AIRCRAFT ACCIDENT REPORT AND EXECUTIVE SUMMARY

			Reference:	CA18/2/3/8362	
Aircraft Registration	**ZS-RWW**	**Date of Accident**	9 September 2007	**Time of Accident**	1000Z
Type of Aircraft	Robinson R44 Raven II		**Type of Operation**	Training Flight	
Pilot-in-command Licence Type	Commercial	**Age**	25	**Licence Valid**	Yes
Pilot-in-command Flying Experience	Total Flying Hours	668.8		Hours on Type	Unknown
Last point of departure	Port Alfred Aerodrome (FAPA)				
Next point of intended landing	Port Alfred Aerodrome (FAPA)				
Location of the accident site with reference to easily defined geographical points (GPS readings if possible)					
Farms Welgevind and Hopedale, Cove Ridge area near East London (GPS: South 33°04.210' East 027°47.212')					
Meteorological Information	Surface wind; 070°/9kt, Temperature; 18℃, Cloud cover; BKN 1000ft, BKN at 2100ft and OVC at 3000ft. Top of cloud between 6000 and 7000ft AGL.				
Number of people on board	2 + 0	**No. of people injured**	0	**No. of people killed**	2 + 0

Synopsis

The helicopter, with two pilots on board, departed from Port Alfred Aerodrome on an instrument training flight (IF). The intention was to fly to East London and perform the VOR/DME instrument approach for Runway 11 at East London Aerodrome (FAEL). The pilot flying (PF) occupied the right front seat and the instructor pilot occupied the left front seat. The helicopter was equipped with dual flight controls, and was certified for operation in compliance with Visual Flight Rules (VFR) by day and night only. The pilot flying was wearing "foggels" for the duration of the flight. On the approach approximately 5 nm to the west of FAEL, the helicopter entered Instrument Meteorological Conditions (IMC). According to several residents that were residing in the vicinity of the accident site, they could hear the helicopter flying overhead in the direction of the aerodrome, but were unable to see it due to the overcast weather conditions that prevailed. An unusual noise was heard, whereupon the helicopter went silent and the next thing the eyewitnesses observed was the helicopter and associated parts/components falling from the sky, through the clouds. Both occupants that were on board were fatally injured in the accident. There was no damage to people and property on the ground.

Probable Cause

Incorrect recovery technique following a low-G push over condition in-flight, resulting in main rotor blade contact with the cockpit/cabin area, and subsequent loss of control.

IARC Date		Release Date	

AIRCRAFT ACCIDENT REPORT

Name of Owner	: Activest 23 (Pty) Ltd
Name of the Operator	: 43 Air School
Manufacturer	: Robinson Helicopter Company
Model	: R44 Raven II
Nationality	: South African
Registration Marks	: ZS-RWW
Place	: Cove Ridge near East London
Date	: 9 September 2007
Time	: 1000Z

All times given in this report are Co-ordinated Universal Time (UTC) and will be denoted by (Z). South African Standard Time is UTC plus 2 hours.

Purpose of the Investigation:

*In terms of Regulation 12.03.1 of the Civil Aviation Regulations (1997) this report was compiled in the interest of the promotion of aviation safety and the reduction of the risk of aviation accidents or incidents and **not to establish legal liability**.*

Disclaimer:

This report is produce without prejudice to the rights of the CAA, which are reserved.

1. FACTUAL INFORMATION

1.1 History of Flight:

1.1.1 The helicopter, occupied by two crew members, departed from Port Alfred Aerodrome on an Instrument Flight Rules (IFR) training flight to East London. An IFR flight plan was filed and the helicopter was refuelled to capacity, with 130 litres of 100LL Avgas being uplifted prior to their departure.

1.1.2 The flight was conducted under the call sign of Prima 442 (PIU442). The pilot flying occupied the right front seat and the instructor pilot occupied the left front seat. The helicopter was equipped with dual flight controls. The pilot flying (PF) was wearing “foggels” for the duration of the flight. These “foggels” are special glasses that are worn by flight crew members during IF training in order to obscure/limit their outside visibility, however, allowing adequate visibility to view the instrument panel, which would be the primary function of the pilot while engaged in instrument flight training.

Photo 1. A view of the foggel-type glasses, referred to in the paragraph 1.1.2.

1.1.3 The initial phase of the flight was conducted at 1 500 feet Above Mean Sea Level (AMSL) until they were abeam Hamburg, as they approached East London Aerodrome from the west. Radio communication was established with the East London control tower on the VHF frequency 118.3 MHz and the aircraft was cleared to climb to the Minimum Sector Altitude (MSA) of 4 500 feet AMSL. The Air Traffic Controller (ATC) on duty was able to track the approaching aircraft via radar on a monitor at his workstation. Radio communication between the ATC and the aircraft was limited to this once-off clearance.

1.1.4 According to the radar footage, the aircraft climbed from 1 500 feet to 4 500 feet AMSL where it levelled off and maintained its airspeed between 80 and 100 knots. The height of the aircraft was noted as fluctuating between 4 400 feet and 4 600 feet AMSL. At no time had the ATC alerted the crew of this deviation, as they managed to maintain their altitude within the 300 feet safety margin either way.

1.1.5 With the aircraft on the approach for the VOR/DME Runway 11 at East London Aerodrome (approach plate included for reference on page 5 of report) the following observations were noted from the radar footage. At the time the aircraft was approximately 5 nm from the aerodrome. The values indicated below were as the sequence of events followed.

Height indicated at 4 500 feet, airspeed 100 knots.

Height indicated at 4 400 feet, airspeed 110 knots.

Height indicated at 4 400 feet, airspeed 80 knots.

Height indicated at 4 300 feet, airspeed 40 knots.

Height indicated at 4 300 feet, airspeed 20 knots.

The aircraft (target) then disappeared from the radar screen. The sequence of events occurred within a time frame of between 30 to 40 seconds.

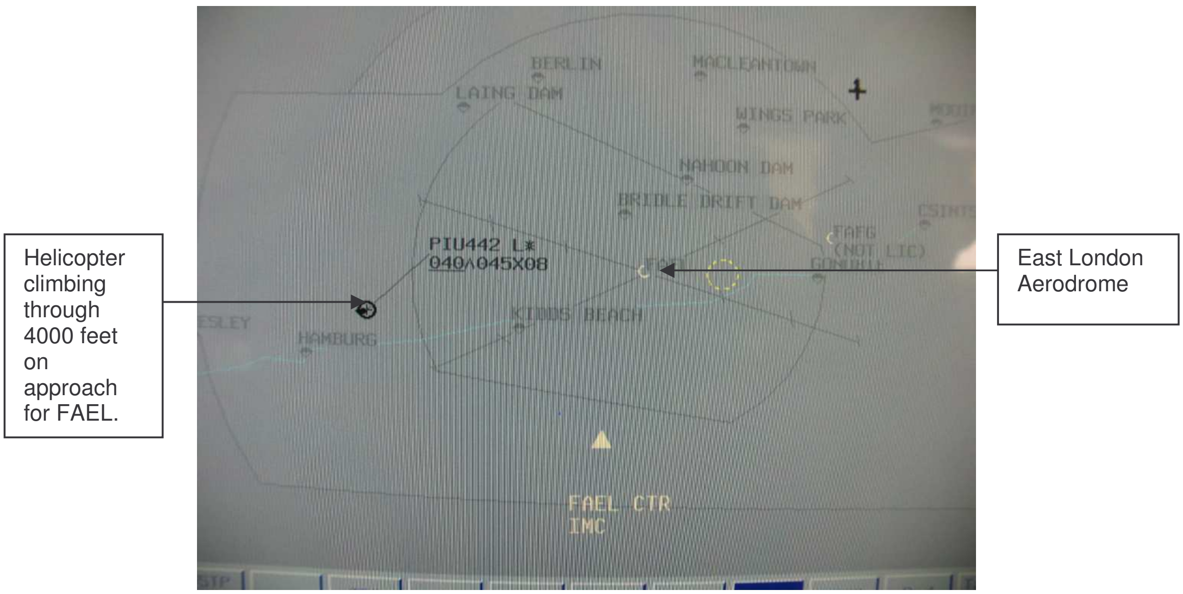

Photo 2. A view of the radar screen with the helicopter (PIU442) approaching FAEL.

