FINAL REPORT

AAIU Synoptic Report No: 2004-021
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In accordance with the provisions of SI 205 of 1997, the Chief Inspector of Accidents, on 5 April 2004, appointed Jurgen Whyte as the Investigator-in-Charge to carry out a Field Investigation into this occurrence and prepare a Synoptic Report.

Aircraft Type and Registration:	Bell 206B JetRanger-II, G-AYMW
No. and Type of Engines:	1 x Rolls Royce Allison 250 C20
Aircraft Serial Number:	587
Year of Manufacture:	1970
Date and Time (UTC):	5 April 2004 @ 08.05 hrs
Location:	Newgrange, Co. Meath, Ireland
Type of Flight:	Aerial Work
Persons on Board:	Crew-1 Passengers - 2
Injuries:	Crew-1 (Serious) Passengers - 2 (Minor)
Nature of Damage:	Extensive
Commander's Licence:	IAA issued JAA CPL (H)
Commander's Details:	Male, aged 47 years
Commander's Flying Experience:	5,499 hours of which 1,176 were on type
Information Source:	Field Investigation, AAIU Report Form submitted by Pilot.

SYNOPSIS

The helicopter was engaged in aerial filming of the Megalithic Passage Tomb at Newgrange, Co. Meath. During its fourth orbit of the mound, the helicopter was seen to yaw suddenly to the right and spiral out of control. Appropriate corrective action by the Pilot i.e., of opposite left pedal, reduction of collective and pitching the nose down to increase airspeed, proved ineffective as the helicopter continued yawing right in a spiral descent. The helicopter impacted heavily into a field immediately east of the mound, but remained upright. The three persons on board suffered various sudden impact injuries and were transferred to hospital by the emergency services a short time later. There was no fire.

Distribution and analysis of the wreckage and the evidence of an eyewitness determined that the helicopter was fully intact at the point of initial impact. An engineering investigation did not find any technical fault that could have accounted for the accident. Onboard film footage recovered from the accident site did, however, provide evidence that the helicopter was operating in a part of the flight envelope where it was susceptible to loss of tail rotor effectiveness (LTE)[1].

The Report makes five Safety Recommendations.

NOTIFICATION

The Dublin Airport ATC Watch Manager advised the Chief Inspector of Air Accidents at 08.10 hrs on the 5 April 2004, that a helicopter, registration G-AYMW had crash-landed near Newgrange with three souls on board. The Pilot of the accident aircraft telephoned his base from the accident site, almost immediately after the event, and advised that he had been involved in an accident. The Irish Operator subsequently informed the AAIU. An AAIU go-team was immediately dispatched to the accident site, where, on arrival at 09.30 hrs the investigation commenced. The Chief Inspector of Accidents appointed Jurgen Whyte, Inspector of Air Accidents, as Investigator-in-Charge (IIC), to carry out an investigation into the circumstances of this accident and to prepare a Synoptic Report. Graham Liddy, Inspector of Air Accidents, provided technical assistance to the investigation.

1. FACTUAL INFORMATION

1.1 History of the flight

The Pilot had been tasked to fly an aerial photography (filming) mission at the Megalithic Passage Tomb at Newgrange, Co Meath. The Operator had been hired by the British Broadcasting Company (BBC) who required aerial footage for a television documentary entitled “The History of Light”.

Prior to departing his home, the Pilot obtained weather for the intended flight from Met Éireann at Shannon Airport. He arrived at his base facility at Westpoint, Dublin Airport (EIDW) at 06.40 hrs and met up with the maintenance engineer a short time later. The Pilot confirmed with the engineer that the Certificate of Release to Service (CRS) had been signed, that the Daily Inspection (D.I.) had been carried out and the helicopter had been refuelled to 96 US gallons.

Following a satisfactory Pre-flight Inspection (PFI), the Pilot checked the weather on the EIDW Automatic Terminal Information Service (ATIS), which at 07.00 hrs gave the wind as 270 degrees 22 kt, visibility 10 km, cloud FEW at 2000 feet, and temperature +6ºC.

[1] Loss of Tail Rotor Effectiveness (LTE) is also referred to in different publications as “Unanticipated Yaw” and “Loss of Tail Rotor Authority”. For the purpose of this report the term LTE will be used hereafter.

The Pilot then filled in the Pilot Log and called for start from the engineer. G-AYMW took-off from EIDW at 07.15 hrs with only the Pilot onboard and routed via Naul, direct to Newgrange. After an uneventful transit, G-AYMW landed at Newgrange (approximately 07.35 hrs) on an open grass area in front of the passage entrance to the tomb and the Pilot closed down the helicopter. The Pilot estimated the wind on landing to be westerly 12-14 kt.

After taking the right-hand side door off for filming, the Pilot met with the Producer, the Assistant Producer, the Presenter, the Cameraman and the Sound Recordist, to discuss the type of shot they required. In general, the brief was for the helicopter to circle the mound, while filming the Presenter on top of the mound, as he gave a live commentary from a memorised script.

Following a safety briefing by the Pilot for the Cameraman and the Sound Recordist, G-AYWM took-off with three souls onboard at approximately 07.55 hrs. The Pilot completed two filming orbits of the mound before positioning for a westerly into-wind hover at 500 feet above ground level (AGL) in front of the passage entrance to the tomb. The tomb is orientated north - south with the passage entrance located on the southern side of the mound. The top of the mound is measured at 200 feet above mean sea level (AMSL). From the hover, the Cameraman (using a shoulder mounted camera) filmed the Presenter on top of the mound. The Pilot estimated the hover wind to be westerly 15-18 kt. Just prior to the end of commentary, the helicopter transitioned forward and then commenced a gentle right-hand orbiting turn, in order that the Cameraman could keep the mound and the Presenter in centre camera view. 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 impacted heavily on a southerly heading in the field immediately adjacent (east) to the mound. It bounced several feet further to the east and then came to a rest on a southwesterly heading. (**Appendix A**)

1.2 Witness Observations

1.2.1 General

A number of personnel associated with the filming were present at Newgrange on the day of the accident. In order to remain clear of the camera shot, the majority of these personnel located themselves in the tea rooms, just west of the mound. They heard the helicopter complete a number of orbits of the mound. Then they heard the sound of the helicopter change suddenly. They ran out into the open to see the helicopter spiralling away to the east. They ran in the direction of the helicopter and found the impact site in the next field. Having initially been told to stand clear by the Pilot, they waited for the main blades to stop rotating, before they went to the aid of the occupants.

1.2.2 Witness No. 1.

The Pilot recalled completing three successful orbits of the mound. On the downwind leg of the fourth orbit, the helicopter experienced a severe undemanded 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. At the time, he elected not to wind off the throttle as he saw trees below. He noted that the helicopter was drifting 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. He then shut down the engine, switched off the battery master switch and fuel valve.

The Sound Recordist, who was seated in the left rear seat sought to immediately evacuate the helicopter. However, the Pilot told him to remain seated, as the main rotor blades were still rotating and the helicopter was resting on an uphill slope. G-AYMW was not fitted with a rotor brake, nor was it required to be. The Pilot then observed a number of BBC personnel running down the hill towards the helicopter. He shouted to them to remain clear until the rotors stopped. The Pilot then evacuated the helicopter from the right-hand cockpit door, shouted for someone to call 999 and then went immediately to the aid of the Cameraman who was lying on the ground on the right-hand side of the helicopter. He unclipped the Cameraman's harness and removed the camera, which was pinning him to the ground. The Cameraman was then pulled uphill away from the wreckage and tended to by the Pilot and members of the BBC Crew.

The Pilot then called 999 himself, he called his base (Irish Operator), who in turn relayed the message the Air Operator's Certificate (AOC) holder in the UK and the AAIU in Dublin. The Pilot also received a call from EIDW ATC, in which he confirmed that he had been involved in an air accident.

On seeing fuel leaking from the port side of the helicopter, the Pilot, called 999 a second time to ensure that they were sending a fire tender. A third 999 call was made by the Pilot to confirm the progress of the ambulance, as he had concern for the well-being of the Cameraman.

At this stage, the Pilot noticed that his back was becoming very painful. As there was nothing else he could do, he sat down and waited the arrival of the emergency services. A short time later all three persons were taken to Our Lady of Lourdes Hospital, Drogheda, for examination.

The Pilot was diagnosed as having two fractures of the vertebrae and a crush injury. He was detained in Drogheda for a number of days before being referred to the Beaumont Orthopaedic Unit, Dublin. At Beaumont, the Pilot was diagnosed as having three fractures to two vertebrae, plus a 20% crush injury, with additional muscular and soft tissue injury.

The Pilot advised the Investigation that prior to the undemanded yaw to the right the helicopter had been performing normally and that he had no pre-warning of a technical problem.

In addition, the Pilot confirmed that while he had been trained to cope with tail rotor failures, he had not received training for LTE nor was he aware of the LTE phenomenon.

The Pilot had served with the UK Army Air Corps for 22 years, 19 of which he flew as a pilot on an assortment of military type helicopters, including battlefield helicopters. In 1998, he retired from the UK Armed Forces and took up civilian employment as a commercial helicopter pilot. At the time of the accident, the Pilot was operating as a freelance pilot. He was rated and current on four helicopter types and was certified as an Irish Aviation Authority (IAA) Instructor and Examiner.

In his response to the Draft Report, the Pilot stated that, *"I wish to place on record the exemplary job done by the Emergency Response crew who dispatched ambulances to both areas of Newgrange as a precautionary measure. The ambulance crew succeeded in stabilising my condition, despite the difficult ground conditions and stretchered me, and the others across the field, to the waiting ambulances"*.

1.2.3 Witness No. 2.

The Cameraman, who was very familiar with operating from helicopters, was seated on the right-hand side rear seat, facing right angles to the direction of travel with his legs hanging outside the cabin. He was secured by means of a waist harness, which was attached, via a strap, to the forward left seat.

On completion of the safety brief by the Pilot, they took off and immediately commenced filming the Presenter (top/centre of mound) while orbiting the mound. The Cameraman considered the conditions to be "*a bit windy and turbulent*", but suitable for filming. The first indication that something was wrong was when he was thrown back in along the rear seat towards the Sound Recordist.

He was unsure of the direction of rotation but he did recall the heavy impact, being thrown from the helicopter, being dragged along side the helicopter prior to it coming to rest, being attended to by the Pilot (when blades were still turning), and then the BBC crew and the ambulance service. Following detailed examination at Our Lady of Lourdes Hospital, Drogheda, the Cameraman was released the same day having suffered soft tissue injuries.

1.2.4 Witness No. 3.

The Sound Recordist, who was familiar with operating from helicopters, was seated in the left-hand rear seat. The flight was normal up to the point where it suddenly jerked to the right and started spinning. He recalled being pinned to the left-hand side of the cabin and seeing the Pilot fighting with the controls. On impact he struck his head against the seat in front of him and after the helicopter came to rest he could smell fuel. On expressing concern of this to the Pilot, he was advised to remain seated until the blades stopped turning. The Sound Recordist released the cameraman's harness from the attachment point and left the helicopter when the blades eventually stopped.

After a medical examination at Our Lady of Lourdes Hospital, Drogheda, he was released the same day without requiring treatment, having suffered some bruising to the face.

The Sound Recordist paid tribute to the professionalism of the Pilot, in particular, in the way that he cared for his passengers (while injured himself) immediately after the occurrence.

1.2.5 Witness No 4.

The Presenter was positioned on top of the mound as the helicopter commenced its filming. As he was, "talking to camera", he kept the helicopter in his line of sight throughout the flight. The first three orbits of the mound appeared normal. He judged the wind conditions on top of the mound as "*blustery*".

On the fourth orbit, the Presenter tracked the helicopter as it slowly moved away from the hover (in front of the passage entrance) and into the right turn around the western edge of the mound. When it was on the northern side of the mound, it suddenly spun very fast to the right and spiralled in a descent towards the east. He lost sight of the helicopter as it descended below the crest of the mound. There then followed a loud bang and the sound of the engine being switched off, or stopping.

