SOUTH AFRICAN CIVIL AVIATION AUTHORITY

Section/division **Accident and Incident Investigations Division** Form Number: CA 12-12c

HELICOPTER ACCIDENT REPORT AND EXECUTIVE SUMMARY

				Reference:	CA18/2/3/9714
Aircraft Registration	**ZS-MZS**	**Date of Accident**	1 June 2018	**Time of Accident**	0940Z
Type of Aircraft	Robinson R44 Raven II		**Type of Operation**	Private (Part 91)	

Pilot-in-command Licence Type	Private Pilot (Helicopter)	**Age**	36	**Licence Valid**	Yes
Pilot-in-command Flying Experience	Total Flying Hours	±406.8		Hours on Type	±68.6

Last point of Departure	Rustenburg Aerodrome (FARG), North West Province
Next Point of Intended Landing	Zebula Golf Estate & Spa Aerodrome, Limpopo Province

Location of the accident site with reference to easily defined geographical points (GPS readings if possible)

Lumarie Game Farm, 8 nautical miles south-west of Zebula Golf Estate & Spa Aerodrome at GPS co-ordinates S24°52'07.71" E027°52'27.97" at an elevation of 3 920ft

Meteorological Information	Wind: 280°/10 kts, visibility: >10km, temperature: 21°C, dew point: 15°C				
Number of People On Board	1 + 1	**No. of People Injured**	0	**No. of People Killed**	2

Synopsis

The pilot and a passenger took off on a private flight from Rustenburg Aerodrome (FARG) with the intention to land at Zebula Golf Estate & Spa Aerodrome for a game of golf.

According to the two eyewitnesses who were near the farm gate, the helicopter approached from a southerly direction. A few minutes before the accident, the helicopter was observed hovering at a very low height above Quinta Domingo Farm gate, which is approximately 187 metres (m) from the accident site. Both eyewitnesses stated that the helicopter started moving forward, reducing height while making a left bank for approximately 100m before it rolled to the left and crashed on Lumarie Game Farm in a nose-down attitude. One of the eyewitnesses ran towards the fence to try to assist the occupants but was restricted by the electric fence. The other eyewitness alerted the police about the accident.

Both occupants were fatally injured and the helicopter was destroyed but there was no pre- or post-impact fire.

It is possible that there was a debonding of the blade skin(s) from one of the main blade spars during flight. This would have resulted in alteration of the aerofoil profile, loss of effectiveness (lift) and severe destabilisation of the main rotor (MR) blade; however, this possibility could not be conclusively proven.

It is probable that during forward movement, the helicopter entered a transverse flow effect which resulted in the helicopter rolling to the right. To correct the roll, the pilot moved the cyclic control to the left but he over compensated, resulting in the loss of control and the subsequent crash.

SRP Date	13 August 2019	Release Date	28 August 2019

ABBREVIATION	DESCRIPTION
AD	Airworthiness Directive
AGL	Above Ground Level
AIID	Accident and Incident Investigation Division
AMO	Aircraft Maintenance Organisation
AOA	Angle of Attack
CARs	Civil Aviation Regulations
CoA	Certificate of Airworthiness
CoR	Certificate of Registry
CVR	Cockpit Voice Recorder
°C	Degrees Celsius
ETL	Effective Translational Lift
ft	Feet
FARG	Rustenburg Aerodrome
FEW	Few (2-3 octas)
FDR	Flight Data Recorder
GPS	Global Positioning System
HRV	Heat Recovery Ventilation
kts	Knots
lbs	Pounds
MPI	Mandatory Periodic Inspection
MR	Main Rotor
MHz	Megahertz
m	Metre(s)
nm	Nautical Mile
POH	Pilots Operating Handbook
PPL	Private Pilot Licence
RoD	Rate of Descent
rpm	Revolution per Minute
SACAA	South African Civil Aviation Authority
SAWS	South African Weather Services
SCT	Scattered (5-7 octas)
UTC	Coordinated Universal Time
VHF	Very High Frequency
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions

Name of Owner/Operator	**:** Marico Hill Game Lodge (Pty) Ltd
Manufacturer	**:** Robinson Helicopter Company
Model	**:** R44 Raven II
Nationality	**:** South African
Registration Marks	**:** ZS-MZS
Place	**:** Lumarie Game Farm at GPS coordinates 24˚52´07.71˝ S; 027˚52´27.97˝ E
Date	**:** 1 June 2018
Time	**:** 0940Z

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 (2011), 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 apportion blame or liability.***

Investigations process:

The accident was notified to the Accident and Incident Investigation Division (AIID) on 1 June 2018 at about 1005Z. The investigator/s went to Bela-Bela, Limpopo, on 1 June 2018. The investigator/s coordinated with all authorities on site by initiating the accident investigation process according to Civil Aviation Regulations (CAR) Part 12 and investigation procedures. The AIID of the South African Civil Aviation Authority (SACAA) is leading the investigation as the Republic of South Africa is the State of Occurrence.