1.1.6 According to a witness who was standing in his garden at the time, he heard the helicopter flying but was unable to see it due to obscure cloud cover. He then heard what sounded to him like the rotor blades slowing down, followed by a loud noise (bang), where after everything went quiet. He then observed the wreckage falling through the clouds towards the ground in a nose-down attitude. The cockpit/cabin area was broken up. He also saw the body of one of the occupants in amongst the wreckage falling towards the ground.

He immediately contacted the emergency services, whereupon he rushed to the scene of the accident. The main wreckage was located in dense bush-type terrain. Once the emergency services arrived at the accident site, he withdrew from the area.

1.1.7. The accident occurred during daylight conditions, and the main wreckage was located at a geographical position determined as South 33°04.210' East 027° 47.212', which was 5 km (2.7 nm) from the aerodrome on a heading of 250°M at an elevation of 300 feet AMSL. Both occupants on board the helicopter were fatally injured in the accident. There was no damage or injury to people or property on the ground.

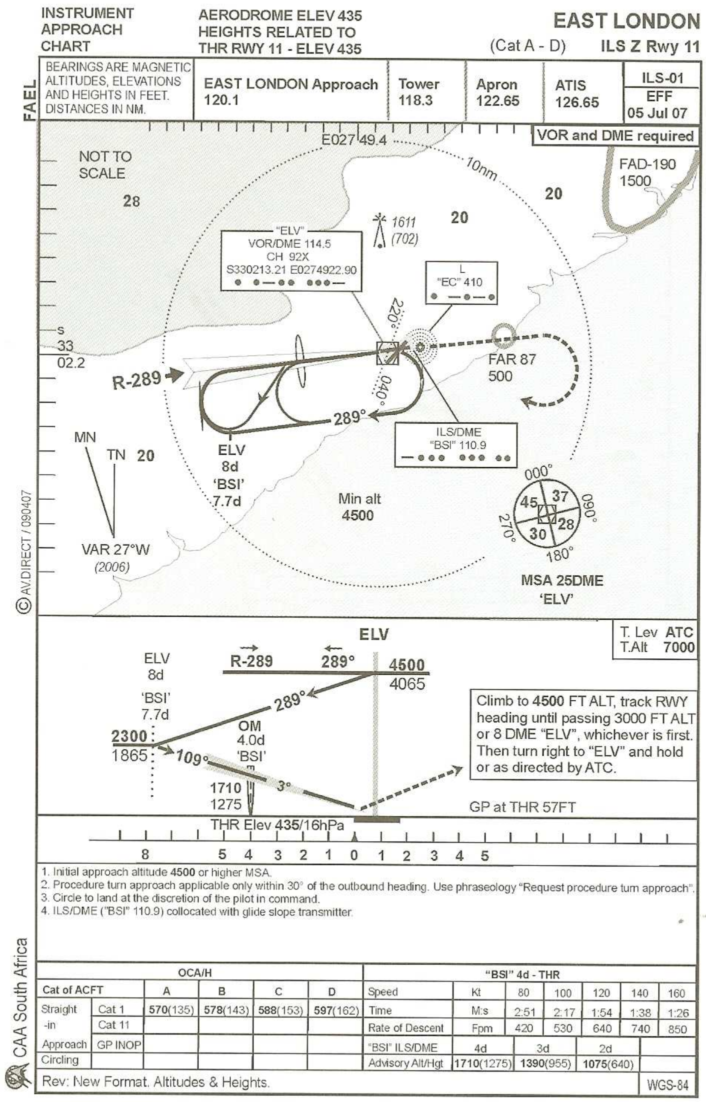

Figure 1. Approach plate for the VOR/DME approach Runway 11 at East London.

1.2 Injuries to Persons:

Injuries	Pilots	Crew	Pass	Other
Fatal	2	-	-	-
Serious	-	-	-	-
Minor	-	-	-	-

None	-	-	-	-

1.3 Damage to Aircraft:

1.3.1 The helicopter was destroyed when the main rotor blades contacted and penetrated the cockpit/cabin area in-flight and it crashed to the ground in a nose-down attitude.

Photo 3. A view of the main wreckage, which crashed in dense bush-type terrain.

1.4 Other Damage:

1.4.1 Although the wreckage was scattered over a large area consisting of two farms, no damage or injury was caused to property or people on the ground.

1.5 Personnel Information:

1.5.1 Pilot-in-command:

Nationality	Botswana	Gender	Male	Age	25
Licence Number	****************	Licence Type	Private (Aeroplane) Commercial (Helicopter)		
Licence valid	Yes	Type Endorsed	Yes		
Ratings	Instructor's Rating Grade III, Instrument Rating, Undersling/ winch Rating. (The ratings are all applicable to helicopter				

	operations)
Medical Expiry Date	30 April 2008
Restrictions	None
Previous Accidents	None

Flying Experience:

Total Hours	668.8
Hours as Instructor on Helicopters	433.2

*NOTE: The pilot's flying hours reflected above were obtained from his SACAA pilot's file. The last entry in the file prior to the accident was dated 31 July 2007, when he submitted the form CA61-01.08 (Application for Renewal of Flight Crew Member's Licence). The hours flown during the Past 90 days prior to the accident could not be concluded due to the unavailability of the pilot's flying logbook, which could not be located.

Flying Experience Aeroplane and Helicopter

Total Hours Aeroplane	224.2
Total Hours Helicopter	444.6
Total Hours	668.8

The pilot applied for a student pilot's licence (aeroplane) to the SACAA on 11 February 2003. On 25 June 2003 he applied for a private pilot's licence (aeroplane), which was issued following compliance with the regulations pertaining to the issue of a flight crew licence.

On 1 April 2004 the SACAA received an application from the pilot for a student pilot's licence (helicopter). On 13 May 2004 he applied for a private pilot's licence (helicopter), which was issued to him following compliance to the requirements as stipulated in the regulations.

On 8 July 2004 the SACAA received a conversion application from the pilot for the Robinson R44 helicopter after obtaining 7.1 hours of dual flight training onto the type in question. The pilot obtained a conversion onto the Bell 206 series helicopter on 2 June 2005 after 13.0 hours of dual flight instruction.

On 30 June 2005 the SACAA received an application form from the pilot for a commercial helicopter pilot's licence, which was issued to him following compliance to the requirements as stipulated in the regulations.

On 23 September 2005 the SACAA received an application from the pilot for an endorsement of a flight instructor's rating on helicopters, which was approved.

On 31 March 2006 the pilot again applied for a student pilot's licence (aeroplane) and on 6 April 2006 he applied for a private pilot's licence (aeroplane), which was approved.

On 31 July 2007 the SACAA received a renewal form for the pilot's commercial helicopter pilot's licence, which included an IF (Instrument Flying) proficiency test that was conducted on 21 July 2007 by a CAA approved designated examiner.

*NOTE: According to the SACAA pilot's file, on 9 May 2005 the pilot wrote one of his Flight Instructor Rating (helicopter) examinations, with the subject being 'Principles of Flight', which he passed. One of the questions in the examination was to explain the phenomenon know as Mast Bumping, which is explained in paragraph 1.18.2 of this report, as it had a direct effect on this accident. The question was correctly answered by the incumbent.