The Presenter confirmed to the Investigation that he saw nothing falling from the helicopter while in flight and that the tail rotor remained turning during its descent. In his opinion the engine noise sounded the same throughout the entire flight.

1.2.6 Witness No 5.

The Assistant Producer was located in the rear seat of a car which was parked a short distance (southeast) from the mound. Looking out the rear window of the car she saw the helicopter complete the first few runs. She then saw the helicopter spin suddenly to the right. She ran from the car in the direction of the spinning helicopter, calling 999 as she did so. After climbing over the hedge of the adjacent field she found the accident site. The Pilot shouted to remain clear. Once the blades stopped turning she went to comfort the Cameraman. An Electrician went to the aid of the Sound Recordist.

1.3 <u>Emergency Response/Survival</u>

The first 999 call was recorded as received at 08.10 hrs from an English National, stating that a helicopter had crashed near Newgrange. Some confusion initially existed with regard to the exact location, i.e., Newgrange Monument or the Newgrange Interpretive Centre. The ambulance controller therefore decided to dispatch ambulances to both locations. An Garda Síochana from Navan arrived on scene at approximately 08.20 hrs. The first ambulance arrived from Navan at 08.25 hrs, followed shortly thereafter by a fire tender and two ambulances from Drogheda. Due to the soft ground conditions at the accident site, the three occupants of the helicopter had to be stretchered across the field to the waiting ambulances, which then departed for Our Lady of Lourdes Hospital, Drogheda, at approximately 09.00 hrs.

1.4 Meteorological Information

1.4.1 After-cast

An after-cast of the weather conditions in the general area of the accident site was provided by the Aviation Office of Met Éireann (the Irish Meteorological Service) at Shannon Airport.

General Situation:	An anticyclone off Biscay and an extensive low-pressure system off the North Sea maintained a relatively fresh unstable northwesterly air flow over the area.
Wind:	Surface (SFC) 250 degrees 14 knots (kt). Occasional (OCNL) 260 degrees 20 kt gusting 30 kt. 2000 feet (ft), 300 degrees 40 kt.
Weather:	Radar imagery indicated fairly extensive convective cells to the north and north west of the area. The intensity indicated that the showers would be predominately light with the possibility of an isolated moderate shower.
Visibility:	10 km
Cloud:	FEW at 2000 ft. Broken (BKN) 3500 ft. OCNL Scattered (SCT) 1200 ft. SCT cumulonimbus (CB) 1800 ft.
Temp Dew-Point:	06/04 degrees Celsius.
Mean Sea Level (MSL) Pressure:	1011 hPa
Comment:	Whilst there was definite convective activity in the region at the time, which would have led to “blustery” conditions, there was no evidence of heavy showers or gusts above 30 kt.

1.5 Technical Information

1.5.1 General

The wreckage of the helicopter was recovered from the accident site on the day of the accident to the AAIU facility at Gormanston, Co Meath. The helicopter, which was constructed in 1970 was found to be in good condition and had been maintained by an approved maintenance facility in accordance with the manufacturers schedules. In the weeks prior to the accident, work had been carried out on the helicopter and on supporting documentation, in preparation for its transfer from the UK Register to the Irish Register. All applicable Airworthiness Directives (AD’s) associated with this particular model had been complied with. The helicopter had a valid Certificate of Airworthiness (COA) and was certified by the UK Civil Aviation Authority (CAA) on the 1 March 2004 for issue of a COA for export in the Transport Category (passengers).

With the reported loss of directional control, the technical examination focused mainly on the tail boom, the tail rotor and the tail rotor controls. It was noted that the main rotor blades were in good condition and did not suffer any impact damage as a result of this occurrence. Continuity of control was confirmed at the accident site. The engine was in good condition and nothing was found that would indicate that the engine was not operating correctly throughout the entire flight.

A metallurgist conducted an examination of the wreckage on the 15 April 2004 and a licensed technician (on type) also examined the helicopter on the 23 April 2004. With specific regard to the tail boom, tail rotor and tail rotor controls the following was determined:

1.5.2 Metallurgical Examination

- The tail fin and tail rotor assembly detached from the tail boom on initial ground impact.
- The tail rotor drive shaft and the pitch actuator shaft (both tubes) also fractured.
- The fracture features on the drive shaft were indicative of single event failure, with considerable torsional loading.
- Fracture in the actuator shaft occurred at a location where it passed through a hole in the bulkhead in the tail boom. The end of the shaft had suffered a further fracture approximately 300 mm nearer the tail rotor. This damage was consequential damage produced following detachment of the tail fin and the tail rotor assembly.
- The general appearance of the fracture, with partial collapse of the tube, indicated that the fracture had occurred through a combination of bending / tensile overload, with bending of the end of the shaft in a downward direction towards the starboard side of the aircraft.
- The tail fin had suffered severe impact damage to its underside, consistent with it being in the normal vertical alignment at the time.
- Consequential damage occurred to the top of the tail fin.
- Examination of the fractures in the tail boom revealed bright fracture features indicative of single event overload failure.
- Examination of a number of fractures in the wishbones / skids also revealed features indicative of single event overload failure.
- There was no indication of any pre-existing defect (corrosion damage, fatigue cracking etc) associated with any of the fractures in the failed components examined.

1.5.3 Technical Examination

- The tail rotor blades, the tail rotor head assembly and the fin assembly were installed in the correct manner as per the Aircraft Maintenance Manuals (AMM). Pitch change was confirmed by operation of the severed section of the tail rotor control rod, and rotation of the tail rotor head was confirmed by rotation of the tail gear box Thomas coupling.

- The tail rotor blades, while damaged, were still attached to the tail rotor head.
- The tail rotor drive shaft cowlings, while damaged, were still attached to the tail boom section.
- The tail rotor drive shaft was severed forward of the tail gearbox Thomas coupling.
- The tail rotor control rod was severed within the tail boom.
- Tail boom cowlings were removed without difficulty. A visual inspection of the assembly with the cowlings removed showed no evidence of being assembled incorrectly.
- Measurement of the fore and aft play on the pitch control mechanism was taken and documented. No excessive play was found on each item of the tail control as it was removed. Items were photographed as they were removed. Bolts, bearings rods and bell cranks were checked for damage / wear limits as determined by the Aircraft Component Repair and Overhaul (CRO) Manuals.
- The tail rotor gearbox chip plug was inspected and found to be clean.
- Lubrication of the tail rotor head, trunion and pitch change assembly were found to be satisfactory.
- The Thomas coupling was damaged but not cracked.
- The fin assembly was damaged and the anti-collision light was broken off the assembly.
- The tail rotor gearbox was found to be in good condition.
- The tail rotor control pedals were found to be Agusta Bell components.

From this detailed examination of the entire tail rotor / tail boom assembly it was possible to conclude that there was no evidence of any pre-impact failure of the tail rotor pitch control system, and the tail rotor drive shaft had been rotating at impact.

1.5.4 Helicopter Weight

At the time of the accident the operating weight of the helicopter, inclusive of filming / recording equipment and a refuelling pump, was approximately 3,050 lbs. The certified maximum all up weight (MAUW) is 3,200 lbs.

1.6 <u>Recovered Film Footage</u>

1.6.1 General

A digital BETACAM video cassette tape was recovered by the AAIU from the camera, which was being used for the aerial filming of the Newgrange site. The running time from start of filming to shutdown of camera was 4 minutes 02 seconds. The weather during that time showed good visibility, dry and blustery conditions. A total of four orbits of the mound (including the final event) were recorded.

1.6.2 Visual Tape Analysis

The opening sequence shows the helicopter completing two continuous orbits of the mound. The helicopter is subjected to some light turbulence and changes in power demand are evident on the sound recording, particularly when turning downwind and turning back into wind.

The third orbit commences from an into-wind hover (westerly) in front of the passage entrance to the tomb. The helicopter transitions away in-to-wind and accelerates around the mound in a right turn towards downwind. The downwind leg extends over the field east of the mound before the helicopter turns into wind and back to the hover position.

The final orbit commences again from the 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. 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 40-60º of the initial upset) before the yaw rate accelerates again further right through 90º. A reduction in power (collective) can be heard as the helicopter passes 100º and enters the spiral descent. The helicopter completes 4 full rotations before impacting into the field. The first rotation was around the 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, 2.56 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.

1.6.3 Audio Tape Analysis

Using the sound track from the recovered video tape, the helicopter-generated noises were analysed. The analysis showed that the ratio of main rotor to tail rotor RPM was maintained until initial ground impact. This is confirmation that no disconnection of the tail rotor drive occurred prior to ground contact. The sound track also indicates that the engine was operating within the normal parameters during the flight and prior to initial ground impact.

1.7 Organisational and Management Information

1.7.1 General

G-AYMW, which was previously registered as EI-BJR, is owned by PDG Helicopters, an established UK helicopter company. PDG has a subsidiary company in the Republic of Ireland called Irish Helicopters Ltd (IHL). On the day of the accident, the commercial arrangement were such that IHL coordinated the mission, provided the facilities and the freelance pilot. Operationally, it was a PDG helicopter being flown under the PDG AOC. The assigned freelance pilot was fully qualified as a PDG pilot to do this. Being an aerial work flight, this arrangement was permitted in Irish Airspace. In the weeks preceding the accident, IHL was in the final process of transferring G-AYMW onto the Irish Register.

1.7.2 Operations Manual

A review of the PDG Operations Manual, which was recovered as part of G-AYMW's aircraft library, found that it was compliant with the requirements contained in UK Civil Aviation Authority (CAA) CAP360.

Under Section 2 Special Operations - 2.3.0 Aerial Filming and Photographic Flights

2.3.1 General

All pilots when engaged in filming and photography operations 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.

2.3.2 Heights and Wind Direction

Low level and downwind flights should be kept to a minimum. Sustained flight in the avoid curve is not permitted.

Under Section 10.8.3 - Emergency Drills (Type related Bell 206)

Detailed guidance is provided under 10.8.3 (20) for Tail Rotor Drive Failure and 10.8.3 (21) for Tail Rotor Control Failure.

No guidance is provided for Loss of Tail Rotor Effectiveness (LTE).

1.7.3 Flight Manual

A review of the USA FAA approved and UK Civil Aviation Authority (CAA) certified (25/11/2003) Flight Manual, which was recovered as part of G-AYMW's aircraft library, determined that Tail Rotor Control Failure, in the form of, Complete Loss of Thrust and Fixed Pitch Failure is adequately covered.

Under Section 3, Operation Vs Allowable Wind (3-6A) the following is stated:

Satisfactory stability and control in rearward and sideward flight has been demonstrated for speeds up to and including 20 MPH (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.

A Critical Relative Wind Azimuth Area Chart is provided in the performance section of the flight manual (Part 3-6C). The wind azimuth chart, which refers to tail rotor control margin is used in conjunction with the In-Ground-Effect (IGE) and Outside-Ground-Effect (OGE) hover ceiling charts.

No written procedures pertaining to the loss of tail rotor effectiveness (LTE) phenomenon are contained in the Bell JetRanger-II model 206B flight manual.

1.7.4 Accident Prevention and Flight Safety

Both PDG Helicopters and IHL have an accident prevention and flight safety programme within their respective companies. A UK Civil Aviation Authority (CAA) Flight Operations Department Communication document (FODCOM 1/2004) issued on the subject of LTE (See Section 1.8.3) was sent by PDG Helicopters to its IHL representative for distribution to those pilots who flew UK Registered Helicopters in Ireland under the PDG AOC. At the time of the accident to G-AYMW, FODCOM 1/2004 had not been communicated to these pilots.

