BEA
Bureau d'Enquêtes et d'Analyses
pour la sécurité de l'aviation civile

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REPORT
ACCIDENT

Rotor mast bumping during cruise, in turbulence, in-flight break-up, collision with the ground

Aircraft	Robinson R44 helicopter registered EC-IVT
Date and time	3 September 2012 at about 10 h 35[(1)]
Operator	Private
Place	Valouse (26), in cruise at 4,200 ft
Type of flight	General aviation
Persons on board	Pilot and one passenger
Consequences and damage	Pilot and passenger fatally injured, helicopter destroyed.

[(1)] Except where otherwise mentioned, the times in this report are expressed in local time

This is a courtesy translation by the BEA of the Final Report on the Safety Investigation. As accurate as the translation may be, the original text in French is the work of reference.

1 - HISTORY OF FLIGHT

The following elements are from witness accounts, radar and radio-communication recordings.

The pilot, accompanied by a passenger, took off from Clermont Ferrand Auvergne (63) aerodrome at 9 h 24 for Luc Le Cannet (83) aerodrome. The pilot had entered a route in a touch-screen tablet which went via Feurs (42), Saint Etienne (42), Givors (69), Saint Rambert d'Albon (26) and then Le Luc. He performed cruise at an altitude of 7,000 ft. At 10 h 19, at the level of the Rhône valley and 25 km north of Montélimar, he began descent, carried out a 360° turn and halted descent at an altitude of about 2,300 ft. He then continued south-east and went back into climb.

At about 10 h 35, at an altitude of about 4,200 ft (height of 1,500 ft) and at a ground speed of 115 kt, the helicopter broke up in flight and collided with the ground.

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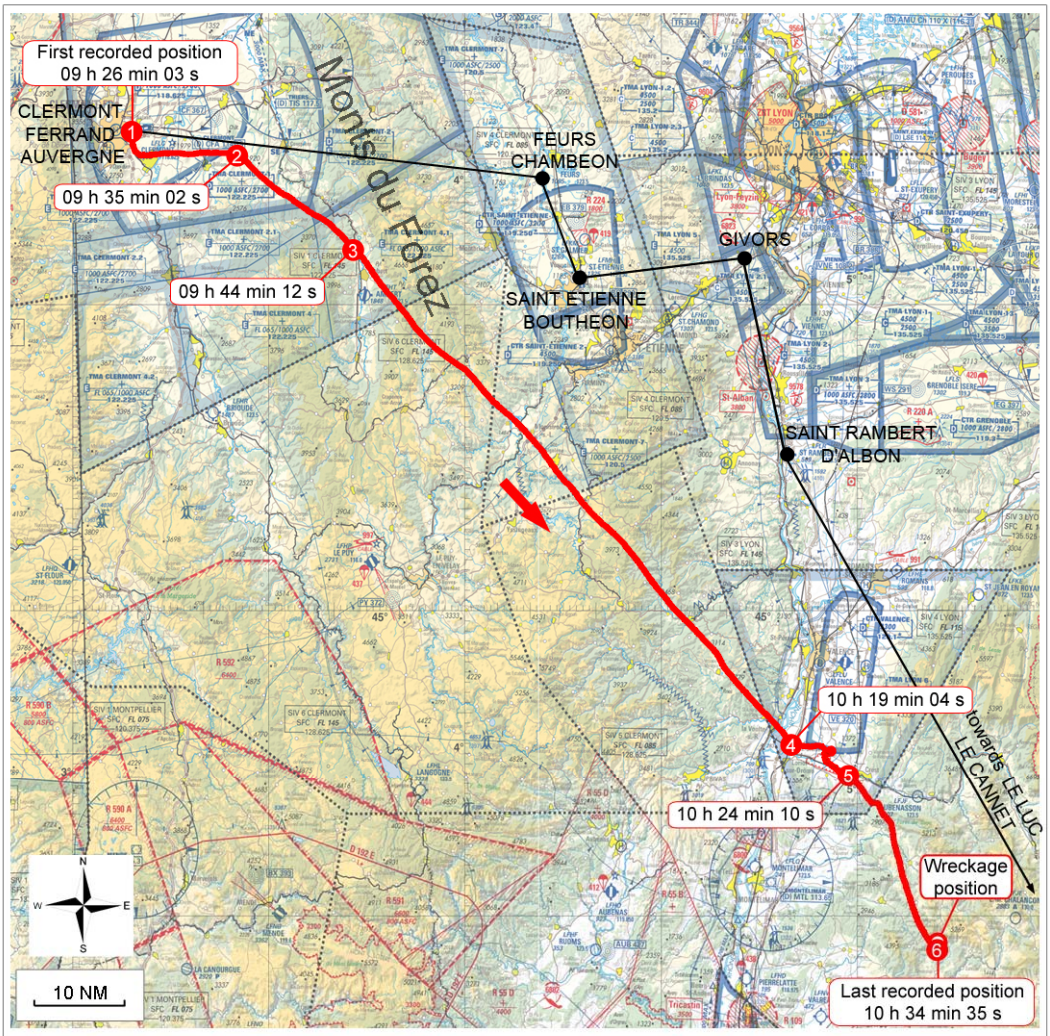
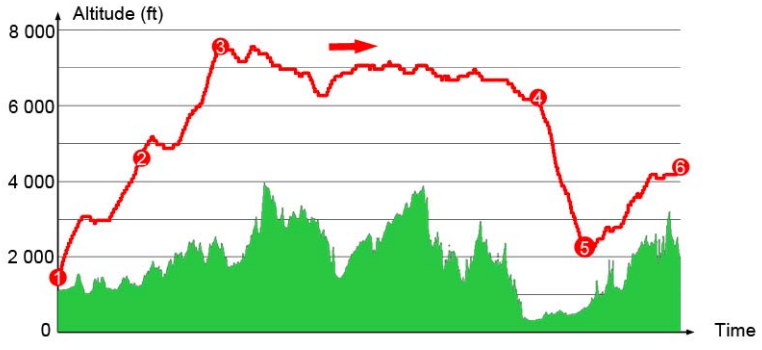