1.5.2 Pilot Flying:

Nationality	Nigerian	Gender	Male	Age	26
Licence Number	*****************	Licence Type	Commercial (Aeroplane) Private (Helicopter)		
Licence valid	Yes	Type Endorsed	Yes		
Ratings	Instrument Rating (on aeroplane, expired on 24 July 2007) The pilot did not hold any rating/s on helicopters.				
Medical Expiry Date	30 April 2008				
Restrictions	None				
Previous Accidents	None				

Flying Experience:

Total Hours	363.1
Total Past 90 Days	52.0
Total on Type Past 90 Days	13.0

Total on Type	13.0

Flying Experience Aeroplane and Helicopter

Total Hours Aeroplane	226.3
Total Hours Helicopter	136.8
Grand Total	363.1

The pilot applied for a student pilot's licence (aeroplane) to the SACAA on 12 May 2004. On 15 July 2004 he applied for a private pilot's licence (aeroplane), which was issued following compliance with the regulations pertaining to the issue of a flight crew's licence. On 14 November 2005 the SACAA received an application for a night rating, which was granted. On 25 July 2006 the SACAA received an application for an instrument rating. Following the required commercial pilot's examinations and practical flight test, the pilot was issued with a commercial pilot's licence aeroplane on the date.

On 22 January 2007 the SACAA received an application from the pilot for a student pilot's licence (helicopter). On 17 May 2007 he applied for a private pilot's licence (helicopter), which was issued to him following the requirements as stipulated in the regulations.

It was noted that the application form for a student pilot's licence (helicopter) contained both the Robinson R22 and R44 models. According to the pilot's logbook he had never flown a Robinson R44 during his training period as a private pilot, although the aircraft type was endorsed onto his student pilot's licence by the SACAA.

According to the pilot's logbook, the first time that he flew a Robinson R44 helicopter was on 2 August 2007, some time after he had already obtained his helicopter private pilot's licence. His conversion onto the Robinson R44 helicopter was not endorsed by the flight school/flight instructor in his pilot's logbook, but was simply entered as a conversion. The conversion was conducted over a period of seven days and comprised 6.0 hours of dual flying training, according to the pilot's logbook. The conversion onto the Robinson R44 was not performed in compliance with the Air Navigation Regulations (ANR) of 1976, Chapter 2, paragraph 2.3 (3)(a)(i), which state the following:

(3) *In the case of a piston-engined aeroplane having a maximum certified mass of 5 700kg or less-*

(a) the flight instructor or designated pilot shall on satisfactory completion of the training for a type rating-

(i) *make an endorsement to this effect in the logbook of the pilot who received the training, whereupon that pilot shall be entitled to exercise the privilege of such rating.*

1.6 Aircraft Information:

1.6.1 The Robinson R44 Raven II is a four-seat, single reciprocating engine helicopter equipped with a skid landing gear. It is certified for Visual Flight Rules (VFR) operations by day. VFR operation at night is permitted only when landing, and navigation, instrument, and anti-collision lights are operational. Operation during night flight must be maintained by visual reference to ground objects illuminated solely by lights on the ground or adequate celestial illumination. NOTE: There may be additional requirements in countries outside the United States.

1.6.2 Airframe:

Type	Robinson R44 Raven II	
Serial Number	10217	
Manufacturer	Robinson Helicopter Company	
Year of Manufacture	2003	
Total Airframe Hours (At time of Accident)	1 315.8	
Last MPI (Hours & Date)	1 304.9	30 August 2007
Hours since Last MPI	10.9	
C of A (Issue Date)	13 February 2004	
C of A (Currency Fee Expiry Date)	12 February 2008	
C of R (Issue Date) (Present owner)	23 March 2007	
Operating Categories	Standard	
SB's and AD's status	Complied with	
Type acceptance in RSA	Yes	

*NOTE: The airframe hours reflected in the table above at the time of the accident was obtained from the aircraft's Flight Folio and reflected the hours prior to the accident flight. Due to the destruction of the airframe it was not possible to locate the hobbs meter reading.

1.6.3 Engine:

Type	Lycoming IO-540-AE1A5
Serial Number	L-29017-48A
Hours since New	1 315.8
Hours since Overhaul	T.B.O. not yet reached

1.6.4 Weight & Balance:

At the time of the accident there were only two occupants on board the four-seater helicopter. They had been airborne for approximately 30 to 40 minutes when the accident occurred. The maximum certified take-off weight for the helicopter according to the Pilot's Operating Handbook (POH), Section 2, page 2-3 was not allowed to exceed 2 500 pounds (1134 kg). According to the post-mortem report received, the two occupants weighed 70kg and 75kg respectively. The helicopter was operated at the time of the accident within its maximum certified take-off weight limitations.

1.6.5 Instrument Panel ZS-RWW

The photo below was obtained from one of the flight instructors at the training school and had been inserted for illustration purposes, to reflect the instrument panel layout of the helicopter in question.

Photo 4. An archive photo of the instrument panel of the accident helicopter ZS-RWW.

1.7 Meteorological Information:

1.7.1 An official meteorological report was obtained from the South African Weather Services following the accident.

(i) Weather conditions at time of accident. (Surface analysis)

A trough of low pressure was present over the southern part of the country with a weak cold front south-east of the country. Another weak cold front was just west of Cape Town. Cloudy conditions were present on the Cape east coast.

(ii) Satellite Image:

The satellite image (below) taken on 9 September 2007 at 1000Z, shows cloudy conditions in the East London area.

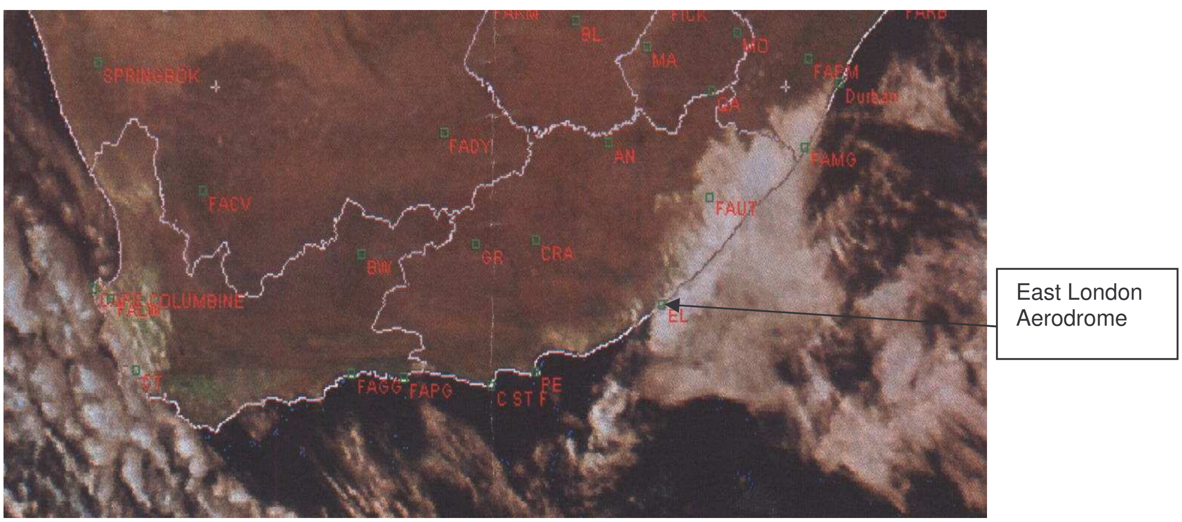

Photo 5. Satellite image of the southern part of the country on 9 September 2007 at 1000Z.

(iii) Weather conditions in the vicinity of the incident.