1.8 Loss of Tail Rotor Effectiveness (LTE)

1.8.1 Description

LTE is a critical, low-speed aerodynamic flight characteristic, which can result in an uncommanded rapid yaw rate[2], which does not subside of its own accord and, if not corrected, can result in the loss of aircraft control. It is not unique to Bell helicopters, nor is it related to a maintenance malfunction, but generally applicable (in varying degrees) to all helicopter designs of single main rotor/anti-torque rotor configuration and at speeds less than 30 knots. Four aircraft characteristics during low speed flight have been identified as contributing factors in LTE. For this to occur, certain relative wind velocities and azimuths (direction of relative wind) must be present. The following aircraft characteristic (for counter-clockwise rotating blades) and relative wind azimuth regions can, either singularly or in combination, create an environment conducive to LTE:

- *Main rotor disc vortex interference occurs with a relative wind of 285° to 315° and involves changes in tail rotor thrust as the airflow experienced at the tail rotor is affected by the main rotor disc vortex.*

- *Tailwinds from a relative wind direction of 120° to 240° will cause the helicopter to yaw into wind and may accelerate an established rate of yaw.*

- *Tail rotor vortex ring state can occur with a relative wind of 210° to 330°. With the relative wind in this region, vortex ring state can cause tail rotor thrust variations.*
- *Loss of translational lift with the relative wind in all azimuths results in an increased power demand and consequent increase in anti-torque demand from the tail rotor.*

The various wind directions can cause significantly differing rates of turn for a given pedal position. 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.

The aircraft can be operated safely in the above relative wind regions if proper attention is given to controlling the aircraft. However, if the pilot is inattentive or distracted for

[2] With regard to LTE, a helicopter with a main rotor that turns counter-clockwise (Cockpit view) will experience right yaw, whereas a helicopter with a main rotor that turns clockwise will experience left yaw.

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.

1.8.2 Recovery Technique

The recognised recovery for LTE is to apply full opposite pedal to oppose the yaw whilst simultaneously moving the cyclic forward to increase speed. If altitude permits, power should be reduced and full opposite pedal should be maintained until rotation stops. As recovery is effected, adjust controls for normal forward flight.

Collective pitch reduction will aid in arresting the yaw rate but may cause an excessive rate of descent. Any subsequent large, rapid increase in collective, to prevent ground or obstacle contact, may further increase the yaw rate and decrease rotor rpm. 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.

1.8.3 Research

1.8.3.1 General

The Loss of Tail Rotor Effectiveness (LTE) has been identified as a contributing factor in a number of accidents in various models of both military and civilian helicopters over the years. An AAIU survey of the USA National Transport Safety Board (NTSB) accident database showed that for the USA alone, between 1983 and 2003, LTE was determined to be a contributing factor in a total of 81 accidents. In general, the mishaps occurred in the low-altitude, low-airspeed flight regime while manoeuvring out of wind. Typical operations during which the accidents occurred included; pipeline and electrical cable inspection, agricultural spraying, traffic watch, movie and TV support flights and aerial photography / filming. In most cases, inappropriate or late corrective action may have resulted in the development of uncontrollable yaw. In addition, insufficient height remaining to effect recovery was a common factor.

In 1983 and 1984 Bell Helicopters issued two Operations Safety Notice (OSN) on the 31 October 1983 (OSN 206L-83-7/206-83-10) and an Information Letter on the 6 July 1984 (206-84-41/206L-84-27) on the subject of Low Speed Flight Characteristics Which Can Result in Unanticipated Right Yaw. (**Appendix B and Appendix C**)

In July 1984, following an accident to a Bell 206B helicopter, the NTSB recommended that the Federal Aviation Administration (FAA) should require Bell to include the contents of the OSN in the FAA approved Flight Manual for Bell 206. The NTSB also recommended that a review should be carried out of the Bell 206 compliance with the controllability requirements of the certification regulation of 14 CFR 27.143.

The FAA did not accept either of the NTSB recommendations. The FAA considered that the LTE phenomenon was 'generally applicable to all single main rotor/anti-torque rotor types' and that information on LTE should be provided to all helicopter pilots and not just those flying Bell 206.

Accordingly, the FAA, as part of its Accident Prevention Programme, took steps to advise all US holders of helicopter pilot certificates of the potential for LTE on helicopters of similar design to the Bell 206. With regard to the question of controllability, the FAA took the view that there was no need to carry out further checks on Bell 206 controllability since this had been done 'numerous times over the period 1963-1977'. The FAA also stated that the OSN 206-83-10 and information letter 206-84-41 were not intended to imply that the existing tail rotor control margin is inadequate.

In July 1994, the NTSB issued the following 4 safety recommendations to the FAA, reiterating the continuing need to educate and train helicopter pilots to prevent future LTE accidents.

- **(A-94-139)** *Issue to all owners, operators, and pilots of single main rotor/anti-torque rotor helicopters a Flight Safety Notice to convey the information contained in Bell Operations Safety Notice 206-83-10 and Information Letter 206-84-41*

  (Response) In July 1995, the FAA distributed an Advisory Circular on information contained in the Bell Operations Safety Notice (OSN) 206-83-100 and Information Letter 206-84-41 to all USA helicopter owners, operators and pilots. **(Appendix D)**

- **(A-94-140)** *Strongly encourage the manufacturers of single main rotor/anti-torque rotor helicopters to include in the operator's handbook and flight manual discussions of the characteristics of and recovery techniques from the phenomenon known as loss of tail rotor effectiveness (unanticipated yaw)* LTE

  (Response) In April 1995, the FAA sent a letter to all USA helicopter manufacturers and European Aviation Authorities of single main rotor/anti-torque rotor helicopters asking them them to include in the operators hand book and flight manual a discussion of the characteristics of the phenomenon known as loss of tail rotor effectiveness (LTE) and appropriate recovery techniques.

- **(A-94-141)** *Amend the Helicopter Practical Test Standards to include appropriate references and questions addressing the loss of tail rotor effectiveness (unanticipated yaw)* LTE

  (Response) In 1996, the FAA amended the Helicopter Practical Test Standards, which includes questions and references addressing LTE.
- **(A-94-142)** *Include in the next revision to the Basic Helicopter Handbook (AC 61-13), a thorough discussion of loss of tail rotor effectiveness (unanticipated yaw) LTE and recommend recovery techniques.*

(Response) In 2000, the FAA published the Rotorcraft Flying Handbook, which includes detailed material on LTE.

1.8.3.2 Recent Accident

An accident to a Bell 206B JetRanger III, G-BAML on the 30 May 2003 was the subject of an investigation by the UK Air Accident Investigation Branch (AAIB). The Final Report (EW/C2003/05/07), which was published in the January 2004 Bulletin and linked to the Foreign Reports page of the AAIU web site in February 2004, determined that:

"The investigation found no evidence of mechanical failure in the tail rotor system. However, the pilot's evidence indicates that he lost control in yaw and was unable to prevent the helicopter from completing several revolutions before impacting the ground. In the absence of any technical reason for this loss of control, it would appear possible that the pilot experienced LTE as described in the Bell Operational Safety Notice and highlighted by the FAA in their AC. A number of the criteria that can lead to LTE were present during the accident flight, but other factors may have been present, and in particular, it is impossible to rule out that the area may have been affected by gusts associated with thunderstorm activity".

The Report also considered that:

"Although the Bell OSN was issued to all Bell 206 owners worldwide, the focus of LTE awareness has been largely in the USA. In the UK there has been little emphasis on the phenomenon, but most of the factors that can lead to LTE should be known by most UK helicopter pilots. However, the relationship of the various factors to the performance capability of Part 27 helicopters is probably less widely known. The pilot involved in this accident had been trained to cope with tail rotor failures, but he had not received training nor was he aware of the LTE phenomenon".

With regards to Safety Recommendations, the Investigation stated that:

"The generally USA based focus of previous LTE awareness efforts has meant that the phenomenon is not widely known in the UK and it is therefore recommended that the CAA take action to publicise information on LTE as widely as possible within the UK helicopter industry. However, the inherent drawback of such publicity efforts is that as time goes by, and new generations of pilots become qualified, the safety message can be lost. It is therefore recommended that the CAA should approach the European Aviation Safety Agency (EASA) with a view to having information on LTE included in helicopter pilot training syllabi".

In response to the safety recommendation made to the UK CAA, the Safety Regulation Group of the UK CAA issued a Flight Operations Department Communication (FODCOM) 1/2004, the purpose of which was to bring to the attention of all

Commercial Helicopter Pilots the latest information on LTE. FODCOM 1/2004 can be viewed at http://www.caa.co.uk/publications

1.8.3.3 Articles

A recent article in the 9 – 15 March 2004 issue of Flight International, entitled, "Sting in the Tail," covered various aspects of tail rotor failures, including guidance on keeping the tail rotor effective.

The Flight Safety Foundation (FSF) also published an article in their Helicopter Safety Bulletin March/April 1989 on unanticipated yaw at low speeds.

Vortex, published by Aviation Safety Programs Transport Canada and distributed to all Canadian Licensed helicopter pilots, contained an extensive article (issue 4/85) on LTE.

The Bell Helicopter Textron Incorporated flight safety publication ROTORBREEZE issued a special insert in the July/August 1984 issue on LOW SPEED FLIGHT CHARACTERISTICS WHICH CAN RESULT IN UNANTICIPATED RIGHT YAW.

2. DISCUSSION

It is acknowledged, by both Bell and the FAA through various publications and articles that the low speed aerodynamic flight characteristics (less than 30 kts) of single rotor type helicopters are such that an uncommanded rapid yaw rate may occur, that it does not subside of its own accord, and if not corrected, can result in the loss of control of the aircraft.

The operating wind velocity at 500 ft agl as reported by the Pilot was 15-18 kts. An aftercast provided by Met Éireann considered the surface wind conditions as 250º/14 kts with occasional wind of 260º/20 gusting 30 kts. The wind at 2,000 ft was 300º/40 kts. With the helicopter operating at 500 ft agl, and given the blustery conditions prevailing on the day, it is possible that the actual wind conditions at Newgrange during the filming sequence was at or exceeded 20 kts with gusts.

When operating out of wind at or below effective translational lift airspeed the helicopter may have a tendency to weathercock (*the shortest distance*) into wind. In addition, any loss of translational lift will result in an increase in power demand (if height is to be maintained) and thus an anti-torque requirement. If the pilot does not maintain positive tail rotor control or anticipate the increased anti-torque requirement, the rate of turn (yaw) may accelerate to such a degree that it exceeds the ability of the opposite pedal input to terminate the rotation.

Analysis of the recovered film footage does confirm that G-AYMW, operating at near MAUW, and in blustery conditions, did complete three successful orbits of the mound. The fundamental difference between these orbits and the accident orbit was that the final orbit was flown at airspeeds less than the effective translation lift airspeed of 30 kts. The initial upset occurs, while the aircraft is downwind, abeam the Presenter, at a groundspeed of near zero. In keeping station with the Presenter on the mound, the Pilot's scan would most likely have been towards the Presenter (at 90º to the direction of travel). While any increased demand for power would have been responded to instinctively by the Pilot (in order to keep station) it is possible that the initial rate of right yaw may not have been as readily apparent.

It is clear from the film footage that the Pilot does react with opposite pedal within the first 40º – 60º of the initial right yaw, as the heading is seen to hesitate momentarily, before the weathercock effect accelerates the right yaw through 90º and into an established spiral descent. The Pilot action of reducing collective (to reduce torque effect) and application of forward cyclic (to increase airspeed) was having an effect on the flight characteristics of the helicopter as the rotation transfers from a masthead rotation to a pirouette rotation moving in an easterly downwind direction. However, insufficient height remained to effect a recovery.

While the Pilot had over 1,000 hours on accident type, the majority of his flying experience was gained on military type helicopters. The nature of military flight operations, in particular battlefield type operations (which the Pilot was most familiar with), necessitates regularly operating in a flight regime of low speed and out of wind. Invariably the type chosen relates to the specific role and a capability to operate safely in such an environment.