Cartographic source: IGN



Flight path of EC-IVT based on Lyon Radar system data

Flight path programmed on a touchpad

Times given are local
The altitudes mentioned come from the transmitted Flight Level and are adjusted to QNH 1019

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2 - ADDITIONAL INFORMATION

2.1 Examination of the Site and Wreckage

The accident site was in a mountainous environment. The helicopter's flight path passed through an altitude of 4,200 ft between two areas of hilly terrain with peaks respectively at 4,395 ft and 5,269 ft.

The wreckage debris was scattered over a distance of 500 metres following a north-west / south-east orientation. Observations carried out on the wreckage did not reveal any malfunction before the in-flight break up. The following points were established:

- one of the main rotor blades came into contact with the front of the airframe and caused the helicopter's in-flight break up;
- the rotor mast was bent (a sign of rotor mast bumping);
- the exhaust manifold was perforated by an assembly screw from the air heat exchanger. This perforation occurred prior to the accident;
- the cabin heating was on.

The carbon monoxide warning system was tested after the accident. The warning light came on more than three minutes after exposure to a concentration of 3,500 ppm (parts per million) of carbon monoxide. Theoretical triggering is expected from 50 ppm. This test made it possible to deduce a likely malfunction of this warning system.

2.2 Pilot Information

The pilot held a valid PPL(H) licence. He had a total of 155 flying hours including 89 hours on type of which 27 hours were in the previous 3 months and none in the 24 hours before the accident. He had obtained his type rating in August 2011, and then taken a Robinson Safety course in July 2012 during the course of which features were covered relating to rotor mast bumping and to speeds in turbulence described in the manufacturer's Safety Notices (*see § 2.4 hereafter*).

2.3 Aircraft Information

During the event, the helicopter weight and balance were within the limits defined by the manufacturer.

2.4 Prevention of Mast Bumping Phenomena

Mast bumping is generally encountered during flight in turbulence or when the pilot pushes the cyclic pitch stick quickly, which may then cause decreases in load factor.

Rotor assembly teetering may become excessive in relation to the mast axis and generate a risk of bumping and fracture of the mast, and/or contact of a blade with the airframe.

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The LIMITATIONS chapter of the R44 flight manual contains the following warning:

"When a ''Pushover'' (a forward manœuvre of cyclic pitch control), is carried out in level flight or after a rapid climb, a condition of near-zero load factor may occur, which may result in a catastrophic loss of lateral control. In this case, gently reapply pressure aft in order to eliminate this condition. If a rolling movement to the right then occurs, it is important to bring the cyclic pitch back and to re-ensure a normal load factor, before applying lateral cyclic pitch to stop the rolling movement.''