No official observations were available at the time and place of the accident. The East London Weather office issued the following Meteorological Aeronautical Report/s (METARs) at 1000Z and 1030Z:

FAEL 091000Z 07009KT 9999 BKN013 BKN021 OVC030 18/14 Q1015
FAEL 091030Z 09010KT 9999 SCT013 BKN021 BKN030 19/15 Q1015

The most likely weather conditions at the place of the accident were as follows:

Time	-	1008Z
Temperature	-	18℃
Dew point	-	14℃
Wind direction	-	070°TN
Wind speed	-	9 knots
Cloud	-	Broken cloud at 1 000 feet, Broken cloud at 2100 feet, Overcast at 3000 feet. Estimated top of cloud between 6000 and 7000 feet.
Freezing level	-	12 500 feet AMSL
Visibility	-	10km+
Pressure Altitude	-	1015 hPa (hector Pascal)

1.8 Aids to Navigation:

1.8.1 The aircraft was equipped with the following navigational aids:

Magnetic Compass
Directional Gyro
VOR (Variable Omni Range) Indicator
ADF (Automatic Direction Finder)
Garmin 150XL GPS (Global Positioning Unit)
Transponder

According to the available evidence, none of these units had any recorded defects prior to the flight.

1.9 Communications:

1.9.1 The helicopter was in radio contact with East London control tower on the Very High Frequency radio (VHF) frequency 118.3 MHz. The communication between ATC and ZS-RWW was limited to the ATC giving an approach clearance. At no stage was there any other communication.

1.9.2 The helicopter was also identified on radar, with the ATC on duty in the tower being able to follow the helicopter on a monitor located at his workstation. It was when the helicopter disappeared from the monitor (radar display) that the ATC attempted several times to establish communication with the helicopter, without any success. There was no distress or Mayday call received by the control tower prior to the helicopter disappearing from radar.

1.10 Aerodrome Information:

1.10.1 The accident did not occur at an aerodrome. Due to the break-up of the helicopter in the air, debris was located over an area of approximately 1½ km, with the terrain varying from very dense bush to open farmland.

Aerodrome Location	5nm West of East London City	
Aerodrome Co-ordinates	South 33° 02 153' East 027° 49 367'	
Aerodrome Elevation	435 feet AMSL	
Runway Designations	06/24	11/29
Runway Dimensions	1 585m x 46m	1 939m x 46m
Runway in Use	11	
Runway Surface	Asphalt	
Approach Facilities	Cat II ILS, VOR, DME, NDB, PAPIs	
Aerodrome Status	Licensed	

1.11 Flight Recorders:

1.11.1 The helicopter was not equipped with a flight data recorder (FDR) or a cockpit voice recorder (FDR), nor was it required by regulation to be fitted to this helicopter type.

1.12 Wreckage and Impact Information:

1.12.1 The main wreckage was observed by witnesses falling from the sky (through the clouds) in a nose down attitude. This observation was confirmed during the on-site investigation with the tail section, which was still attached to the main wreckage, being found elevated in the air as it was supported by surrounding vegetation. The tail boom and tail rotor assembly displayed substantial less damage than the front and centre section of the helicopter. The cockpit/cabin area, which had absorbed most of the impact forces, was severely disrupted. A substantial amount of energy had, however, been absorbed by the dense vegetation during the impact sequence, which was evident from the broken tree branches that were located on the accident site. The engine was still attached to the main wreckage, lying in an inverted attitude. The cockpit/cabin area displayed evidence of main rotor blade impact on the left-hand side, with the main rotor blade having impacted the instrument panel as well as the yaw pedals that were located on the left-hand side where the flight instructor was seated.

1.12.2 The main rotor gearbox, main rotor drive shaft, and one of the main rotor blades, which was still attached to the main rotor head were found approximately 500 m from the main wreckage as it had separated from the fuselage in the air. The second main rotor blade was found to have separated in overload mode from the main rotor head, most probably during blade contact with the cockpit/cabin area in flight. The blade was found some 400 m past the main wreckage along the wreckage trail. Some inner body material of one of the main rotor blades was located in the area where the first pieces of debris were located, which was approximately 1 km from the main wreckage and 6 km (3.2 nm) from the East London Aerodrome on a heading of 068°M.

Photo 6. An aerial view of the wreckage trail, which was taken at a height of about 800 feet above ground level.

1.12.3 The pieces of debris that first indicates a relationship with a accident namely a shattered windscreen (plexi-glass), a section of inner main rotor blade material as well as the roof structure of the cabin/cockpit. The roof structure displayed evidence consistent with main rotor blade contact (blade upset in-flight), which led to the destruction of the cabin/cockpit area and a loss of control.

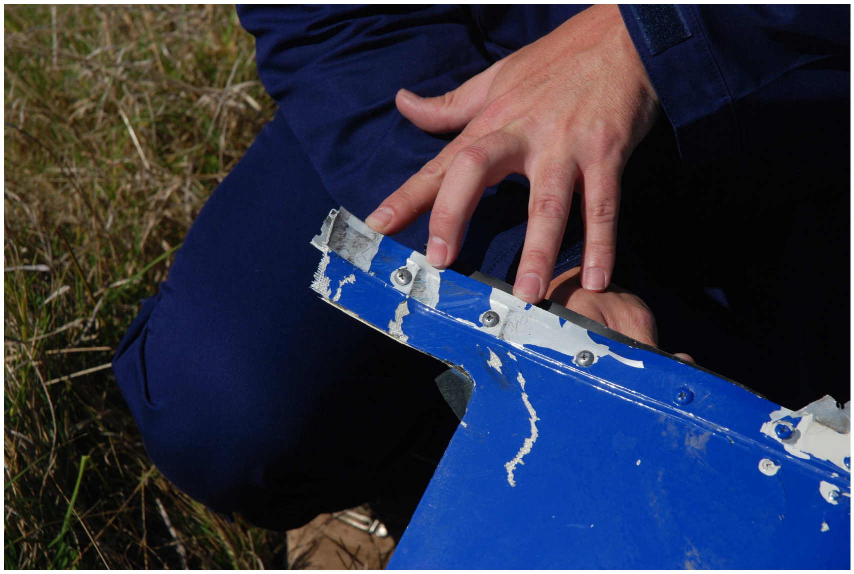

Photo 7. Main rotor blade impact marks evident on the left-hand side of the roof structure.

1.12.4 Moving from the initial debris area towards the main wreckage, the left front seat assembly was accounted for, both shoes of the pilot-in-command, who was seated in the left front seat, the deformed left front door and door beam as well as the right front door, which displayed very little damage.

1.13 Medical and Pathological Information:

1.13.1 Both occupants were fatally injured in the accident.

1.13.2 The Department of Health, Division: Forensic Pathology Services had compiled a medico-legal post-mortem examination on both occupants.

The cause of death in respect of both occupants was found to be the same and was attributed to multiple injuries sustained during the impact sequence.

1.13.3 The toxicological report (blood specimen) of the pilot-in-command obtained the following results:

(i) The concentration of the alcohol in the blood specimen was 0.00 grams per 100 millilitres.
(ii) The concentration of the sodium fluoride in the blood specimen was 2.6%.
(iii) The carbon monoxide content of the blood specimen was 4.6% saturation of the total haemoglobin.

1.13.4 The toxicological report (blood specimen) on the pilot-flying obtained the following results:

(iv) The concentration of the alcohol in the blood specimen was 0.00 grams per 100 millilitres.
(v) The concentration of the sodium fluoride in the blood specimen was 2.9%.
The carbon monoxide content of the blood specimen was 4.4% saturation of the total haemoglobin.

1.14 Fire:

1.14.1 There was no evidence of a pre- or post-impact fire.

1.15 Survival Aspects:

1.15.1 The accident was regarded not to be survivable due to the destruction of the cockpit/cabin area. The helicopter was flying at a height of 4 500 feet AMSL (Above Mean Sea Level) when it disappeared from the radar screen. It was seen falling from the sky (through the clouds) following an induced low-G pushover manoeuvre associated with main rotor blade contact with the cockpit/cabin area. One of the occupants was observed by an eyewitness as falling from the sky, in a free-fall manner, without being secured to the wreckage. The elevation at the crash site was approximately 300 feet AMSL.