In general, commercial or civilian helicopter types do not perform such military type operations and therefore performance capabilities would normally be based around the majority of flight operations being conducted outside of the flight regime of low speed and out of wind. The Pilot informed the Investigation that he was not trained or aware of the phenomenon LTE. 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 mainly USA / Canadian focus of previous LTE awareness efforts have meant that the phenomenon appears not to be widely known on this side of the Atlantic. Many of the LTE safety initiatives date back to the mid 1980s mid 1990s and invariably through passage of time the safety message may have been lost to newer generations of pilots. In both the case of G-AYMW and G-BAML, neither pilot was aware of LTE. Nor was there a general awareness of LTE within IHL, which is an established Irish Operator. The likelihood therefore exists that there are still pilots of single rotor type helicopters who may be operating in flight regimes that are conducive to the onset of LTE, yet they are unaware of that phenomenon and its inherent dangers.

It is in the interest of pilots (on an on-going basis and throughout their career), that they keep abreast of safety initiatives and publications relating to their profession and more importantly to topics relating specifically to the types that they fly. The World Wide Web is one such tool for this purpose.
To bring home this point, the AAIU did provide in February 2004, a foreign reports link on its website to the UK AAIB Report G-BAML, which dealt specifically with LTE.

The NTSB July 1984 Safety Recommendation, *"That the Federal Aviation Administration (FAA) should require Bell to include the contents of the OSN in the FAA approved flight manual for Bell 206"*, was not accepted by the FAA as they considered that, *"the LTE phenomenon was generally applicable to all single main rotor / anti-torque rotor types and that information on LTE should be provided to all helicopter pilots and not just those flying Bell 206"*. The FAA response in the form of AC 90-95 was appropriate to USA licensed pilots. However, the reality is that a large amount of single rotor type helicopters manufactured in the USA operate in different parts of the world and as a result the AC 90-95 safety message would have been lost for a large number of foreign pilots / operators outside of the USA.

A general review of single rotor type helicopter Flight Manuals revealed no written procedures pertaining to 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. 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. In light of the large number of accidents recorded over the past twenty years that have been associated with LTE, and the fact that recent accidents have revealed that some helicopter pilots and organisations are still unaware of the LTE phenomenon, the Investigation considers it appropriate that the USA FAA, 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.

This Investigation is supportive of the UK AAIB Safety Recommendation 2003-127 that; "*The European Aviation Safety Agency (EASA) should ensure that information on Loss of Tail Rotor Effectiveness (LTE) is included in helicopter pilot training syllabi*".

While LTE is not unique to Bell helicopters alone, the Bell 206 and its variants are recognised as one of the worlds workhorses for aerial work applications. The Investigation therefore considers it appropriate, due to passage of time, that Transport Canada, being the Regulator for State of Manufacture for Bell 206 helicopters, should ensure that Bell Helicopter Textron Incorporated re-issue Operations Safety Notice OSN 206-83 and Information Letter 206-84-41 to all Bell 206 operators.

In summary and as stated in AC 90-95, "*avoiding LTE may best be accomplished by pilots being knowledgeable and avoiding conditions which are conducive to LTE. Appropriate and timely response is essential and critical. By maintaining an acute awareness of wind and its effect upon the aircraft, the pilot can significantly reduce LTE exposure"*.

Gaining of this knowledge will best be achieved through training and inclusion of such material in the aircraft Flight Manual.

3. CONCLUSIONS

(a) Findings

3.1 The Pilot was properly licensed and was medically fit to conduct the flight.

3.2 The helicopter had a valid Certificate of Airworthiness (COA) and had been maintained under a valid aircraft operator certificate in the Public Transport Category, in accordance with the approved and appropriate schedules.

3.3 All applicable Airworthiness Directives (AD's) associated with this particular model of helicopter had been complied with.

3.4 While operating at near MAUW, with a blustery tail-wind of approximately 20 kts, and at near zero ground speed, the helicopter suffered an uncommanded yaw to the right.

3.5 There was no evidence found of any malfunction or defect that could have accounted for the uncommanded yaw to the right.

3.6 Film footage recovered from the helicopter indicates that the Pilot experienced LTE as described in the Bell Operational Safety Notice and highlighted by the FAA in their Advisory Circular.

3.7 The Pilot's response to the uncommanded right yaw was appropriate but insufficient height remained to effect a safe recovery.

3.8 The Pilot's handling of the final stages of the forced landing contributed significantly to the avoidance of a more serious outcome to all on board.

3.9 The Pilot's actions, with regard to the well-being and safety of his passengers immediately after the helicopter came to rest, are commendable.

3.10 The Emergency Services response was considered by the Investigation to be both appropriate and timely.

3.11 The Pilot had not received training for LTE nor was he aware of the LTE phenomenon.

3.12 UK CAA safety related material specific to LTE, which was sent by PDG Helicopters (UK) to their representative at IHL (Ireland), prior to the accident of G-AYMW, was not disseminated to those pilots who flew PDG UK registered Helicopters under the PDG AOC in Ireland.

3.13 No written procedures pertaining to the loss of tail rotor effectiveness (LTE) phenomenon are contained in the Bell JetRanger-II model 206B flight manual.

(b) Cause

1. Operation of the helicopter in a flight regime and relative wind velocities / azimuths which were conducive to the loss of Tail Rotor Effectiveness (LTE)

(c) Contributory Factors

1. A lack of awareness by the Pilot on the phenonmenon of LTE.

2. Available safety related material pertaining to the phenonmenon of the LTE was not disseminated correctly to the appropriate pilots.

3. The non-inclusion of safety related material pertaining to LTE in appropriate helicopter Flight Manuals.

4. SAFETY RECOMMENDATIONS

4.1 That the Irish Aviation Authority (IAA) take action to publicise information on LTE as widely as possible within the Irish Helicopter industry. **(SR 39 of 2004)**

Response

The Irish Aviation Authority (IAA) has accepted SR 39 of 2004.

4.2 That PDG Helicopters (UK) review the functionality of their Accident Prevention and Flight Safety programme, in particular, to ensure that all relevant safety related material is disseminated to all appropriate personnel in a timely manner. **(SR 40 of 2004)**

Response

PDG Helicopter UK informed the Investigation that, "*They have reviewed the functionality of its Accident Prevention and Flight Safety Programme and found it to be sound. The failure to disseminate the safety material is regarded as a failure of an individual within the system, rather than of the system itself.*"

4.3 The European Aviation Safety Agency (EASA) should ensure that information on Loss of Tail Rotor Effectiveness (LTE) is included in helicopter pilot training syllabi. **(SR 41 of 2004)**

4.4 That Transport Canada, being the Regulatory Authority and State of Manufacture for Bell 206 helicopters in Canada, ensure that Bell Helicopter Textron Incorporated, re-issue Operations Safety Notice OSN 206-83 and Information Letter 206-84-41 to all Bell 206 operators. **(SR 42 of 2004)**
Response Transport Safety Board (TSB) of Canada

In response to the Draft Report the TSB advised the Investigation that, *"The report accurately represents the sequence of events and circumstances leading to the accident. Consequently, Canada has no state comments on the report*." Observations from

Transport Canada, the Canadian Regulatory Authority and Bell Helicopters were appended to the TSB response.

Response Transport Canada. "*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 Incorporated re-issue the subject document."*

Response Bell Helicopters. Bell Helicopters had no comment on the report but advised the TSB that they plan on re-issuing the previous Safety Notice and Information Letter on the loss of tail rotor effectiveness (LTE) in the future. In the meantime, the Bell Training Academy Heliprops Section (Helicopter Professional Pilots Safety Program) has issued a newsletter, which features LTE as it's feature article in the November issue of their Human A.D. Heliprops publication. The newsletter is mailed to over 13,000 pilots/operators throughout the world.

4.5 That the USA FAA, 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. **(SR 43 of 2004)**

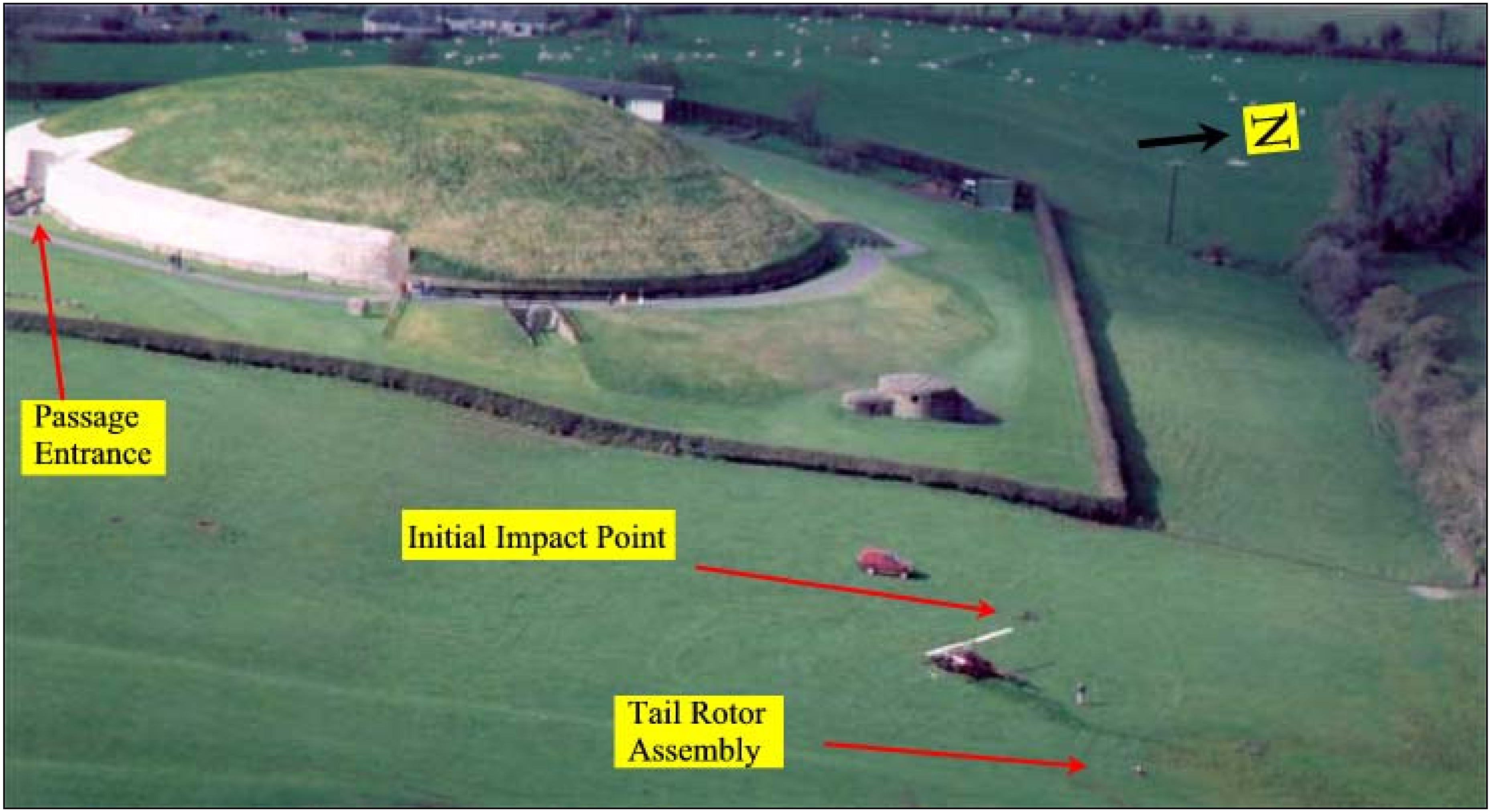
Response Transport Canada. *Transport Canada does not support Recommendation 4.5*

Loss of Tail Rotor Effectiveness (LTE) is not unique to the Bell 206 helicopter. Bell Helicopter Information Letter 206-84-41 (included in the Draft Report as Appendix C), last sentence of the first paragraph states, "These characteristics…apply to all single rotor helicopters." Various other flight conditions and/or pilot actions can place a helicopter at risk and are not all discussed in Rotorcraft Flight Manuals.

