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Loss of Tail-rotor Effectiveness Cited in Bell 206B Accident During Videotaping Flight

The Irish Air Accident Investigation Unit said that the pilot was unaware of the phenomenon of loss of tail-rotor effectiveness (LTE). Printed information on LTE was sent to the operator before the accident but was not distributed to the appropriate pilots.

FSF Editorial Staff

At 0805 local time April 5, 2004, a Bell (now Bell Helicopter Textron) 206B JetRanger II being flown in a videotaping operation in Ireland spiraled out of control and struck the ground. The helicopter was substantially damaged; the pilot received serious injuries, and the two passengers received minor injuries.

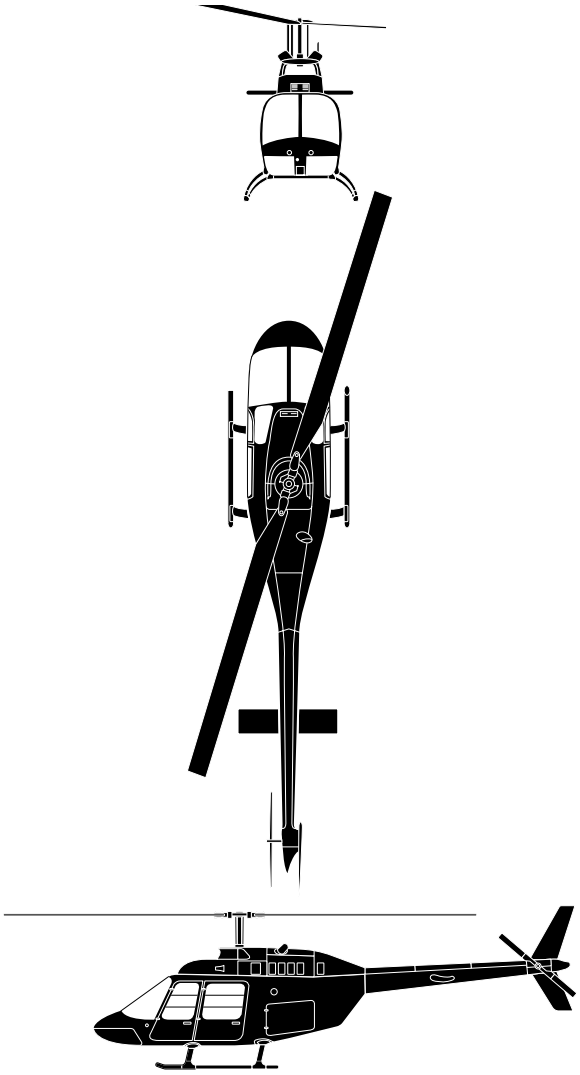
The Irish Air Accident Investigation Unit (AAIU) said, in its final report, that the cause of the accident was the "operation of the helicopter in a flight regime and relative wind velocities/azimuths [directions] which were conducive to the loss of tail-rotor effectiveness (LTE)."

LTE is defined as a "critical, low-speed aerodynamic flight characteristic [that] can result in an uncommanded rapid yaw rate [that] does not subside of its own accord and, if not corrected, can result in the loss of aircraft control."[1]

Contributing factors were "a lack of awareness by the pilot of the phenomenon of LTE, available safety-related material pertaining to the phenomenon of the LTE was not disseminated correctly to the appropriate pilots [and] the non-inclusion of safety-related material pertaining to LTE in appropriate helicopter flight manuals."

The pilot of the accident helicopter had 5,499 flight hours, including 1,176 flight hours in type. He had a Joint Aviation Authorities commercial pilot license (helicopter) issued by the Irish Aviation Authority (IAA) and was certified by IAA as an instructor and examiner. He had been in the U.K. Army Air Corps for 22 years, including 19 years in which he piloted various models of military helicopters. After retiring from the military in 1998, he worked as a civilian helicopter pilot. He was rated and current in four helicopter types, and at the time of the accident, he was working as a freelance pilot.

The accident helicopter was manufactured in 1970. The report said that the helicopter was in good condition and that it had been maintained by an approved maintenance facility in accordance with manufacturer schedules.