1.16 Tests and Research:

1.16.1 The engine, a Lycoming IO-540-AE1A5, Serial No. L-29017-48A was removed from the wreckage following the accident and was taken to an approved engine maintenance facility where a teardown inspection was conducted in the presence of a South African Civil Aviation Authority investigator.

According to the logbook entries, the engine was installed in the airframe (Serial No. 10217) on 20 October 2003 by the Robinson Helicopter Company. This was during the manufacturing process of the helicopter on the assembly line. According to the logbook, both magnetos were removed and subjected to 500-hour inspections on 2 June 2005 and again on 16 August 2006.

- The engine displayed signs of severe ground impact on the bottom section of the engine on the left-hand side (Nos 2, 4 and 6 cylinders). The crank case halves were intact and all the cylinders were attached.
- The exhaust system components remained attached to the engine. All the pipes on the left-hand side were crushed and had to be removed with the assistance of an angle grinder. The pipes on the right-hand side were intact but bent.
- Both crankcases sustained impact damage towards the forward section of the engine, including damage to the crankshaft (unknown object).
- Both magnetos (T.C.M. S6LSC-200 type) were still attached to the engine, but both had sustained impact damage. Left-hand magneto had suffered damage to its attachment at the accessory drive train.
- Ignition harness sustained some impact damage with the lower connections to cylinders 2, 4 and 6 being severely disrupted.
- Sparkplugs (Champion REM-38E type) were in overall good condition and presented a light greyish colour – indicative of normal engine operation. The electrodes exhibited normal wear signatures when compared to the Champion AV-27 card. The bottom sparkplugs on cylinder No. 2 and 4 were found to have broken due to impact damage.
- Fuel pump (Lycoming LW-15473 type) was intact with visible damage to the gasket seal. All pipe connections to the pump were found to be disconnected. It was not possible to bench test the pump.
- Fuel divider/manifold valve (AMS 4290 type) was observed intact and safety wire locked. All the fuel lines to the valve were secured. The cover was removed and the diaphragm was inspected and found to be in a good condition.
- Fuel control unit (Precision RSA-10AD1 type) appeared in overall good condition with linkages still connected although disrupted (bent). The throttle valve/butterfly was intact and functional when the linkage was operated.
- Oil pump was intact and undamaged, still contained some oil. No visible damage was observed to the gears. No discolouration to the gears was observed.

- Oil sump was intact and still contained a small amount of oil.
- Oil filter (Champion Aerospace type) was severely disrupted due to impact damage.
- Oil cooler sustained impact damage.
- Oil pick-up tube was found intact and undamaged.
- Cylinders (Lycoming LW 12993 type) were found to be intact. Nos 2, 4 and 6 sustained some impact damage to the lower half of the cylinder head. The cylinders visually exhibited normal combustion signatures. There was no damage to the inside of the cylinders, nor was any corrosion observed.
- The pistons, rings and pins (Lycoming LW 10207-S type) were found intact and properly located. No visual damage was observed. The piston head exhibited normal combustion signatures.
- All the valve guides were intact and properly secured. No damage was observed.
- All the rocker arms and shafts were intact and properly secured.
- Main bearings (Part Nos 18A19441 and 18D23135 type) were found in overall good condition and were still lubricated.
- The crankcase was damaged but remained together. There was no evidence of fretting corrosion between the case, or to the bearing saddles.
- The data plate did not reflect any anomalies.
- Crankshaft (Serial No. V531931779) was found intact. Run-out on the crank at the centre bearing location was found to be 1 fowl (1000 of an inch) maximum allowed 5 fowl, and 17 fowl at the propeller flange (maximum allowed 30 fowl).
- Crankshaft counter weights (Part No. 14U22539) were intact and properly secured. The snap rings were installed correctly. The counterweights moved freely along the cheeks.
- Main bearings (Part Nos (1 and 2) 18A19441 (3 and 4) 18D23135 type) were found intact and in an overall good condition. No evidence of bearing movement was observed to the bearings. No damage was observed to any of the bearings. They still contained some evidence of lubrication/oil.
- Connecting rods (Lycoming LW 11750 type) and bearings (Part No. 18M19389) were found to be intact. No discolouration was observed to the rod assemblies. No bearing movement was observed to any of the bearings.
- The camshaft (Lycoming LW 19340, Serial No. 5378 (39-03) was found to be intact but bent approximately 15cm from the front end. No damage was observed to any of the cam lobes or cam gears.
- All the accessory gears were accounted for and were intact. All the gear teeth were observed on all the gears.

- The lifters were all intact and no spalling was observed to the lifter faces.
- The starter (BC 315-100-4 type) remained attached to the engine and was observed to have sustained some impact damage.
- The alternator (Kelly Aerospace ALU-8521LS type) remained attached to the engine and was observed to have sustained some impact damage.

Following the teardown inspection, no visual abnormalities were found that would have prevented the engine from operating at its rated power as stipulated in the POH.

1.17 Organisational and Management Information:

1.17.1 The flight was conducted under the auspices of an Aviation Training Organisation (ATO), Certificate No. CAA/0074. The ATO was in possession of a valid ATO Certificate, with an expiry date of 30 November 2007. The accident helicopter was duly authorised to operate under the certificate.

1.17.2 The flight was duly authorised on the flight authorization sheet. The exercise that was entered on the flight authorization sheet was indicated to be lesson number 34 (Instrument Flying).

1.17.3 The last maintenance that was certified on the helicopter prior to the accident was conducted by AMO No. 222. The AMO was in possession of a valid AMO Approval that had been issued by the SACAA.

1.18 Additional Information:

1.18.1 Wreckage Examination:

From the wreckage examination it was evident that the main rotor blades had penetrated the cockpit/cabin area in-flight. Damage to the main rotor blades was observed to be from about midway out towards the tip of the blades. The main rotor blade that most probably penetrated the fuselage first, was observed to be substantially more deformed than the other blade. The 'second' blade displayed a chunk of blade body approximately 1 metre in length, missing about mid-span along its length, which was recovered on the accident site.

The cockpit/cabin roof area displayed evidence of a main rotor blade strike. These markings were located more to the left-hand side of the roof structure. There was evidence that the main rotor blades had struck a section of the instrument panel as well as the floor structure on the left-hand side. The left shoe of the pilot-in-command (flight instructor) that was seated on the left-hand side, also displayed evidence of main rotor blade damage with the left rudder/yaw pedal being pushed inwards (towards the pilot's seat).

The main rotor shaft was bent just below the main rotor head attachment and both droop stop damper rubbers located on the main rotor shaft displayed evidence of excessive deformation associated with a low-G, mast bumping event. It can be seen from the photo below that the droop stop damper rubber on the right-hand side is substantially more disrupted than the one on the left, even though both rubbers reflect extensive deformation evidence associated with main rotor hub contact with the mast (main rotor drive shaft).

Photo 8. A view of the upper main rotor shaft displaying deformation evidence to the rubber stops.

1.18.2 Mast Bumping

Reference: Principles of Helicopter Flight, by W.J. Wagtendonk, page 161, 162

Mast bumping is the result of poor pilot technique. The phenomenon occurs when the helicopter's main rotor hub is allowed to make contact with and deform the main rotor mast. The consequence: rotor separation from the mast. Mast bumping is peculiar to two-bladed rotor systems that use the teetering hinge, such as Bell and Robinson helicopters.

The hub making contact with the mast requires excessive flapping. Even under high speed, high gross weight and high altitude conditions, the degree of blade flapping is well within maximum allowable values and the risk of mast bumping is zero under all normal flight conditions when correct piloting techniques are maintained. However, incorrect techniques that cause excessive flapping set the stage for disaster.