Notes:
1. Whenever the following words are mentioned in this Report, they shall mean the following:
Accident — this investigated accident
Helicopter — the Robinson R44 involved in this accident
Investigation — the investigation into the circumstances of this accident
Pilot — the pilot involved in this accident
Report — this accident report

2. Photos and figures used in this report are taken from different sources and may be adjusted from the original for the sole purpose of improving the clarity of the report. Modifications to images used in this report are limited to cropping, magnification, file compression; or enhancement of colour, brightness, contrast; or addition of text boxes, arrows or lines.

Disclaimer:

This report is produced without prejudice to the rights of the SACAA, which are reserved.

1. FACTUAL INFORMATION

1.1 History of Flight

1.1.1 On 1 June 2018, the pilot and a passenger took off on a private flight from Rustenburg Aerodrome (FARG) at approximately 0900Z, with the intention to land at Zebula Golf Estate & Spa Aerodrome for a game of golf. The flight was conducted under visual flight rules (VFR) by day.

1.1.2 According to the two eyewitnesses near the accident site who were sitting in a car at the Quinta Domingo Farm gate, the helicopter approached from a southerly direction towards Zebula Golf Estate & Spa Aerodrome. The two witnesses stated that they had stopped at the gate to wait for the helicopter to fly overhead their car, but the helicopter started hovering overhead the gate. One of the witnesses stated that he exited the car for a clearer visual and saw that it was hovering at a low height of less than 150 feet (ft.) above ground level (AGL). Both eyewitnesses stated that after a few minutes, the helicopter started moving forward while losing height and it made a left turn. The helicopter crashed in a nose-dive attitude on Lumarie Game Farm, approximately 187m from where the eyewitnesses were positioned.

1.1.3 The eyewitness who was standing outside the car stated that he ran towards the fence to try to assist the occupants, but an electric fence restricted access to the accident site. Both occupants were fatally injured and the helicopter was destroyed. There was no pre- or-post impact fire.

1.1.4 The accident occurred at approximately 0940Z during daylight conditions, at a geographical position determined to be S24°52'07.71" E027°52'27.97" and at an elevation of 3 920ft.