Robinson published several Safety Notices, two of which relate to flights in turbulence and with a low load factor:

- **Safety Notice SN-11**[2] published in 1982 stated that low load factors on pitch-down inputs are extremely dangerous. The fact of applying cyclic pitch control aft during level flight causes a decrease in the load factor. If the helicopter pitch attitude decreases further while the pilot applies a rear input to the cyclic pitch control to reload the rotor, the rotor disk may tilt aft from the helicopter's vertical axis before being loaded again. The main rotor torque reaction will combine with the thrust from the rotor counter-torque applying to the airframe a moment of powerful rolling to the right. With the main rotor not producing any lift, there is no lateral control of the flight path using the cyclic pitch control and there is a risk of mast bumping. Sudden mast bumping in flight will generally lead to either main rotor separation and/or contact of the main blades with the airframe.

[2] Available on the manufacturer's website at: http://www.robinsonheli.com/service_library/safety_notices/rhc_sn11.pdf

As flights with a low load factor can specifically occur in the context of flight in a turbulent atmosphere, the flight manual states that *"flights are prohibited in winds of over or equal to 25 kt, gusts included, or when gusts on the surface exceed 15 kt, except if the pilot has followed a "Robinson Safety Course'' approved by the minister responsible for civil aviation."*

The Flight Manual does not contain any specific procedure relating to flights in turbulence.

However, Robinson published a Safety Notice relating to flight in a turbulent atmosphere:

- **Safety Notice SN-32**[3] published in 1998 stated that flight in high winds or turbulence should be avoided. In the event of entering an unexpected area of turbulence, it recommends in particular reducing speed to 60 to 70 kt, not over controlling, and avoiding flying on the downwind side of hills, ridges or large buildings where turbulence is likely to be severe. This procedure is not covered in the flight manual, in the paragraph relating to limitations.

[3] Available on the manufacturer's website at: http://www.robinsonheli.com/service_library/safety_notices/rhc_sn32.pdf

2.5 Medical Information

Laboratory tests performed on the pilot revealed a level of carbon monoxide of 16%.

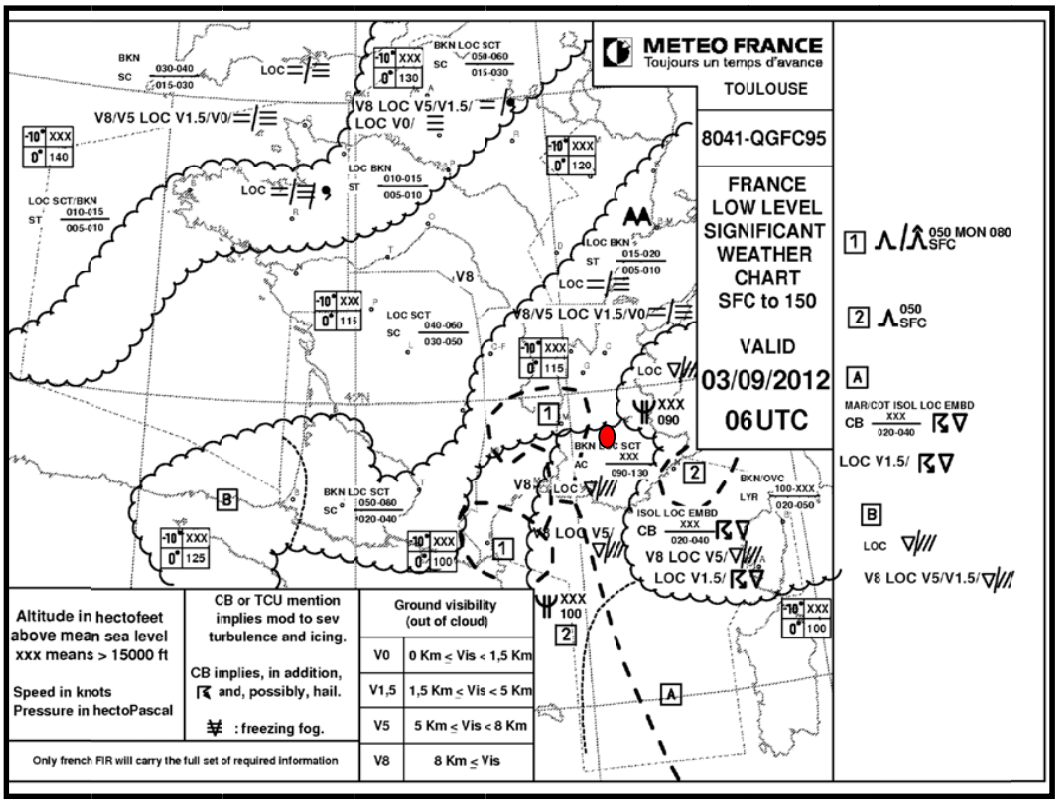
A level of 16 % may cause headaches, nausea, vertigo and behaviour likely to affect the pilot's abilities. For individuals, the normal level is between 7% and 2% depending on whether they are smokers or not.