LTE is a condition resulting from poor management of important flight parameters such as indicated airspeed, power, wind direction, yaw rate, etc. In Canada, LTE is discussed during initial training and student pilots are taught how to avoid conditions leading to LTE, as well as proper recovery techniques. Information on LTE can be found in both the Canadian, Flight Instructor Guide – Helicopter 1995 (TP4818) and the Canadian, Private and Commercial Pilot Licences, including Aeroplane to Helicopter Pilot Licences – Helicopter (TP 2476) student study and reference guide. These documents are available at Transport Canada's Internet site: www.tc.gc.ca."

A follow-up response from Transport Canada (through TSB of Canada) informed the Investigation that, *"Transport Canada remains committed that the issues dealing with flight anomalies such as LTE are not appropriate for inclusion in the Aircraft Flight Manual (AFM). 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."*

APPENDIX A


N
Passage Entrance
Initial Impact Point
Tail Rotor Assembly

APPENDIX B

Bell Helicopter TEXTRON

Bell Helicopter Textron Inc.
A Subsidiary of Textron Inc.

Post Office Box 482
Fort Worth, Texas 76101
(817) 280-2011

OPERATIONS SAFETY NOTICE

OCTOBER 31, 1983

OSN 206-83-10

TO: 206A, 206B JRII, 206B JRIII, TH-57 SERIES HELICOPTER OPERATORS

SUBJECT: SUPPLEMENTAL OPERATING & EMERGENCY PROCEDURES

RECENT FLIGHT TESTING HAS REVEALED THAT THERE IS A REMOTE POSSIBILITY THAT AN UNANTICIPATED RIGHT YAW MAY OCCUR UNDER CERTAIN CONDITIONS NOT RELATED TO A MECHANICAL MALFUNCTION. THESE CONDITIONS MAY INCLUDE HIGH POWER DEMAND SITUATIONS WHILE HOVERING, AND/OR WHEN RELATIVE WIND AFFECTS AIRSPEED VERSUS GROUND SPEED. THE PURPOSE OF THIS OSN IS:

1. TO EMPHASIZE THE IMPORTANCE OF STAYING AWARE OF POWER AND WIND CONDITIONS.

2. TO PROVIDE A WIND AZIMUTH CHART.

3. TO RECOMMEND A TECHNIQUE FOR RECOVERY FROM AN UNANTICIPATED RIGHT YAW.

7851 59398

OPERATORS SHOULD:

- VERIFY THAT THE TAIL ROTOR IS RIGGED IN ACCORDANCE WITH THE MAINTENANCE MANUAL.

- MAINTAIN MAIN ROTOR RPM WITHIN THE GREEN ARC. NOTE: IF MAIN ROTOR RPM IS ALLOWED TO DECREASE THE ANTI-TORQUE THRUST REQUIRED TO BALANCE THIS CHANGE INCREASES.

- WHEN MANEUVERING BETWEEN HOVER AND 30 MPH:

  - BE AWARE THAT A TAIL WIND WILL REDUCE RELATIVE WIND SPEED IF A DOWN WIND TRANSLATION OCCURS. IF LOSS OF TRANSLATIONAL LIFT OCCURS IT CAN RESULT IN A HIGH POWER DEMAND AND AN ADDITIONAL ANTI-TORQUE REQUIREMENT.

  - BE ALERT DURING HOVER (ESPECIALLY OGE) AND HIGH POWER DEMAND SITUATIONS SUCH AS LOW SPEED DOWNWIND TURNS.

  - BE ALERT DURING HOVER IN WINDS OF ABOUT 8-12 KNOTS (ESPECIALLY OGE) SINCE THERE ARE NO STRONG INDICATIONS TO THE PILOT, TO THE POSSIBILITY OF A REDUCTION OF TRANSLATIONAL LIFT. THIS REDUCTION RESULTS IN AN UNEXPECTED HIGH POWER DEMAND AND INCREASED ANTI-TORQUE REQUIREMENTS.

- BE AWARE THAT IF A CONSIDERABLE AMOUNT OF LEFT PEDAL IS BEING MAINTAINED, THAT A SUFFICIENT AMOUNT OF LEFT PEDAL MAY NOT BE AVAILABLE TO COUNTERACT AN UNANTICIPATED RIGHT YAW.

- BE ALERT TO CHANGING AIRCRAFT FLIGHT AND WIND CONDITIONS SUCH AS EXPERIENCED WHEN FLYING ALONG RIDGE LINES AND AROUND BUILDINGS.

• OBSERVE THE RELATIVE WIND CONDITIONS SET OUT IN THE ATTACHED CHART.

• IF A SUDDEN UNANTICIPATED RIGHT YAW OCCURS THE RECOMMENDED RECOVERY TECHNIQUE IS:

1. APPLY FULL LEFT PEDAL.

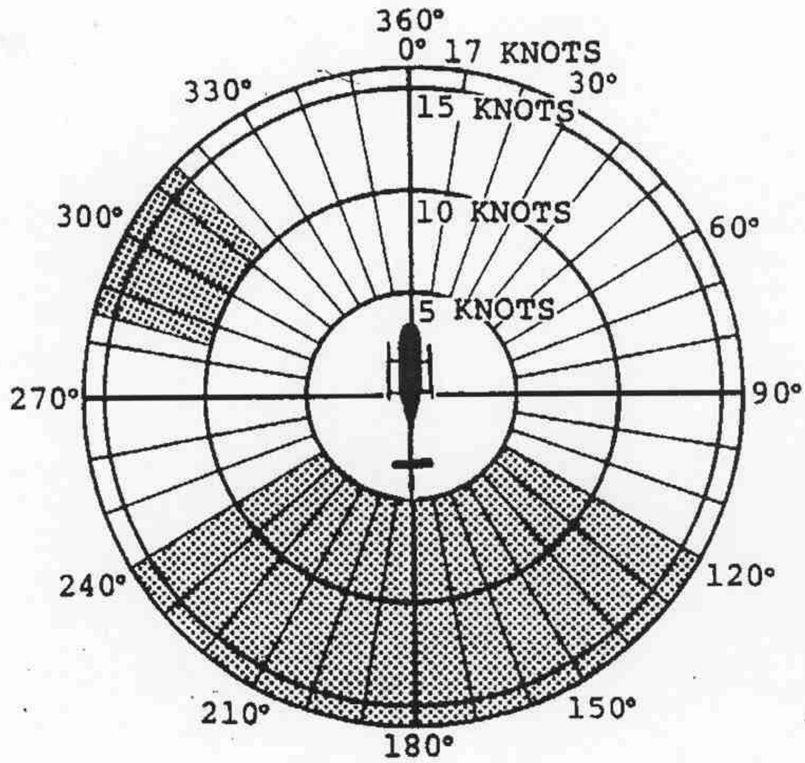
2. APPLY FORWARD CYCLIC, AND RECOVER.

3. IF ALTITUDE PERMITS, REDUCE POWER.

NOTE

THE TAIL ROTOR IS CONTINUING TO PROVIDE THRUST. THE TIME TO ARREST THE YAW RATE DEPENDS ON THE MAGNITUDE OF THE YAW RATE TO BE OVERCOME.

RELATIVE WIND CHART



NOTE

An unanticipated right yaw may occur when operating in the shaded areas of the chart.

NOTE

This chart refers to unanticipated right yaw and does not replace the critical relative wind azimuth chart in the performance section of the flight manual which refers to tail rotor control margin.

APPENDIX C

Bell Helicopter TEXTRON

Bell Helicopter Textron Inc.
A Subsidiary of Textron Inc.

Post Office Box 482
Fort Worth Texas 76101
(817) 280-2011

6 July 1984

INFORMATION LETTER 206-84-41
206L-84-27

TO: ALL MODEL 206A/B, 206B-JRIII, TH-57, 206L, 206L-1, AND 206L-3 OWNERS/OPERATORS

SUBJECT: LOW SPEED FLIGHT CHARACTERISTICS WHICH CAN RESULT IN UNANTICIPATED RIGHT YAW

This Information Letter supplements Operations Safety Notices OSN 206-83-10 and OSN 206L-83-7, dated October 31, 1983: "Supplemental Operating & Emergency Procedures".

NOTE

The following discussion does not replace the Critical Relative Wind Azimuth Chart or Performance Data in the Flight Manual.

Recent testing of the OH-58 series helicopter operated by the U.S. Army has revealed the occurrence of an unanticipated right yaw under certain low speed mission conditions. The Army has referred to the right yaw characteristic as loss of tail rotor effectiveness (LTE). The following is a discussion of low speed flight characteristics which can result in an unanticipated right yaw if appropriate attention is not paid to controlling the aircraft. These characteristics are present only at airspeeds less than 30 knots and apply to all single rotor helicopters.

Definition of Unanticipated Right Yaw

Unanticipated right yaw is the occurrence of an uncommanded right yaw rate which does not subside of its own accord and which, if not corrected can result in the loss of aircraft control. The term "loss of tail rotor effectiveness" is misleading. The tail rotor of the OH-58 and 206 series helicopters has exhibited the capability to produce thrust during all approved flight regimes.

Low Speed Flight Characteristics

Four aircraft characteristics during low speed flight have been identified through extensive flight and wind tunnel tests as contributing factors in unanticipated right yaw.

For this occurrence, certain relative wind velocities and azimuths (direction of relative wind) must be present. The aircraft characteristics and relative wind azimuth regions are:

1. Weathercock stability (120 to 240 degrees)
2. Tail rotor vortex ring state (210 to 330 degrees)
3. Main rotor disc vortex interference (285 to 315 degrees)
4. Loss of translational lift (all azimuths)

The aircraft can be operated safely in the above relative wind regions if proper attention is given to controlling the aircraft. However, if the pilot is inattentive for some reason and a right yaw rate is initiated in one of the above relative wind regions, the yaw rate may increase unless suitable corrective action is taken.

Weathercock Stability (120 to 240 degrees)

Winds within this region will attempt to weathervane the nose of the aircraft into the relative wind. This characteristic comes from the fuselage and vertical fin. The helicopter will make an uncommanded turn either to the right or left depending upon the exact wind direction unless a resisting pedal input is made. If a yaw rate has been established in either direction, it will be accelerated in the same direction when the relative winds enter the 120 to 240 degree shaded area of Figure 1 unless corrective pedal action is made. The importance of timely corrective action by the pilot to prevent high yaw rates from occurring cannot be overstressed.

Tail Rotor Vortex Ring State (210 to 330 degrees)

Winds within this region, as shown in Figure 3, will result in the development of the vortex ring state of the tail rotor. The vortex ring state causes tail rotor thrust variations which result in yaw rates. Since these tail rotor thrust variations do not have a specific period, the pilot must make corrective pedal inputs as the changes in yaw acceleration are recognized. The resulting high pedal workload in tail rotor vortex ring state is well known and helicopters are operated routinely in this region. This characteristic presents no significant problem unless corrective action is not timely. If a right yaw rate is allowed to build, the helicopter can rotate into the wind azimuth region where weathercock stability will then accelerate the right turn rate. Pilot workload during vortex ring state will be high; therefore, the pilot must concentrate fully on flying the aircraft and not allow a right yaw rate to build.

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Main Rotor Disc Vortex (285 to 315 degrees)

Winds within this region, as shown in Figure 2, can cause the main rotor vortex to be directed onto the tail rotor. The effect of this main rotor disc vortex is to change the tail rotor angle of attack. Initially as the tail rotor comes into the area of the main rotor disc vortex during a right turn, the angle of attack of the tail rotor is increased. This increase in angle of attack requires the pilot to add right pedal (reduce thrust) to maintain the same rate of turn. As the main rotor vortex passes the tail rotor, the tail rotor angle of attack is reduced. The reduction in angle of attack causes a reduction in thrust and a right yaw acceleration begins. This acceleration can be surprising, since the pilot was previously adding right pedal to maintain the right turn rate. Analysis of flight test data during this time verifies that the tail rotor does not stall. The helicopter will exhibit a tendency to make a sudden, uncommanded right yaw which, if uncorrected, will develop into a high right turn rate. When operating in this region, the pilot must anticipate the need for sudden left pedal inputs.