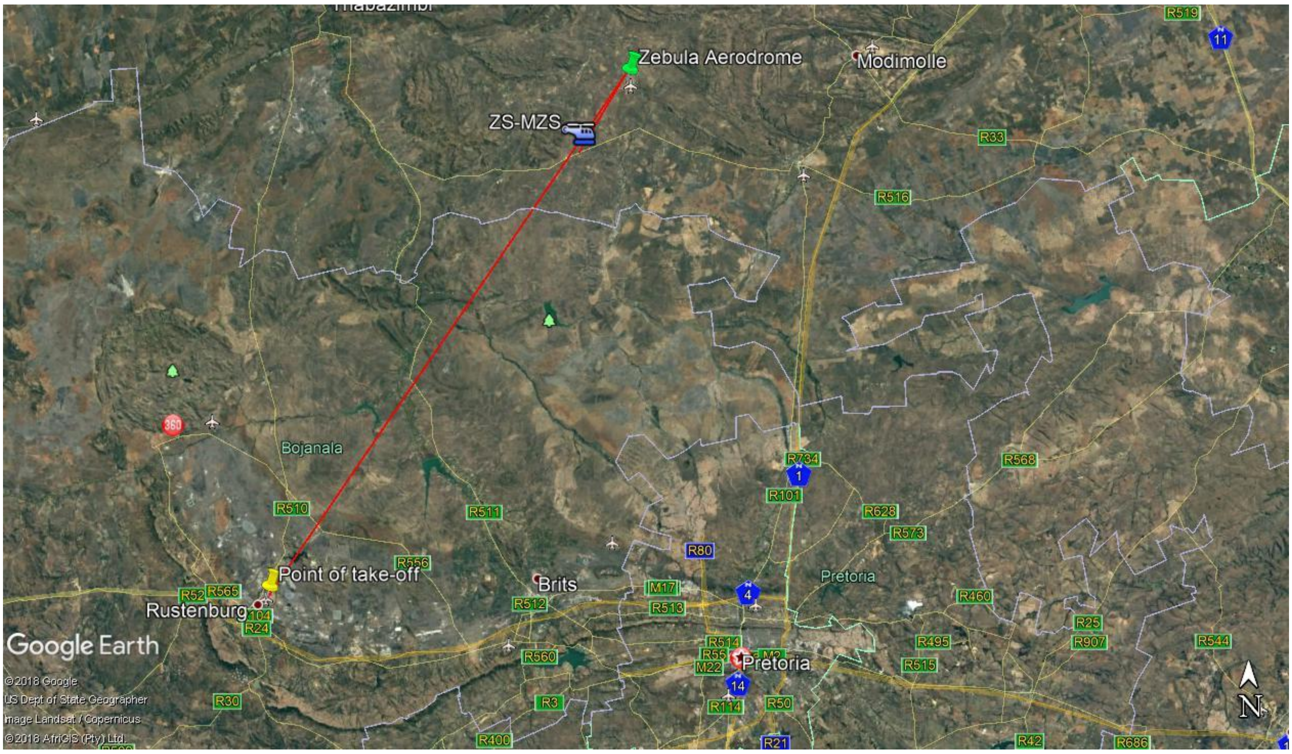

Figure 1: Google Earth map showing the accident site and route taken.

1.2 Injuries to Persons

Injuries	Pilot	Crew	Pass.	Other
Fatal	1	-	1	-
Serious	-	-	-	-
Minor	-	-	-	-
None	-	-	-	-

1.3 Damage to Helicopter

1.3.1 The helicopter was destroyed during the accident sequence.

Figure 2: The main wreckage as found on site.

1.4 Other Damage

1.4.1 A perimeter fence was damaged by the main rotor (MR) blade that separated during the accident sequence.

Figure 3: Damage to the steel rod and fence.

1.5 Personnel Information

Pilot-in-command:

Nationality	South African	Gender	Male	Age	36
Licence Number	***************	Licence Type	Private Pilot Licence		
Licence valid	Yes	Type Endorsed	Yes		
Ratings	None				
Medical Expiry Date	31 July 2019				
Restrictions	None				
Previous Accidents	None				

1.5.1 The following information was obtained from the pilot's documents (South African Civil Aviation Authority [SACAA] pilot's file and the pilot's helicopter instructor):

a) On 10 November 2015, the pilot reported that he lost his logbook in October 2014. At the time, the pilot had a total of 338.2 hours on fixed-wing aircraft. There was no information available between December 2015 and February 2017.

b) The pilot started his helicopter training in March 2017. He obtained his helicopter Private Pilot Licence (PPL) on 8 November 2017. During his helicopter training, the pilot only flew Robinson R44s, and had accumulated a total of 68.6 hours at the time of the accident.

Flying Experience:

Total Hours	406.8
Total Past 90 Days	10.1
Total on Type Past 90 Days	10.1
Total on Type	68.6

1.6 Aircraft Information

Airframe:

Type	Robinson Raven II	
Serial Number	12180	
Manufacturer	Robinson Helicopter Company	
Date of Manufacture	20 February 2008	
Total Airframe Hours (At time of Accident)	653.6	
Last MPI (Date & Hours)	8 September 2017	576.7
Hours since Last MPI	76.9	
C of A (Issue Date)	29 November 2011	
C of A (Expiry Date)	30 November 2018	
C of R (Issue Date) (Present owner)	8 May 2018	
Operating Categories	Standard normal category	

1.6.1 The R44 Raven II is a four-place, single main rotor, and single engine helicopter constructed primarily of metal and equipped with skid type landing gear. The primary fuselage is a welded steel tubing and riveted aluminium sheet. It has an enclosed cabin with two rows of side-by-side seating for a pilot and three passengers. Tail rotor direction of rotation on the Robinson R44 is reversed compared to the R22 for improved yaw control authority. On the Robinson R44, the advancing blade is on the bottom. The helicopter is certified for a single pilot operation. It has two doors. The helicopter has a total fuelling capacity of around 47.7 U.S. gallons (Tanks with Bladders) and the usable fuel is 46.5 gallons.