A blade's flapping amplitude is increased by:

- Gusty wind conditions.
- Sudden altitude changes caused by abrupt cyclic inputs.
- Flight under low, zero or negative-*g* conditions.
- Sideways flight at or near the helicopter's maximum allowable speed.

Any of the above, or a combination of them, imposes a risk of excessive flapping, but the low-*g* situation is the most dangerous for the development of mast bumping. Airplane pilots who have recently transitioned to helicopters are at a higher risk for mast bumping accidents because reactions honed by years of airplane flying are not necessarily conductive to safe helicopter flying. For example, if the pilot must descend suddenly to avoid another object, say, a bird; helicopter technique is to rapidly lower the collective. The airplane/helicopter pilot is prone to push the cyclic forward in the same situation, lowering the nose of the helicopter into a dive, as he would an airplane. Such a pushover is the exact formula for mast bumping.

Low-*g* flight occurs when cyclic is moved forward rather firmly, such as during a pushover at the end of a zoom climb, especially if the pilot lowers collective at the same time. The effect of low, zero or negative-*g* on total main rotor thrust production (see Figure 2 below) is devastating.

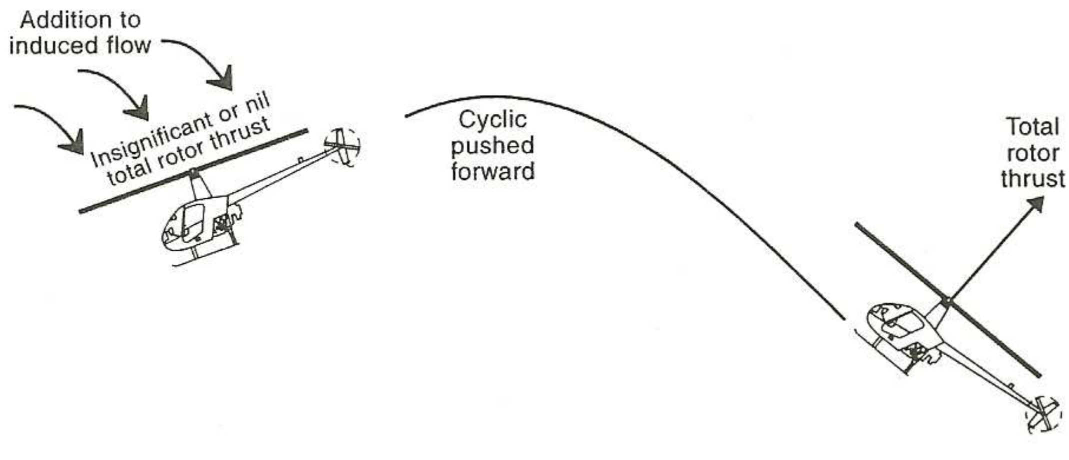

Figure 1. Firm application of forward cyclic can cause low, zero or negative-*g* and a severe reduction in total rotor thrust.

Tail rotor drift (translating tendency) is typically balanced by a slight tilt of the main rotor disc in a direction opposite tail rotor thrust. With a counter clockwise rotor, the disc is tilted slightly to the left, so the horizontal component of main rotor thrust opposes drift, and through that it opposes yaw. The amount of main rotor thrust is reduced or even eliminated by a combination of reduced collective and forward cyclic. Forward cyclic decreases blade angles of attack as the helicopter's up and forward momentum increases the induced flow. A greatly reduced or zero total rotor thrust allows the tail rotor thrust to yaw the aircraft's nose to the left. The resulting skid to the right causes the fuselage to lag so that a right toll results. The tail rotor thrust also forms a right-hand turning moment around the aircraft's centre of gravity, which is now much lower down than the tail rotor. As the aircraft continues to roll right (while cyclic is forward but not to the side) the clearance between the rotor head and the mast is reduced (see Figure 2 below). This condition is not in itself dangerous, but incorrect flying techniques can make it so.

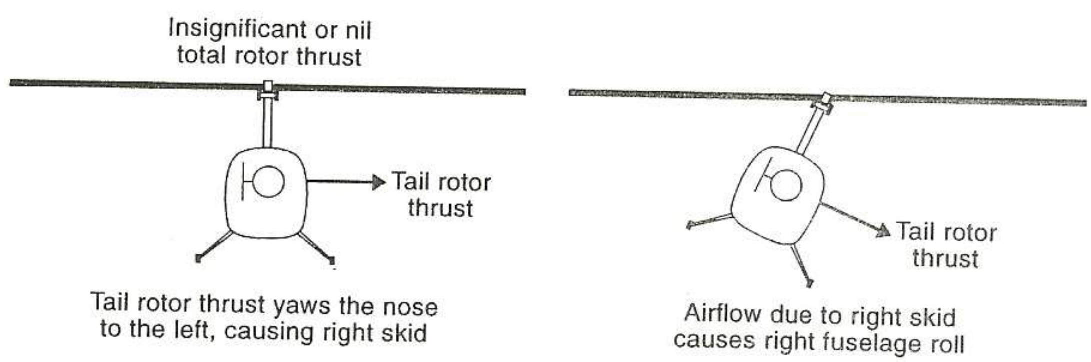

Figure 2. Lateral cyclic neutral. Right fuselage roll reduces the clearance between the rotor head and shaft.

The unwary pilot may instinctively use left cyclic to oppose the increasing right roll. This left lateral cyclic action causes upward flapping on the right-hand side of the disc, so that the clearance between the rotor head ad the mast on the left-hand side lessens even more. Under normal, positive-*g* conditions, this left cyclic input would have produced a horizontal component of total thrust to the left, creating a moment that would have brought the aircraft back to the required attitude.

Under zero or negative-*g* conditions, however, initial left cyclic fails to provide the restoring moment resulting from disc tilt and further left cyclic is similarly ineffective. The clearance between rotor head and mast becomes smaller still, and is not corrected, the two connect and the rotor may separate from the mast.

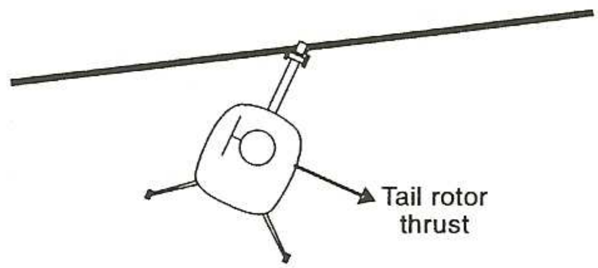

Figure 3. Left lateral cyclic application further reduces rotor head clearance. Mast contact may become inevitable.

Avoiding Mast Bumping

Clearly, the answer to mast bumping is to avoid flight conditions that involve reduced or negative-*g.* If a pilot inadvertently finds him/herself in a zero or negative-*g* state, he or she must react with the correct instincts and particularly resist the natural tendency to move cyclic left when right roll starts.

Total rotor thrust must be restored. To do this the pilot must *reload* the disc by either moving the cyclic aft or increasing collective. Of the two techniques, increasing collective is less desirable because the associated increase in power tends to produce more yaw problems, particularly under low-*g* conditions. Also, tests have shown a tendency for main rotor under speed or gearbox over torque when the collective recovery technique is used.

Recovery from Low and Zero-*g*

The most effective recovery technique from a low or zero-*g* condition is:

- Apply gentle rearward cyclic to reload the rotor (reintroducing a positive-*g* situation), then
- Use left cyclic to roll the aircraft level.

1.18.3 Pilot's Operating Handbook, Section 2, Limitations, page 2-5, 2-6.

Flight and Manoeuvre Limitations

Low-G cyclic pushovers prohibited.