Bell 206B JetRanger

The Bell Helicopter (now Bell Helicopter Textron) 206B JetRanger is a general-purpose light helicopter powered by a 400-shaft-horsepower (298-kilowatt) Allison 250-C20 engine. The 206B was developed as a more powerful version of the 206A, which had a 317-shaft-horsepower (236-kilowatt) engine. The first deliveries of the 206B were made in early 1971.

The 206B is configured with two seats in front and a rear-bench seat for three people. It has a fuel capacity of 76 U.S. gallons (288 liters) and a range at sea level with maximum fuel, maximum payload and no fuel reserve of 299 nautical miles (555 kilometers). Range at 5,000 feet is 337 nautical miles (624 kilometers).

Empty weight is 1,455 pounds (660 kilograms), and maximum takeoff weight is 3,200 pounds (1,451 kilograms).

Maximum level speed at sea level is 122 knots, and cruising speed at sea level is 118 knots. Service ceiling is more than 20,000 feet; hovering ceiling in ground effect is 11,300 feet, and hovering ceiling out of ground effect is 5,800 feet.

Source: *Jane's All the World's Aircraft*

The helicopter was owned by PDG Helicopters in the United Kingdom. A subsidiary, Irish Helicopters Ltd. (IHL) coordinated the videotaping flight. Before the accident, IHL had been completing requirements for the transfer of the aircraft onto the civil aircraft registry of Ireland.

The morning of the accident, the pilot obtained weather information for the planned flight from Dublin Airport and arrived at the airport at 0640. The pilot talked with maintenance personnel and confirmed that the certificate of release to service had been signed, the daily inspection had been conducted and the helicopter's fuel tanks held 96 U.S. gallons (363 liters) of fuel. He conducted a preflight inspection and listened to the automatic terminal information service (ATIS) recording, which at 0700 included the information that the winds were from 270 degrees at 22 knots.

The pilot departed from Dublin at 0715 for the 20-minute flight to Newgrange, where he landed the helicopter on a grassy area in front of the entrance to the Megalithic Passage Tomb. The tomb, which was built about 3200 B.C., and which covers about one acre (0.4 hectare), was to be a subject of a television documentary. The pilot said that winds at the landing site were from the west at 12 knots to 14 knots.

The pilot then discussed plans for the flight with the producer and assistant producer of the documentary, the presenter (narrator), a video cameraman and a sound-recording technician. The cameraman and the sound-recording technician received a safety briefing from the pilot before boarding the helicopter.

The pilot conducted a takeoff about 0755 and flew the helicopter in two orbits of the tomb to allow the cameraman to videotape the area. Then he positioned the helicopter into the wind at 500 feet to hover near the passage entrance on the south side of the tomb while the cameraman filmed the narrator atop the tomb. The pilot said that the winds during the hover were from the west at 15 knots to 18 knots. A passenger and a witness on the ground described conditions as "a bit windy and turbulent" and "blustery." An aftercast of weather conditions prepared by the Irish Meteorological Service said that at the time of the accident, surface winds were from 250 degrees at 14 knots, and occasionally from 260 degrees at 20 knots, with gusts to 30 knots; at 2,000 feet, winds were from 300 degrees at 40 knots.

"Just prior to the end of [the presenter's] commentary, the helicopter transitioned forward and then commenced a gentle right-hand orbiting turn," the report said. "On the next circuit (accident circuit), the helicopter was seen by the presenter to transition away from the hover in front of the passage entrance and commence a gentle, slow, right turn around the western point of the mound. When the helicopter was abeam the presenter, on the northern downwind segment of the circuit, it was seen to yaw rapidly to the right, followed by a spiral descent eastwards."

The helicopter struck the ground in a field east of the mound. The pilot telephoned for emergency assistance, and ambulances arrived to transport the pilot and both passengers to a hospital.

Helicopter Functioned Normally Before Accident

The pilot said later that the helicopter was functioning normally until the downwind leg of the fourth orbit, when there was a severe uncommanded yaw to the right.