1.6.2 According to the airframe logbook, in April 2008, the helicopter had a hard landing incident due to engine power loss because of fuel contamination (incorrect fuel type used). The helicopter had flown a total of 12.7 hours since new at the time of that incident. The MR gearbox and tail rotor gearbox and their blades were replaced on 13 March 2009 after the hard landing incident. The P/N of the MR blades fitted was C016-5 and they were due for replacement with P/N C016-7 on 3 March 2021. The MR blades accrued a total of 653.6 flying hours and a calendar of 10 years.

1.6.3 An Airworthiness Directive (AD) 2011-12-10 was released in 2012. The AD required inspection of each blade at the skin-to-spar line for debonding, corrosion, separation, a gap or dents, and replacement of any damaged blade with an airworthy blade. The accident helicopter complied with the AD inspections from 22 August 2012 until 24 July 2015.

1.6.4 On 9 January 2015, AD 2014-23-16 was released and it superseded AD 2011-12-10. AD 2014-23-16 required replacement of MR blades P/Ns C016-2 or C016-5 with P/N C016-7 within five years of issuing of the AD or before the year 2022. If the blades are not replaced, the requirements are an inspection for delamination and any exposed (bare metal) skin-to-spar joint area on the lower surface of each blade before every first flight of each day. This inspection may be performed by the owner/operator or a pilot holding at least a private pilot certificate; and it must be entered in the aircraft flight folio to show compliance with this AD. According to the airframe logbook entry, the AD was only complied with by the aircraft maintenance organisation (AMO) on 8 September 2017. There was no evidence of every first flight of the day compliance in the aircraft flight folio and airframe logbook.

1.6.5 Weight and Balance

		LONGITUDINAL		LATERAL	
	WEIGHT	ARM	MOMENT	ARM	MOMENT
BASIC EMPTY MASS	1566,4	107.6	168519.6	0	0
REMOVE FRONT RIGHT DOOR	0	49,4	-371	24	0
REMOVE FRONT LEFT DOOR	0	49,4	-371	-24	0
REMOVE BACK RIGHT DOOR	0	75,4	-403	23	-161
REMOVE BACK LEFT DOOR	0	75,4	-403	-23	161
PILOT	180	49,5	8910	12,2	2196
FRONT PAX	180	49,5	8910	-10,4	-1872
PILOT BAGGAGE	25	44	1100	11,5	287,5
FRONT PAX BAGGAGE	25	44	1100	-11,5	-287,5
REAR LEFT PAX & BAGGAGE	80	79,5	6360	-12,2	-976
REAR RIGHT PAX & BAGGAGE		79,5	0	12,2	0
ZERO FUEL MASS	2056,4	12,8	26380	-0,2	-328
MAIN TANK FUEL	132,8	106	14076,8	-13,5	-1792,8
AUX TANK FUEL	76,5	102	7803	13	994,5
TAKE OFF MASS	2265,7	21,3	48259,8	-0,5	-1126,3
MAIN TANK FUEL	54	106	5724	-13,5	-729
AUX TANK FUEL	0	102	0	13	0
LANDING MASS	2110,4	15,2	32104	-0,5	-1057

- According to the Robinson R44 Pilot Operating Handbook (POH), the helicopter's maximum take-off weight is 2500 pounds (lbs). The accident helicopter's estimated weight was 2110.4 lbs which was within limits.

- According to density altitude charts at a temperature of 21°C and the pressure altitude of 8200ft, the density altitude was determined to be 11000ft. It did not exceed the limit which is 14000ft.

Engine:

Type	Textron Lycoming IO-540-AE1A5
Serial Number	L-32638-48E
Hours since New	576.7
Hours since Overhaul	Not yet reached

Main Rotor Gearbox:

Type	C006-5
Serial Number	1097
Hours Since New	564.2
Hours since Overhaul	Not yet reached

Main Rotor Blades:

Type	C016-5
Serial Numbers	5688 & 5699
Hours since New	564.2
Hours since Overhaul	Not yet reached

Tail Rotor Gearbox:

Type	C021-1
Serial Number	1097
Hours since New	564.2
Hours since Overhaul	Not yet reached

Tail Rotor Blades:

Type	C029-2
Serial Numbers	7597 & 7630
Hours since New	564.2
Hours since Overhaul	Not yet reached

Fuel:

- On 1 June 2018, the helicopter was re-fuelled with 124.13 litres of Aviation Gasoline (Avgas). Fuel consumption per hour for a Robinson R44 Raven II is 56.78 litres. The flight to Zebula Game Estate & Spa Aerodrome was going to take approximately 45 minutes, therefore, the helicopter had sufficient amount of fuel for the flight.