Loss of Translational Lift

The loss of translational lift results in increase power demand and additional anti-torque requirements. If the loss of translational lift occurs when the aircraft is experiencing a right turn rate, the right turn will be accelerated as power is increased, unless corrective action is taken by the pilot. When operating at or near maximum power, this increased power demand could result in rotor rpm decay.

This characteristic is most significant when operating at or near maximum power and is associated with unanticipated right yaw for two reasons. First, if the pilot's attention is diverted as a result of an increasing right yaw rate, he may not recognize that he is losing relative wind and hence losing translational lift. Second, if the pilot does not maintain airspeed while making a right downwind turn, the aircraft can experience an increasing right yaw rate as the power demand increases and the aircraft develops a sink rate. Insufficient pilot attention to wind direction and velocity can lead to an unexpected loss of translational lift. The pilot must continually consider aircraft heading, ground track, and apparent groundspeed, all of which contribute to wind drift and airspeed sensations. Allowing the helicopter to drift over the ground with the wind results in a loss of relative wind speed and a corresponding decrease in the translational lift produced by the wind. Any reduction in translational lift will result in an increase in power demand and anti-torque requirements.

Recovery Technique

If a sudden unanticipated right yaw occurs, the following recovery technique should be performed:

1. Pedal - Full left;
   simultaneously, cyclic - forward to increase speed.

2. As recovery is effected, adjust controls for normal forward flight.

CAUTION

COLLECTIVE PITCH REDUCTION WILL AID IN ARRESTING THE YAW RATE BUT MAY CAUSE AN EXCESSIVE RATE OF DESCENT. THE SUBSEQUENT LARGE, RAPID INCREASE IN COLLECTIVE TO PREVENT GROUND OR OBSTACLE CONTACT, MAY FURTHER INCREASE THE YAW RATE AND DECREASE ROTOR RPM.

THE DECISION TO REDUCE COLLECTIVE MUST BE BASED ON THE PILOT'S ASSESSMENT OF THE ALTITUDE AVAILABLE FOR RECOVERY.

3. If spin cannot be stopped and ground contact is imminent, an autorotation may be the best course of action. Maintain full left pedal until the spin stops, then adjust to maintain heading.

Summary:

The various wind directions can cause significantly differing rates of turn for a given pedal position. The most important principle for the pilot to remember is that THE TAIL ROTOR IS NOT STALLED. Thus, the corrective pedal position to be applied is always in the normal direction of OPPOSITE PEDAL to the turn direction.

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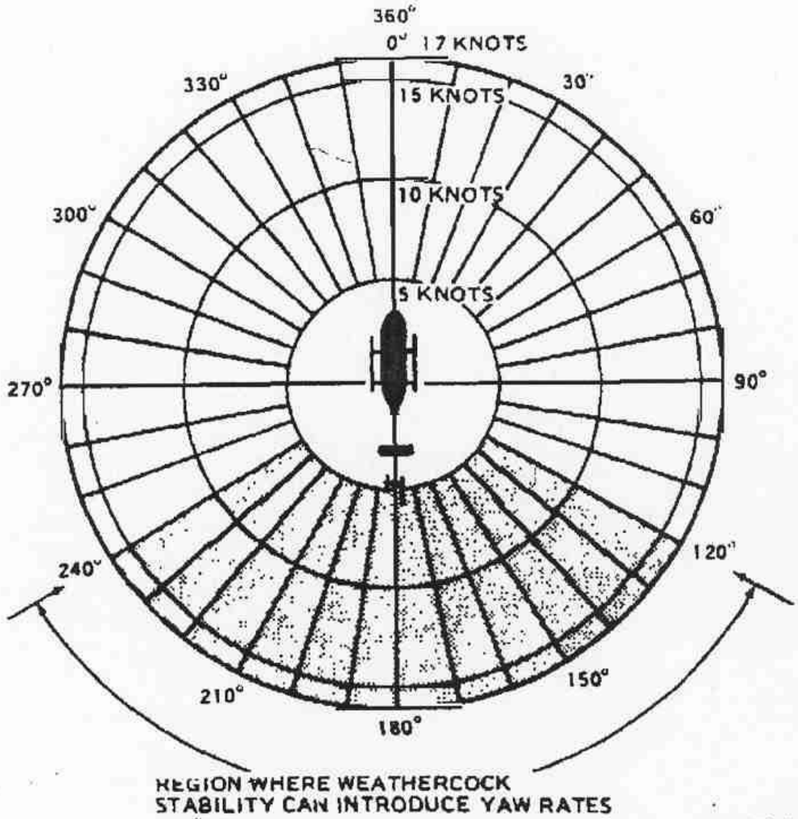

FIGURE 1. WEATHERCOCK STABILITY

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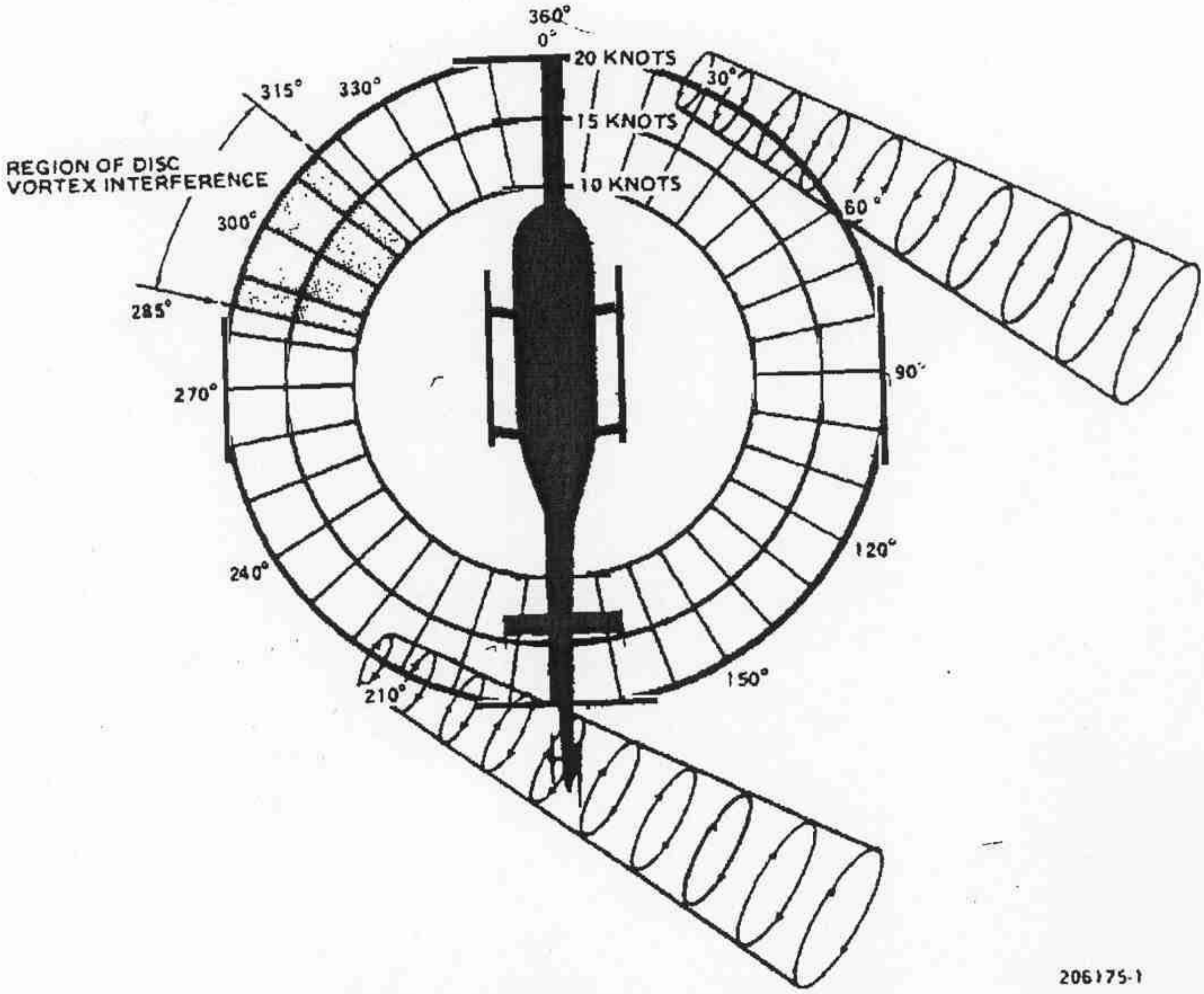

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FIGURE 2. MAIN ROTOR DISC VORTEX INTERFERENCE

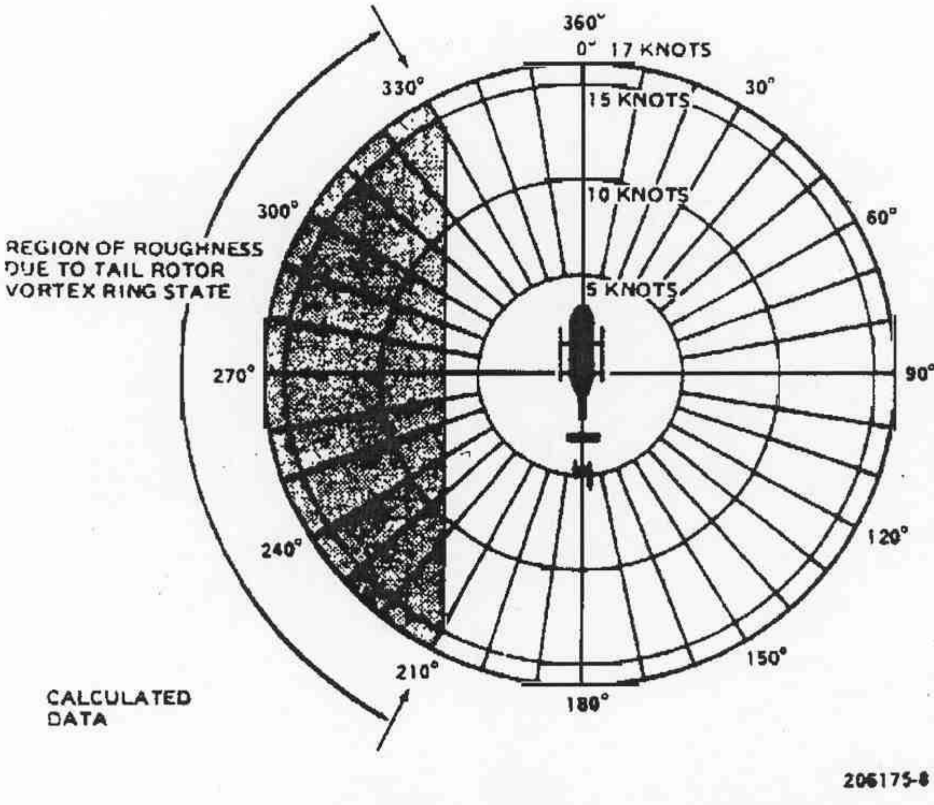

FIGURE 3. TAIL ROTOR VORTEX RING STATE

APPENDIX D

U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: **UNANTICIPATED RIGHT YAW IN HELICOPTERS**

Date: **12/26/95**
Initiated by: **AFS-804**

AC No: **90-95**
Change:

1. PURPOSE. This advisory circular (AC) will examine unanticipated right yaw phenomenon, the circumstances under which it may be encountered, how it can be prevented, and how the pilot should react if it is encountered.

