provided by the same manufacturer during the course of the investigation for the assembly of the tail rotor group. Specifically, the installation of the spindle results in a longitudinal variance of 180° with respect to the blades, depending on which instructions are used. In practice, the component's design allows mounting it in either position indistinctly. There is no indication on either set of instructions as to which orientation is correct. Of the two possibilities, the configuration of this component on the accident aircraft was improper, as confirmed by the manufacturer. Operating under these conditions could result in increased forces on the delta pin and the spindle in excess of design criteria when full pedal was applied or when wind gusts impinged on the tail rotor.

The likelihood of improper assembly should be avoidable, and on that purpose the manufacturer has communicated their intention of engraving such spindle by indicating which side has to be placed in the outside area. Therefore it is considered that these measures adopted by the manufacturer are sufficient enough in order to avoid future wrong assemblies.

In this case no determination could be made as to when, during the life of the helicopter, the improper installation of the spindle took place. Considering the information available, it could have taken place in May of 2001 when the tail rotor head and blades were adjusted, or even before, in 1999, when the main transmission and the tail rotor were replaced, as documented in the aircraft's records. It is uncertain whether other activities were carried out on the tail rotor without being documented. In any case, the incorrectly-installed spindle probably remained in place long enough for fatigue to develop undetected in the delta pin and in the spindle itself.

According to the data provided by the manufacturer some details of this incident will be included in the owners' section in their website. This way the owners of aircrafts presently operating will have available information enough to check the right tail rotor spindle assembly and to take the pertinent corrective measures in case it is not so.

3. CONCLUSION

3.1. Findings

1. The helicopter owner had not requested the proper permits for assembling the aircraft from the DGAC. The helicopter was not registered and it did not have an Airworthiness Certificate.
2. Neither occupant held a Pilot's License.
3. The helicopter had tipped over the previous year. The resulting damage was fixed and had no discernible bearing on the events described herein.
4. The spindle used to attach the tail rotor blades was mounted incorrectly, according to information provided by the manufacturer in its assembly instructions.
5. The position in which the spindle was found matched that shown on a diagram of the tail rotor head supplied by the manufacturer.
6. The spindle may be mounted indistinctly in two different positions. There is nothing in the design to indicate which is the proper position.
7. The incorrect assembly of the spindle can result in increased loads on the delta pin from the rotor shaft.
8. Both the delta pin and the spindle experienced fatigue failure.
9. The material in the failed components met the manufacturer's specifications.
10. The in-flight loss of control of the helicopter resulted from the failure of the spindle and the detachment of a tail rotor blade.

3.2. Causes

The cause of the accident is considered to be the fatigue failure of the delta pin that attaches the spindle to the tail rotor driveshaft, which in turn led to the breakage of a spindle arm and the detachment of the tail rotor blades.

The tail rotor spindle had been incorrectly mounted at an undetermined point over the life of the helicopter.

The following factors contributed to the above occurrence:

- A design that allows the spindle to be mounted incorrectly.
- Insufficiently qualified technical personnel assembling and operating the helicopter.
- Failure to comply with construction and assembly requirements, which precluded proper oversight of those activities.

4. SAFETY RECOMMENDATIONS

None.