2.6 Meteorological Information

The meteorological conditions estimated in the accident area at 4,000 ft were as follows:

- a northerly wind of 10 to 25 kt, SCT at 2,400 ft, SCT at 3,700 ft, BKN at 7,000 ft;
- visibility of more than 10 km;
- temperature of 13 to 15 °C, QNH 1017 hPa;
- presence of strong turbulence close to the terrain.

The TEMSI chart indicates a moderate to strong area of turbulence in the accident area.



TEMSI chart for 06 h UTC (in red: the accident site)

The WINTEM chart mentioned winds of 45 kt to 850 hPa and 30 kt to 950 hPa over the Rhône valley. These charts were available for flight preparation.

Before departure, the pilot had consulted meteorological information on the internet, but it was not possible to know the content of this information.

2.7 Previous Events

The BEA investigated the accident to an R22 registered G-CBVL[4] that occurred in December 2010. The report concluded that there was mast bumping, divergence of the main rotor plane of rotation and contact of a blade with the airframe in a highly turbulent zone.

This report also mentioned thirteen accidents that had occurred in similar circumstances.

[4] http://www.bea.aero/docspa/2010/g-vl101209/pdf/g-vl101209.pdf

2.8 Testimony

Before departure, an instructor from a local flying club had advised the pilot, given the meteorological conditions, to fly via the Rhône valley. The latter had then expressed his wish to reach his destination as soon as possible.

A witness living near the accident site stated having heard a loud noise and seeing the helicopter lose components and fall to the ground out of control.

3 - LESSONS LEARNED AND CONCLUSION

The break-up of the helicopter resulted from mast bumping, which caused interference of one of the main rotor blades with the airframe. This break-up occurred while the pilot was flying at high speed in an area close to hilly terrain where there was strong turbulence and high winds and where he may have gone in order to avoid clouds.

The accident resulted from a combination of the following factors:

- the pilot's wish to reach his aerodrome destination quickly whereas the meteorological forecasts were adverse for the flight;
- the failure to decrease speeds to those recommended by the manufacturer in a turbulent atmosphere;
- the pilot's probable degraded abilities due to absorbing carbon monoxide.

The manufacturer's documentation which mentioned a speed recommended in turbulence solely in Safety Notice SN 32 appended at the end of the flight manual without this information appearing in the Limitations chapter of this manual made this information less visible.

The possible malfunction of the carbon monoxide detection warning may have led to the non-detection of a gas leak by the pilot.

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4 - SAFETY RECOMMENDATIONS

Note: In accordance with Article 17.3 of European Regulation (EU) 996/2010 of the European Parliament and Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation, a safety recommendation shall in no case create a presumption of blame or liability for an accident, a serious incident or an incident. The addressee of a safety recommendation shall inform the safety investigation authority which issued the recommendation of the actions taken or under consideration, under the conditions described in Article 18 of the aforementioned Regulation.

Risks linked to mast bumping during flight in turbulence

The investigation showed that the accident occurred following mast bumping leading to contact of one of the blades with the airframe while the helicopter was flying in turbulence at speeds higher than those recommended in turbulence by the manufacturer. Several accidents involving Robinson R22s and R44s have occurred in similar circumstances.

The investigation also showed that the manufacturer's literature mentioned a recommended speed in turbulence only in Safety Notice SN 32, appended at the end of the flight manual, without this information appearing in the *"Limitations"* chapter of this manual, making this information less visible.

Consequently the BEA recommends that:

- **FAA ensure that Robinson modifies the R22 and R44 flight manual by adding information relating to flight in turbulence to the Limitations section. [Recommendation 2015-029]**

- **EASA ensure that all European operators of Robinson R44 and R22 are informed of this limitation, which must be strictly observed in a turbulent atmosphere. [Recommendation 2015-030]**

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