2. RELATED READING MATERIAL. Bell Helicopter Textron, *Supplemental Operating and Emergency Procedures*, Operations Safety Notice, OSN 206-83-10 (October 31, 1983), Bell Helicopter Textron; Bell Helicopter Textron, *Low Speed Flight Characteristics Which Can Result in Unanticipated Right Yaw*, Information Letter 206-84-41 and 206-84-27 (July 6, 1984), Bell Helicopter Textron; Sneelen, D.M., OH-58 Loss of Tail Rotor Effectiveness - Why It Occurs, *U.S. Army Aviation Digest* (September 1984), U.S. Army Aviation Center; Prouty, R.W., The Downwind Turn: Losing Directional Control, *Rotor and Wing* (May 1994), Phillips Business Information, Inc.; More on the OH-58 LTE Problem, *Flightfax: Report of Army Aircraft Mishaps*, Vol. 13, No. 32 (May 22, 1985), U.S. Army Safety Center; Loss of Tail Rotor Effectiveness...When It Is and When It Isn't, *Flightfax: Report of Army Aircraft Mishaps*, Vol. 14, No. 1 (September 25, 1985), U.S. Army Safety Center; U.S. Army, *OH-58 Helicopter Operators Manual*, TM 55-1520-228-10, U.S. Army; U.S. Naval Air Training Command, *Flight Training Instructions, TH-57* (1989), U.S. Naval Air Training Command.

3. BACKGROUND. Unanticipated right yaw, or loss of tail rotor effectiveness (LTE), has been determined to be a contributing factor in a number of accidents in various models of U.S. military helicopters. The National Transportation Safety Board (NTSB) has identified LTE as a contributing factor in several civil helicopter accidents wherein the pilot lost control. In most cases, inappropriate or late corrective action may have resulted in the development of uncontrollable yaw. These mishaps have occurred in the low-altitude, low-airspeed flight regime while maneuvering, on final approach to a landing, or during nap-of-the-earth tactical terrain flying. Typical civil operations include powerline patrol, electromagnetic survey, agricultural spraying, livestock herding, police/radio traffic watch, emergency medical service/rescue, and movie or television support flights.

4. THE PHENOMENA OF LTE.

*a. **LTE is a critical, low-speed aerodynamic flight characteristic*** which can result in an uncommanded rapid yaw rate which does not subside of its own accord and, if not corrected, can result in the loss of aircraft control.

*b. **LTE is not related to*** a maintenance malfunction and may occur in varying degrees in *all* single main rotor helicopters at airspeeds less than 30 knots. LTE is not necessarily the result of a control margin deficiency. The anti-torque control margin established during Federal Aviation Administration (FAA) testing is accurate and has been determined to adequately provide for the approved sideward/rearward flight velocities plus counteraction of gusts of reasonable magnitudes. This testing is predicated on the assumption that the pilot is knowledgeable of the critical wind azimuth for the helicopter operated and maintains control of the helicopter by not allowing excessive yaw rates to develop.

*c. **LTE has been identified*** as a contributing factor in several helicopter accidents involving loss of control. Flight operations at low altitude and low airspeed in which the pilot is distracted from the dynamic conditions affecting control of the helicopter are particularly susceptible to this phenomena. The following are three examples of this type of accident:

(1) A helicopter collided with the ground following a loss of control during a landing approach. The pilot reported that he was on approach to a ridge line landing zone when, at 70 feet above ground level (AGL) and at an airspeed of 20 knots, a gust of wind induced loss of directional control. The helicopter began to rotate rapidly to the right about the mast. The pilot was unable to regain directional control before ground contact.

(2) A helicopter impacted the top of Pike's Peak at 14,100 feet mean sea level (MSL). The pilot said he had made a low pass over the summit into a 40-knot headwind before losing tail rotor effectiveness. He then lost directional control and struck the ground.

(3) A helicopter entered an uncommanded right turn and collided with the ground. The pilot was maneuvering at approximately 300 feet AGL when the aircraft entered an uncommanded right turn. Unable to regain control, he closed the throttle and attempted an emergency landing into a city park.

5. UNDERSTANDING LTE PHENOMENA. To understand LTE, the pilot must first understand the function of the anti-torque system.

a. On U.S. manufactured single rotor helicopters, the main rotor rotates counterclockwise as viewed from above. The torque produced by the main rotor causes the fuselage of the aircraft to rotate in the opposite direction (nose right). The anti-torque system provides thrust which counteracts this torque and provides directional control while hovering.

b. On some European and Russian manufactured helicopters, the main rotor rotates clockwise as viewed from above. In this case, the torque produced by the main rotor causes the fuselage of the aircraft to rotate in the opposite direction (nose left). The tail rotor thrust counteracts this torque and provides directional control while hovering.

NOTE: This AC will focus on U.S. manufactured helicopters.

c. Tail rotor thrust is the result of the application of anti-torque pedal by the pilot. If the tail rotor generates more thrust than is required to counter the main rotor torque, the helicopter will yaw or turn to the left about the vertical axis. If less tail rotor thrust is generated, the helicopter will yaw or turn to the right. By varying the thrust generated by the tail rotor, the pilot controls the heading when hovering.

d. In a no-wind condition, for a given main rotor torque setting, there is an exact amount of tail rotor thrust required to prevent the helicopter from yawing either left or right. This is known as tail rotor trim thrust. In order to maintain a constant heading while hovering, the pilot should maintain tail rotor thrust equal to trim thrust.

e. The environment in which helicopters fly, however, is not controlled. Helicopters are subjected to constantly changing wind direction and velocity. The required tail rotor thrust in actual flight is modified by the effects of the wind. If an uncommanded right yaw occurs in flight, it may be because the wind reduced the tail rotor effective thrust.

f. The wind can also add to the anti-torque system thrust. In this case, the helicopter will react with an uncommanded left yaw. The wind can and will cause anti-torque system thrust variations to occur. Certain relative wind directions are more likely to cause tail rotor thrust variations than others. These relative wind directions or regions form an LTE conducive environment.

6. CONDITIONS UNDER WHICH LTE MAY OCCUR.

a. Any maneuver which requires the pilot to operate in a high-power, low-airspeed environment with a left crosswind or tailwind creates an environment where unanticipated right yaw may occur.

b. There is greater susceptibility for LTE in right turns. This is especially true during flight at low airspeed since the pilot may not be able to stop rotation. The helicopter will attempt to yaw to the right. Correct and timely pilot response to an uncommanded right yaw is critical. The yaw is usually correctable if additional left pedal is applied immediately. If the response is incorrect or slow, the yaw rate may rapidly increase to a point where recovery is not possible.

c. Computer simulation has shown that if the pilot delays in reversing the pedal control position when proceeding from a left crosswind situation (where a lot of right pedal is required due to the sideslip) to downwind, control would be lost, and the aircraft would rotate more than 360° before stopping.

d. The pilot must anticipate these variations, concentrate on flying the aircraft, and not allow a yaw rate to build. Caution should be exercised when executing right turns under conditions conducive to LTE.

7. FLIGHT CHARACTERISTICS.

a. Extensive flight and wind tunnel tests have been conducted by aircraft manufacturers. These tests have identified four relative wind azimuth regions and resultant aircraft characteristics that can, either singularly or in combination, create an LTE conducive environment capable of adversely affecting aircraft controllability. One direct result of these tests is that flight operations in the low speed flight regime dramatically increase the pilot's workload.

b. Although specific wind azimuths are identified for each region, the pilot *should be aware* that the azimuths shift depending on the ambient conditions. *The regions do overlap.* The most pronounced thrust variations occur in these overlapping areas.

c. These characteristics are present only at airspeeds less than 30 knots and apply to all single rotor helicopters. Flight test data has verified that the tail rotor does not stall during this period.

d. The aircraft characteristics and relative wind azimuth regions are:

(1) Main rotor disc vortex interference (285° to 315°). (See figure 1.)

(a) Winds at velocities of about 10 to 30 knots from the left front will cause the main rotor vortex to be blown into the tail rotor by the relative wind. The effect of this main rotor disc vortex is to cause the tail rotor to operate in an extremely turbulent environment.

(b) During a right turn, the tail rotor will experience a reduction of thrust as it comes into the area of the main rotor disc vortex. The reduction in tail rotor thrust comes from the air flow changes experienced at the tail rotor as the main rotor disc vortex moves across the tail rotor disc. The effect of this main rotor disc vortex is to increase the angle of attack of the tail rotor blades (increase thrust).

(c) The increase in the angle of attack requires the pilot to add right pedal (reduce thrust) to maintain the same rate of turn.

(d) As the main rotor vortex passes the tail rotor, the tail rotor angle of attack is reduced. The reduction in the angle of attack causes a reduction in thrust and a right yaw acceleration begins. This acceleration can be surprising, since the pilot was previously adding right pedal to maintain the right turn rate.

(e) This thrust reduction will occur suddenly and, if uncorrected, will develop into an uncontrollable rapid rotation about the mast. When operating within this region, the pilot must be aware that the reduction in tail rotor thrust can happen quite suddenly and the pilot must be prepared to react quickly and counter that reduction with additional left pedal input.

(2) Weathercock stability (120° to 240°). (See figure 2.)

(a) Tailwinds from 120° to 240°, like left crosswinds, will cause a high pilot workload. The most significant characteristic of tailwinds is that they are a yaw rate accelerator. Winds within this region will attempt to weathervane the nose of the aircraft into the relative wind. This characteristic comes from the fuselage and vertical fin.

(b) The helicopter will make a slow uncommanded turn either to the right or left depending upon the exact wind direction unless a resisting pedal input is made. If a yaw rate has been established in either direction, it will be accelerated in the same direction when the relative winds enter the 120° to 240° area unless corrective pedal action is made.

(c) If the pilot allows a right yaw rate to develop and the tail of the helicopter moves into this region, the yaw rate can accelerate rapidly. It is imperative that the pilot maintain positive control of the yaw rate and devote full attention to flying the aircraft when operating in a downwind condition.

(d) The helicopter can be operated safely in the above relative wind regions if proper attention is given to maintaining control. If the pilot is inattentive for some reason and a right yaw rate is initiated in one of the above relative wind regions, the yaw rate may increase.