"He immediately put in full left pedal, lowered the collective lever and pitched the nose down in an effort to increase airspeed, but the helicopter continued to yaw severely to the right," the report said. "The helicopter was [moving] east in the spiral descent towards an open grassy area. Just as the helicopter was about to impact, the pilot pulled full collective and wound off the throttle [reduced speed]."

An examination of the wreckage found no technical problem that could have caused the accident.

Investigators reviewed the cameraman's videotape, which showed all four orbits of the tomb.

The videotape showed that during the fourth orbit, which began from a hover position in front of the passage entrance, "the helicopter is seen to transition slowly into an immediate gentle right-hand turn crosswind and onto downwind close to the mound," the report said. "On downwind, abeam the presenter and at near zero groundspeed, the helicopter pitches nose-down and starts to yaw slowly to the right. The right yaw momentarily hesitates (passing through 40 [degrees] to 60 degrees of the initial upset) before the yaw rate accelerates again further right through 90 degrees.

"A reduction in power (collective) can be heard as the helicopter passes 100 degrees and enters the spiral descent. The helicopter completes four full rotations before impacting into the field. The first rotation was around the [rotor] masthead and took approximately 6.92 seconds from the initial upset. The following three rotations transition from a masthead rotation to a spiral descending pirouette towards the east. The recorded time for each of these three rotations was 2.56 [seconds], 2.56 [seconds] and 2.28 seconds, respectively.

"The time recorded from initiation of the event to first impact was 14.32 seconds. The time recorded from initiation of the event to the helicopter coming to rest was 17 seconds."

Analysis of the videotape soundtrack showed no disconnection of the tail-rotor drive before the impact; the soundtrack also showed that the engine was operating normally.

Operations Manual Did Not Discuss LTE

The PDG Helicopters operations manual, which was recovered from the accident helicopter, said that pilots of filming flights or photographic flights "are to fly in such a way that any emergency situation, such as power failure or tail-rotor failure, would not put the operation at risk." In addition, the manual said, "Low-level [flights] and downwind flights should be kept to a minimum. Sustained flight in the avoid curve is not permitted." [The "avoid curve" is the area on a helicopter height-velocity graph that depicts a combination of slow airspeeds and low altitudes to be avoided because of the unlikelihood of a successful landing in the event of engine failure.]

The manual provided guidance for tail-rotor drive failure and tail-rotor control failure but not for LTE.

The report said that analysis of the helicopter flight manual found that discussion of tail-rotor control failure was adequate. The manual said that "satisfactory stability and control in rearward and sideward flight has been demonstrated for speeds up to and including 20 miles per hour (17 knots) at all loading conditions; however, this is not to be considered a limiting value as maximum operating wind velocities have not been established. The manual included a "Critical Relative Wind Azimuth Area Chart," which referred to tail-rotor control margin and which was used in conjunction with an in-ground-effect hover ceiling chart and an outside-ground-effect hover ceiling chart. The *Flight Manual* did not include written procedures for LTE.

The U.K. Civil Aviation Authority (CAA) issued *Flight Operations Department Communication Document (FODCOM) 1/2004* early in 2004 to discuss LTE. Copies of the document were sent by PDG Helicopters to IHL for distribution to pilots who flew U.K.-registered helicopters in Ireland. When the accident occurred, the document "had not been communicated to these pilots," the report said.

The report said that, although the accident pilot had been trained in coping with tail-rotor failures, "he had not received training for LTE, nor was he aware of the LTE phenomenon."

The investigation found that within IHL, there also was no general awareness of LTE, and the report said that although the manufacturer issued operational safety notices in 1983 and an information letter in July 1984 about LTE, most LTE-awareness efforts occurred in Canada and the United States. As a result, "the phenomenon appears not to be widely known on this side of the Atlantic," the report said.

"Many of the LTE safety initiatives date back to the mid 1980s … and invariably, through passage of time, the safety message may have been lost to newer generations of pilots."

In addition, an AAIU review of single-rotor helicopter flight manuals found that they typically contained no written procedures for LTE.