CAUTION

A pushover (forward cyclic manoeuvre) performed from level flight following a pull up causes a low-G (near weightless) condition, which can result in catastrophic loss of lateral control. To eliminate a low-G condition, immediately apply gentle aft cyclic. Should a right roll commence during a low-G condition, apply gentle aft cyclic to reload rotor <u>before</u> applying lateral cyclic to stop the roll.

Kinds of Operation Limitations:

VFR (Visual Flight Rules) day is approved.

VFR operation at night is permitted only when landing, navigation, instrument, and anti-collision lights are operational. Orientation during night flight must be maintained by visual reference to ground objects illuminated solely by lights on the ground or adequate celestial illumination.

1.18.4 Pilot's Operating Handbook, Section 4, Normal Procedures.

Mast Bumping:

Mast bumping may occur with a teetering rotor system when excessive main rotor flapping results from low "G" (load factor below 1.0) or abrupt control input. A low "G" flight condition can result from the abrupt cyclic pushover in forward flight. High forward airspeed, turbulence, and excessive sideslip can accentuate the adverse effects of these control movements. The excessive flapping results in the main rotor hub assembly striking the main rotor mast with subsequent main rotor system separation from the helicopter.

To avoid these conditions, pilots are strongly urged to follow these recommendations:

1) Maintain cruise airspeeds greater than 60 knots indicated airspeed and less than 0.9 Vne.

2) The possibility of rotor stall is increased at high density altitudes; therefore, avoid flight at high density altitudes.

3) Use maximum "power-on" RPM at all times during powered flight.

4) Avoid sideslip during flight. Maintain in-trim flight at all times.

5) Avoid large, rapid forward cyclic inputs in forward flight, and abrupt control inputs in turbulence.

1.18.5 Civil Aviation Regulations (CAR's) of 1997 (Visual Flight Rules)

Part 91.06.21 (Visibility and distance from cloud)

Every VFR flight shall be so conducted that the aircraft is flown with visual reference to the surface by day and to identifiable objects by night and at no time above more than three eights of cloud within a radius of five nautical miles of such aircraft and –

(b) in the case of helicopters, under conditions of visibility and distance from cloud equal to, or greater than, those conditions specified in the following table: Provided that the limitations as contained in the above-mentioned table shall not prevent a helicopter from conducting hover-in-ground effect of hover-taxi operations if the visibility is not less than 100m.

Airspace	**Flight visibility**	**Distance from clouds**	**Ground visibility and ceiling**
Control zones	Two and a half km	Horizontally; 1000 feet, Vertically; Clear of cloud	No helicopter shall take off from, land at, or approach to land at an aerodrome or fly within the control zone when the ground visibility at the aerodrome is less

			than 2,5 km and the ceiling is less than 600 feet.

Airspace excluding control zones of aerodrome traffic zones or aerodrome traffic areas	**Flight visibility**	**Distance from clouds**	**Ground visibility and ceiling**
Above 1 500 feet above the surface, by day and night	Five km	Horizontally; 2000 feet, Vertically; 500 feet	-

1.18.5 Airworthiness Directive (AD) FAA 95-26-05

ROBINSON HELICOPTER COMPANY

Amendment: 39-9300

Docket No. No. 95-SW-25-AD

Applicability:

Model R44 helicopters, certificated in any category.

NOTE 1

This AD applies to each helicopter identified in the preceding applicability provision, regardless of whether it has been modified, altered, or repaired in the area subject to the requirements of this AD. For helicopters that have been modified, altered, or repaired so that the performance of the requirements of this AD is affected, the owner/operator must use the authority provided in paragraph (c) to request approval from the FAA. This approval may address either no action, if the current configuration eliminates the unsafe condition, or different actions necessary to address the unsafe condition described in this AD. Such a request should include an assessment of the effect of the changed configuration on the unsafe condition addressed by this AD. In no case does the presence of any modification, alteration, or repair remove any helicopter from the applicability of this AD.

Compliance: Required before further flight, unless accomplished previously.

NOTE 2

Compliance with this AD may be accomplished by completing the "Compliance Procedure" of Robinson Helicopter Company R44 Service Bulletin SB-6, dated May 23, 1995, and by incorporating into the Model R44 FAA-approved Rotorcraft Flight Manual the revised pages 2-7 and 2-12, both of which were approved by the FAA on May 19, 1995.

To prevent in-flight main rotor separation or contact between the main rotor blades and the airframe of the helicopter, and subsequent loss of control of the helicopter, accomplish the following:

(a) Insert the following information into SECTION 2, LIMITATIONS, of the Model R44 FAA-approved Rotorcraft Flight Manual:

FLIGHT AND MANEUVER LIMITATIONS

Low-G cyclic pushovers are prohibited.

PLACARDS

In clear view of the pilots:

LOW-G PUSHOVERS PROHIBITED

(b) Install a placard that contains the following statement in the helicopter in clear view of the pilots. The size and location of the placard must be such that it is easily readable by the pilots:

LOW-G PUSHOVERS PROHIBITED

NOTE 3

This placard may be produced locally.

(c) An alternative method of compliance or adjustment of the compliance time that provides an acceptable level of safety may be used when approved by the Manager, Los Angeles Aircraft Certification Office, FAA. Operators shall submit their requests through an FAA Principal Maintenance or Operations

Inspector, who may concur or comment and then send it to the Manager, Los Angeles Aircraft Certification Office.

NOTE 4

Information concerning the existence of approved alternative methods of compliance with this AD, if any, may be obtained from the Los Angeles Aircraft Certification Office.

(d) Special flight permits may be issued in accordance with sections 21.197 and 21.199 of the Federal Aviation Regulations (14 CFR 21.197 and 21.199) to operate the helicopter to a location where the requirements of this AD can be accomplished.

(e) This amendment becomes effective on July 14, 1995, to all persons except those persons to whom it was made immediately effective by Priority Letter AD 95-11-10, issued May 25, 1995, which contained the requirements of this amendment.

1.19 Useful or Effective Investigation Techniques:

1.19.1 None.

2. ANALYSIS

2.1 The two crew members that were on board the helicopter both held pilot's licences on aeroplanes as well as helicopters. The pilot-flying (under training) was receiving instruction towards his commercial helicopter pilot's licence in instrument flying. The pilot was the holder of a commercial aeroplane pilot's licence, with an instrument rating, which had lapsed on 24 July 2007. The flight instructor held a valid commercial helicopter pilot's licence at the time, including an instrument rating on helicopters, which was valid at the time of the accident flight.

2.2 The helicopter that was being utilized for the instrument training flight was not certified to fly in Instrument Meteorological Conditions (IMC). This was known by the Aviation Training Organisation (ATO) that utilized the helicopter for this type of training. All flying crew that therefore utilized this type of helicopter for IF training was aware of the fact that they were not allowed to enter into IMC conditions at any time and therefore had to remain clear of any cloud, and to maintain visual reference to the ground as stipulated in the regulations. The SACAA had granted ATOs the required authorisation to conduct IF training, by utilizing this type of helicopter, knowing that the certification limitations of the helicopter only allow for VFR (visual flight rules) flying.

2.3 It is a matter of concern that the flight instructor during a recent theoretical examination (helicopter flight instructor's examination) had to answer a question on mast bumping, which he answered correctly. Yet on the day (the accident flight) he allowed the pilot-flying to deviate from the certified flight profile (no visual reference to the ground) by allowing him to enter meteorological conditions that could be associated with unstable air/turbulence and possible limited visibility, conditions that were not conducive to VFR flying. Witnesses that observed the helicopter falling from the sky indicated that they could hear a helicopter fly but was unable to see it due to the overcast conditions that prevailed in the area at the time. A witness further stated that he heard a loud noise (bang), whereafter everything went silent and then the witness observed the wreckage falling through the clouds in a nose down attitude (out of control) towards the ground. The weather information indicates that it was cloudy in the area of the accident site, with an estimated cloud base of between 6000 to 7000 feet AGL. The helicopter was at a height (according to radar) of between 4 400 and 4 500 feet AGL when a sudden decay in speed was witnesses (on radar) whereafter the helicopter disappeared from the radar screen.