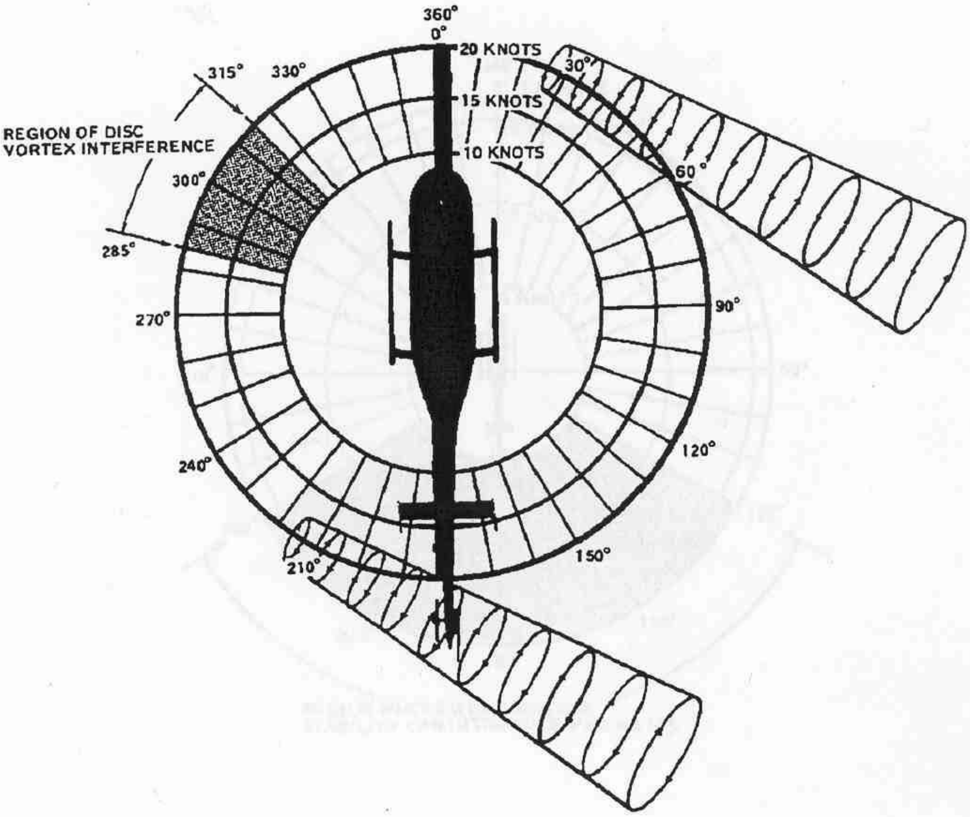

FIGURE 1. MAIN ROTOR DISC VORTEX INTERFERENCE

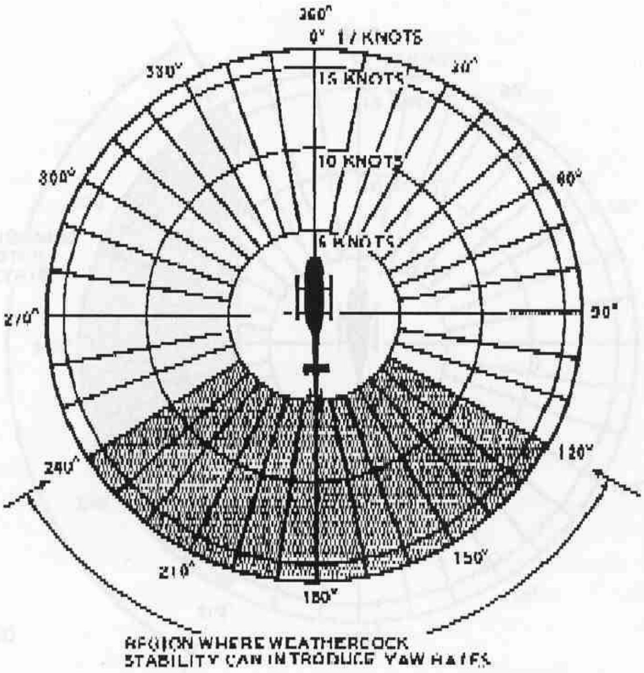

FIGURE 2. WEATHERCOCK STABILITY

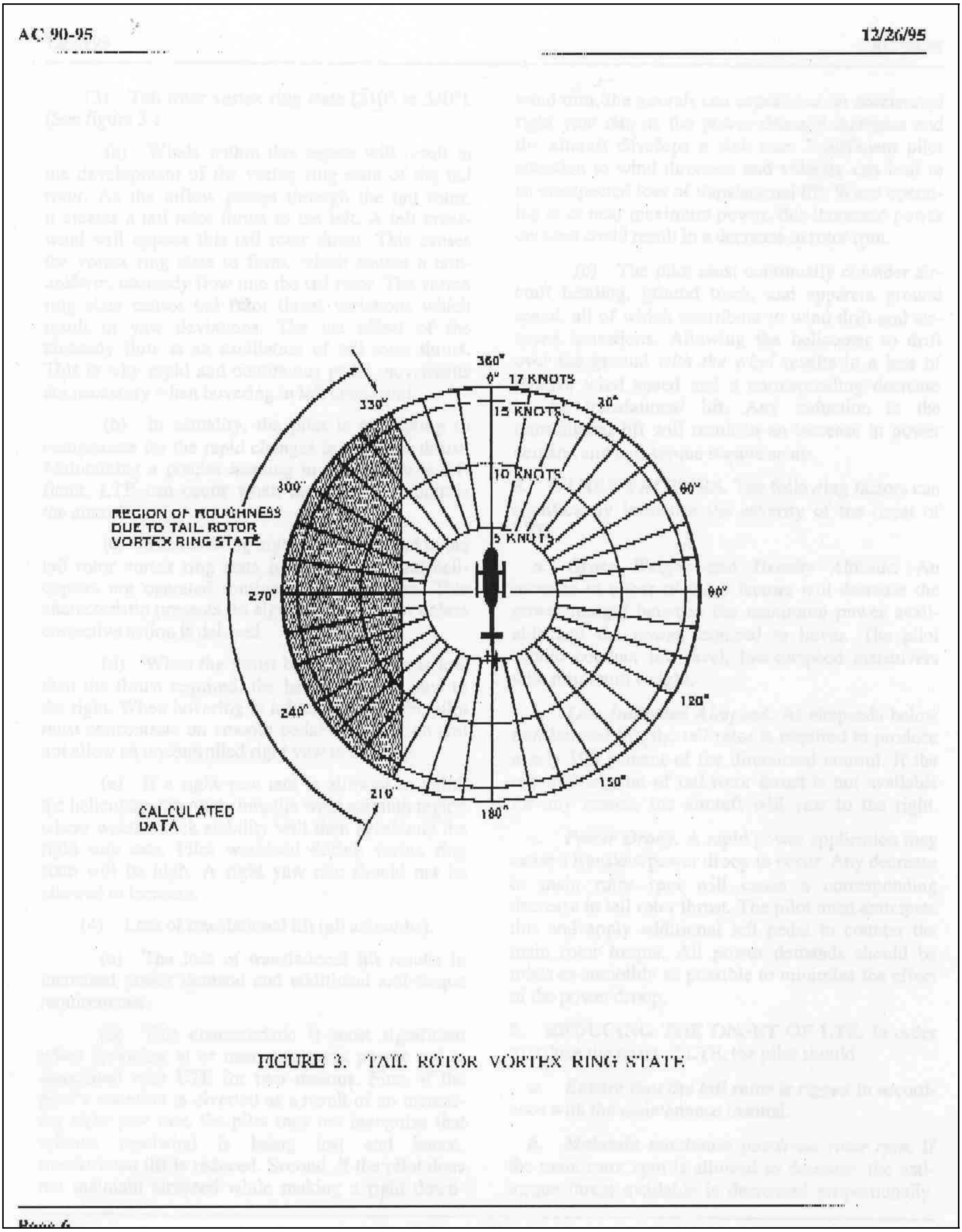

FIGURE 3. TAIL ROTOR VORTEX RING STATE

(3) Tail rotor vortex ring state (210° to 330°). (See figure 3.)

(a) Winds within this region will result in the development of the vortex ring state of the tail rotor. As the inflow passes through the tail rotor, it creates a tail rotor thrust to the left. A left crosswind will oppose this tail rotor thrust. This causes the vortex ring state to form, which causes a nonuniform, unsteady flow into the tail rotor. The vortex ring state causes tail rotor thrust variations which result in yaw deviations. The net effect of the unsteady flow is an oscillation of tail rotor thrust. This is why rapid and continuous pedal movements are necessary when hovering in left crosswind.

(b) In actuality, the pilot is attempting to compensate for the rapid changes in tail rotor thrust. Maintaining a precise heading in this region is difficult. LTE can occur when the pilot overcontrols the aircraft

(c) The resulting high pedal workload in the tail rotor vortex ring state is well known and helicopters are operated routinely in this region. This characteristic presents no significant problem unless corrective action is delayed.

(d) When the thrust being generated is less than the thrust required, the helicopter will yaw to the right. When hovering in left crosswinds, the pilot must concentrate on smooth pedal coordination and not allow an uncontrolled right yaw to develop.

(e) If a right yaw rate is allowed to build, the helicopter can rotate into the wind azimuth region where weathercock stability will then accelerate the right turn rate. Pilot workload during vortex ring state will be high. A right yaw rate should not be allowed to increase.

(4) Loss of translational lift (all azimuths).

(a) The loss of translational lift results in increased power demand and additional anti-torque requirements.

(b) This characteristic is most significant when operating at or near maximum power and is associated with LTE for two reasons. First, if the pilot's attention is diverted as a result of an increasing right yaw rate, the pilot may not recognize that relative headwind is being lost and hence, translational lift is reduced. Second, if the pilot does not maintain airspeed while making a right downwind turn, the aircraft can experience an accelerated right yaw rate as the power demand increases and the aircraft develops a sink rate. Insufficient pilot attention to wind direction and velocity can lead to an unexpected loss of translational lift. When operating at or near maximum power, this increased power demand could result in a decrease in rotor rpm.

(c) The pilot must continually consider aircraft heading, ground track, and apparent ground speed, all of which contribute to wind drift and airspeed sensations. Allowing the helicopter to drift over the ground *with the wind* results in a loss of relative wind speed and a corresponding decrease in the translational lift. Any reduction in the translational lift will result in an increase in power demand and anti-torque requirements.

8. OTHER FACTORS. The following factors can significantly influence the severity of the onset of LTE.

a. Gross Weight and Density Altitude. An increase in either of these factors will decrease the power margin between the maximum power available and the power required to hover. The pilot should conduct low-level, low-airspeed maneuvers with minimum weight.

b. Low Indicated Airspeed. At airspeeds below translational lift, the tail rotor is required to produce nearly 100 percent of the directional control. If the required amount of tail rotor thrust is not available for any reason, the aircraft will yaw to the right.

c. Power Droop. A rapid power application may cause a transient power droop to occur. Any decrease in main rotor rpm will cause a corresponding decrease in tail rotor thrust. The pilot must anticipate this and apply additional left pedal to counter the main rotor torque. All power demands should be made as smoothly as possible to minimize the effect of the power droop.

9. REDUCING THE ONSET OF LTE. In order to reduce the onset of LTE, the pilot should:

a. Ensure that the tail rotor is rigged in accordance with the maintenance manual.

b. Maintain maximum power-on rotor rpm. If the main rotor rpm is allowed to decrease, the antitorque thrust available is decreased proportionally.

c. When maneuvering between hover and 30 knots:

(1) Avoid tailwinds. If loss of translational lift occurs, it will result in an increased high power demand and an additional anti-torque requirement.

(2) Avoid out of ground effect (OGE) hover and high power demand situations, such as low-speed downwind turns.

(3) Be especially aware of wind direction and velocity when hovering in winds of about 8-12 knots (especially OGE). There are no strong indicators to the pilot of a reduction of translational lift. A loss of translational lift results in an unexpected high power demand and an increased anti-torque requirement.

(4) Be aware that if a considerable amount of left pedal is being maintained, a sufficient amount of left pedal may not be available to counteract an unanticipated right yaw.

(5) Be alert to changing aircraft flight and wind conditions which may be experienced when flying along ridge lines and around buildings.

(6) Stay vigilant to power and wind conditions.

10. RECOMMENDED RECOVERY TECHNIQUES.

a. If a sudden unanticipated right yaw occurs, the pilot should perform the following:

(1) Apply full left pedal. Simultaneously, move cyclic forward to increase speed. If altitude permits, reduce power.

(2) As recovery is effected, adjust controls for normal forward flight.

b. Collective pitch reduction will aid in arresting the yaw rate but may cause an increase in the rate of descent. Any large, rapid increase in collective to prevent ground or obstacle contact may further increase the yaw rate and decrease rotor rpm.

c. The amount of collective reduction should be based on the height above obstructions or surface, gross weight of the aircraft, and the existing atmospheric conditions.

d. If the rotation cannot be stopped and ground contact is imminent, an autorotation may be the best course of action. The pilot should maintain full left pedal until rotation stops, then adjust to maintain heading.

11. SUMMARY.

a. The various wind directions can cause significantly differing rates of turn for a given pedal position. The most important principle for the pilot to remember is that the tail rotor is not stalled. The corrective action is to apply pedal opposite to the direction of the turn.

b. Avoiding LTE may best be accomplished by pilots being knowledgable and avoiding conditions which are conducive to LTE. Appropriate and timely response is essential and critical.

c. By maintaining an acute awareness of wind and its effect upon the aircraft, the pilot can significantly reduce LTE exposure.

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