"Ultimately, safety-related material should be contained in the aircraft flight manual, as it is the main source of information for pilots, specific to type," the report said. "It is also considered that information contained in the flight manual will stand the test of time for generations of new pilots, as opposed to having to refer to a chance encounter with periodical publications."

LTE Most Likely to Occur at Slow Speeds

LTE has occurred among all helicopter designs with a single main rotor/anti-torque rotor configuration, usually when the helicopters are being flown at less than 30 knots. (If the helicopter's main rotor turns counterclockwise, LTE involves right yaw; if the main rotor turns clockwise, LTE involves left yaw.)

The report said that the following aircraft characteristics and relative wind azimuth regions can create an environment conducive to LTE:

- "Main-rotor disc vortex interference occurs with a relative wind of 285 degrees to 315 degrees and involves changes in tail-rotor thrust as the airflow experienced at the tail rotor is affected by the main-rotor disc vortex;
- "Tail winds from a relative wind direction of 120 degrees to 240 degrees will cause the helicopter to yaw into [the] wind and may accelerate an established rate of yaw;
- "Tail-rotor vortex ring state [a condition involving disruption of airflow over the tail rotor] can occur with a relative wind of 210 degrees to 330 degrees. With the relative wind in this region, vortex ring state can cause tail-rotor thrust variations; [and,]
- "Loss of translational lift [additional lift obtained when transitioning to forward flight because of improved efficiency of the rotor system] with the relative wind in all azimuths results in an increased power demand and consequent increase in anti-torque demand from the tail rotor."

Helicopters can be operated safely in these relative-wind regions, "if proper attention is given to controlling the aircraft," the report said.

"However, if the pilot is inattentive or distracted for some reason and a yaw rate is initiated in one of the above relative-wind regions, the yaw rate may increase unless suitable timely corrective action is taken."

Different wind directions can result in "significantly differing rates of turn for a given pedal position," the report said. "The most important principle for the pilot to remember is that the tail rotor is not stalled and is continuing to provide thrust. Thus, the corrective pedal position to be applied is always in the normal direction of opposite pedal to the turn direction."

LTE has been identified as a contributing factor in accidents involving various models of civilian helicopters and military helicopters.[2] Typically, the accidents occur at low altitude and low airspeed as the helicopter is being maneuvered downwind.

The recognized technique for LTE recovery involves application of full opposite pedal to oppose the yaw and simultaneous forward movement of the cyclic to increase airspeed. With sufficient altitude, power should be reduced and full opposite pedal should be maintained until the helicopter's rotation stops. Then controls should be adjusted to achieve normal forward flight.

"Collective pitch reduction will aid in arresting the yaw rate but may cause an excessive rate of descent," the report said. "Any subsequent large, rapid increase in collective to prevent ground [contact] or obstacle contact may further increase the yaw rate and decrease motor rpm [revolutions per minute]. The decision to reduce collective must be based on the pilot's assessment of the height available for recovery. If aircraft rotation cannot be stopped and ground contact is imminent, the final stages of an autorotation may be the best course of action."

The report said that the videotape showed that the accident pilot applied opposite pedal within the first 40 degrees to 60 degrees of the initial right yaw, and that his application of collective and forward cyclic "was having an effect on the flight characteristics of the helicopter." Nevertheless, there was insufficient height for recovery.

Most of the pilot's flight experience was acquired in military flight operations, especially battlefield-type operations in which the helicopter often was operated at low airspeed and "out of wind."

"It is therefore likely, in light of his military experience, that he considered it safe to operate in the flight regime of low speed/out of wind, once he had sufficient power reserve available," the report said.

Initial Upset Occurred at Near-zero Groundspeed

Analysis of the videotape showed that the fourth obit of the tomb differed from the three previous orbit because the fourth was flown at airspeeds slower than the effective translation lift airspeed of 30 knots. The initial upset occurred when the helicopter was downwind and the groundspeed was near zero. At the time, the pilot probably was looking toward the presenter — about 90 degrees to the direction of travel — and the initial rate of right yaw may not have been readily apparent.