2.4 The pilot-flying at the time was wearing foggels (special glasses for IF flying), which limited his outside view/visibility and basically allowed him only to focus on the instrument panel in order to fly the helicopter. Not knowing what the actual weather conditions were like on the outside, he continued to fly the helicopter to the best of his ability.

2.5 It was not possible to obtain any evidence indicating that the pilot-flying was familiar with the low-G push over conditions and the recommended recovery technique as stipulated in the POH. It is believed that once the right roll commenced the pilot-flying did not follow the recommended procedure as stipulated in the POH, where it indicates that a gentle/gradual aft cyclic should be applied to reload/restore positive "G" forces and main rotor thrust. "Do not apply lateral cyclic until positive "G" forces have been established to stop the right roll." The POH further recommend that in the case where uncommanded pitch, roll and yaw result from turbulence, cyclic inputs should be minimized as it could result in over-control and such an area should be departed from immediately. If the turbulence prevails, the pilot should consider landing the helicopter as soon as practical.

2.6 It is believed that the pilot-flying at the time reacted to the right roll as he would have in an aeroplane, by immediately correcting the attitude (to wings level) of the aircraft/helicopter by applying left cyclic input. With no positive load on the main rotors, excessive blade flapping occurred and the main rotor blades made contact with the fuselage, resulting in the destruction of the left cockpit/cabin area and subsequent loss in control of the helicopter. It is believed that the sequence of events was sudden, which did not allow the flight instructor any time to take over control of the helicopter and recover from the condition they suddenly found themselves in. It should be noted that the cyclic design of the Robinson R44 is such that the position of the cyclic control handles for either side (pilot and co-pilot) is located on a T-bar with one pilot flying holding the cyclic handle and should control be transferred or the other pilot should take over control the T-bar (see picture below) needs to be tilted to the respective side for that pilot to take control of the helicopter. This design is totally unconventional when compared with most other helicopter types available on the market, where both crewmen will have his/her own cyclic stick to manipulate the controls, a design that allows for immediate control transfer or take-over from one pilot to the other.

Photo 9. The picture illustrates the T-bar design that functions like a see-saw.

3. CONCLUSION

a) Findings:

(i) The pilot-in-command was the holder of a valid commercial pilot's licence (helicopter) and had the aircraft type endorsed on his logbook.

(ii) The pilot-in-command was also the holder of a private pilot's licence (aeroplane).

(iii) The pilot-in-command on 9 May 2005 wrote a theoretical examination for his helicopter instructor's rating, where he correctly answered the question on mast bumping.

(iv) The pilot-in-command acted as the safety pilot and look-out pilot during this training flight.

(v) The pilot-flying was the holder of a valid private pilot's licence (helicopter).

(vi) The toxicology report did not identify any anomalies.

(vii) He had the Robinson R44 helicopter type endorsed on his private pilot licence, without him ever having flown a Robinson R44 prior to obtaining his private pilot license.

(viii) The first time that the pilot flew a Robinson R44 was on 2 August 2007. The conversion onto the helicopter type was not endorsed in his logbook.

(ix) The pilot-flying was also the holder of a commercial pilot's licence (aeroplane).

(x) The pilot-flying was wearing foggels (special glasses) used in IF training which limited his outside view/visibility.

(xi) The maintenance records indicated that the helicopter was maintained in accordance with the manufacturer's maintenance schedule.

(xii) Wreckage examination displays evidence of main rotor blade contact with the airframe (cockpit/cabin area) consistent with a low-G push over condition.

(xiii) The placard as called for in FAA AD 95-26-05 (Low-G pushovers prohibited) was displayed on the T-bar or cyclic control arm.

(xiv) Weather conditions in the area of the accident were reported to be overcast with the top of cloud estimated between 6 000 to 7 000 feet.

(xv) The flight was found not to be in accordance with the VFR requirements as stipulated in Part 91.06.21 of the CARs.

(xvi) The helicopter that was being utilized for the training flight was certified for VFR day and night operations only.

(xvii) The accident was considered to be a non-survivable accident.

b) Probable Cause/s:

(i) Incorrect recovery technique following a low-G push over condition in-flight, resulting in main rotor blade contact with the cockpit/cabin area, and subsequent loss of control.

c) Contributory Factor/s:

(i) Poor airmanship and lack of command/authority displayed by the flight instructor in order to avoid hazardous flying conditions that could be associated with low-G push over / mast bumping conditions.

(ii) Failure to operate the helicopter within its certified limitations, by not complying with VFR flight rules, even though this was an ‘IF training’ flight.

(iii) Flying into conditions associated with turbulence/unstable air, which would require control input by the pilot to maintain steady/level flight, without any stabilization system (autopilot) on board.

4. SAFETY RECOMMENDATIONS

4.1 The utilization of the Robinson R44 helicopter for IF (Instrument Flight) training should be reviewed, as it constitutes an aviation safety hazard, which has a direct effect on the safety of people and property.

The helicopter type in question should be regarded as unsuitable for the purpose for which it was utilized, due to the fact that it is an unstable platform aggravated by the fact that it is equipped with a teetering main rotor head assembly, which when exposed to certain flight conditions could cause a Low-G condition, (cyclic pushover, mast bumping phenomena) which can result in a catastrophic loss of lateral control, as was the case in this accident.

The certification regarding the Operating Limitations of the helicopter as reflected in the POH (Pilot's Operating Handbook) Section 2, Pg. 2-6 indicates it to be utilized during VFR day and night operations only.

It is therefore recommended that the SACAA Flight Operations Department responsible for Part 141 operations, stipulates the following requirements before such training should commence.

(i) An appropriately rated pilot should be on board each training flight, either a flight instructor or a safety pilot. That person should be the holder of a valid IF rating on helicopters.

(ii) All flights utilizing a non-IFR certified helicopter (including Robinson R44) should conduct such training flight under VFR conditions, and a VFR flight plan should be filed for such a flight.

(iii) An IFR certified helicopter should be utilized during IMC conditions. Proceeding into IMC conditions with low visibility with a non-IFR certified helicopter could result in a much faster pitch and roll rates than in airplanes, which could cause the pilot to become disorientated, accompanied by incorrect control inputs and an uncontrolled crash.

NOTE: This safety recommendation was drafted in memo format and was submitted to the Commissioner for Civil Aviation for review (possible corrective action) within 30 days following this accident.

4.2 It is recommended that the SACAA Airworthiness Department implement a procedure to ensure that a number of photos of each and every aircraft/helicopter that are being registered on the South African Register, be placed on the SACAA aircraft file. A copy of the instrument panel layout should form part of this requirement. Aircraft are constantly being upgraded or modified, retro fitted and resprayed, which require changes to certain essential equipment on board such an aircraft. This recommendation is issued to assist Aircraft Accident Investigators in the process of accident investigation as similar aircraft types may have substantial different cockpit layouts and flight instrumentation layouts, which could be problematic during the accident investigations process, at it requires additional research, which is time- consuming and avoidable with proper record-keeping.

4.3 It is recommended that the SACAA Airworthiness Department (Part 127) engage in a campaign to ensure that all Robinson R44 helicopters on the SA Register comply with FAA AD 95-26-05. It is recommended that should a physical inspection of such a helicopter not be possible by a SACAA inspectors, the owner of such a helicopter would be required to provide proof to the SACAA, consisting of a statement and a photo indicating that such a placard had been installed accordingly. The required amendment to the POH should also be complied with.

5. APPENDICES

5.1 There are no appendices attached to this report.

Report reviewed and amended by Advisory Safety Panel: 25 August 2009.

-END-