As a result of the investigation, AAIU issued the following safety recommendations:

- "That the … IAA take action to publicize information on LTE as widely as possible within the Irish helicopter industry."

  IAA accepted the recommendation;

- "That PDG Helicopters (U.K.) review the functionality of their accident prevention and flight safety program, in particular, to ensure that all relevant safety-related material is disseminated to all appropriate personnel in a timely manner."

  The company's response said that a review of the program found that it was sound and that "the failure to disseminate the safety material is regarded as a failure of an individual within the system, rather than of the system itself";

- "That European Aviation Safety Agency (EASA) should ensure that information on … LTE is included in helicopter pilot-training syllabi."

  EASA said that it had no jurisdiction over flight crew licensing activities and training activities.

- "That Transport Canada, being the regulatory authority and state of manufacture for Bell 206 helicopters in Canada, ensure that Bell Helicopter Textron … re-issue Operations Safety Notice OSN 206-83 and Information Letter 206-84-41 to all Bell 206 operators."

  In response, Transport Canada said, "Although Transport Canada supports dissemination and periodic re-issuance of important safety information, Transport Canada does not control a manufacturer's safety notices and information letters. Therefore, Transport Canada cannot ensure that Bell Helicopter Textron … re-issues the subject document[s]."

  Bell Helicopter Textron said that the safety notice and information letter would be re-issued at an unspecified date. The Helicopter Professional Pilots Safety Program of the Bell Training Academy in November 2004 published a newsletter with an article on LTE. The newsletter is distributed to more than 13,000 pilots/operators worldwide; and,

- "That the U.S. FAA [Federal Aviation Administration], Transport Canada and EASA, being the main certification authorities for helicopter manufacturers, develop a combined initiative to have, where appropriate, information pertaining to LTE included in helicopter flight manuals."

  In response, Transport Canada said that "issues dealing with flight anomalies such as LTE are not appropriate for inclusion in the aircraft flight manual. Rather, the factors that could lead to flight conditions conducive to a loss of tail-rotor effectiveness, the avoidance of these conditions and the recovery techniques are training issues that should be addressed in appropriate training manuals and programs. In addition, other safety communications, like the Bell Helicopter safety bulletins, are educational media that could help to increase awareness of the risk of LTE and to further mitigate the risks."

  As of Jan 21, 2005, FAA was reviewing the recommendation.

  EASA said that it "partially accepts" the recommendation.

  "We believe that LTE parameters vary on a number of environmental/helicopter factors, with different helicopter types having different LTE sensitivity, and some are possibly more prone than others to fall into LTE conditions," EASA said. "The agency will write to TCCA [Transport Canada Civil Aviation] requesting further information pertaining to LTE be added to the Bell 206 models rotorcraft flight manual."♦

[FSF editorial note: This article, except where specifically noted, is based on Irish Air Accident Investigation Unit synoptic report no. 2004-21. The 42-page report contains appendixes and illustrations.]

Notes

1. Loss of tail-rotor effectiveness (LTE) also is known as "unanticipated yaw" and "loss of tail-rotor authority."

2. An Irish Air Accident Investigation Unit survey of the U.S. National Transportation Safety Board accident database found 81 accidents between 1983 and 2003 in which LTE was identified as a contributing factor. Flight operations during which LTE accidents occurred included pipeline inspection, agricultural application, traffic patrol and aerial photography or filming. In most of the accidents, inappropriate actions or late corrective actions may have led to uncontrollable yaw; in addition, most of the accident helicopters were too low for the pilots to achieve a recovery.

Further Reading From FSF Publications

Harris, Joel S. "Object Strikes, Complete Loss of Thrust Were Leading Causes of U.S. Turbine-engine Helicopter Tail-rotor Accidents, 1988 Through 1993." *Helicopter Safety* Volume 22 (May–June 1996).

McAdams, Timothy J. "Low Rotor RPM Threatens Safe Helicopter Flight." *Helicopter Safety* Volume 18 (May–June 1992).

"Unanticipated Right Yaw at Low Speeds." *Helicopter Safety* Volume 15 (March–April 1989).

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