- On arrival at the accident site, both the main tank and auxiliary tank had separated from the airframe as a result of impact sequence. Both tanks were ruptured; however, there was evidence of spilled fuel on the ground.

1.7 Meteorological Information

1.7.1 The following meteorological information was obtained from the South African Weather Service official report using Rustenburg as reference.

Wind direction	300°	Wind speed	3kts	Visibility	>10km
Temperature	18°C	Cloud cover	Nil	Cloud base	N/A
Dew point	12°C				

Figure 4 is the Heat Recovery Ventilation (HRV) satellite image as at 0930Z, 10 minutes before the accident. It attests to the clear weather conditions at the accident location at the approximate time of the accident, notwithstanding banks of clouds to the south extending to Rustenburg.

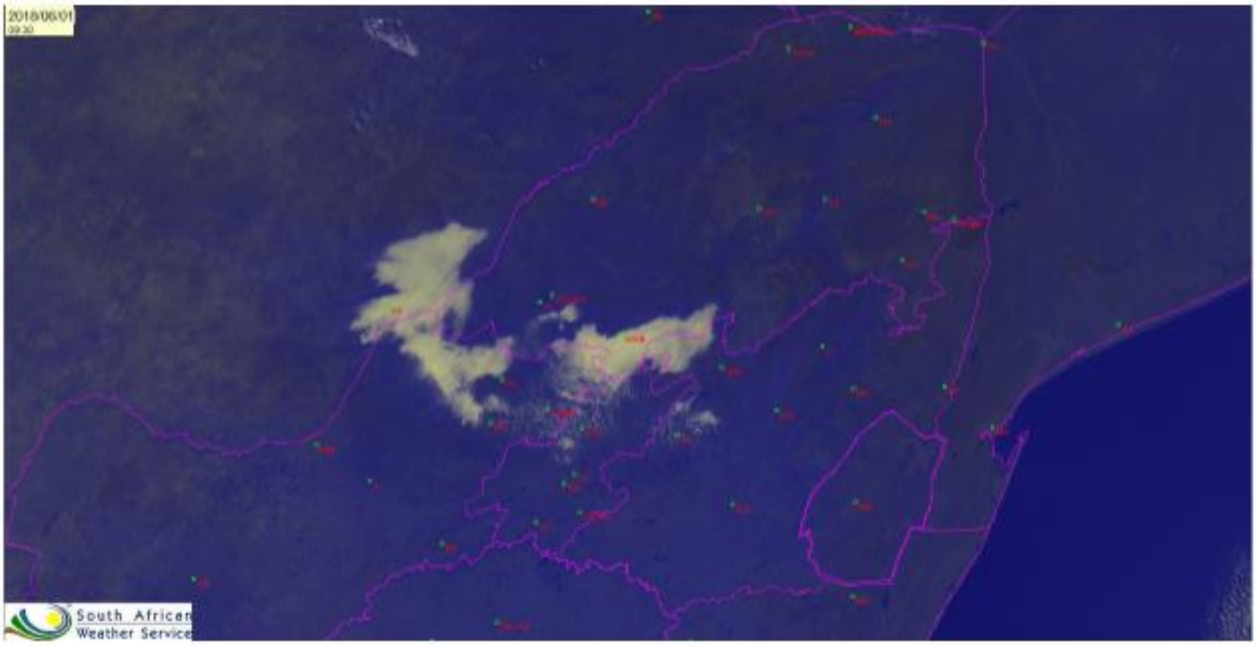

Figure 4: HRV cloud enhance satellite image at 0930Z on 1 June 2018.

A loop of satellite images from 0900Z to 1000Z clearly indicate the rapid clearance of this low-level cloud such that by 0945Z, just 5 minutes after the accident, the accident location shows no presence of cloud or any other significant weather (Figure 5).

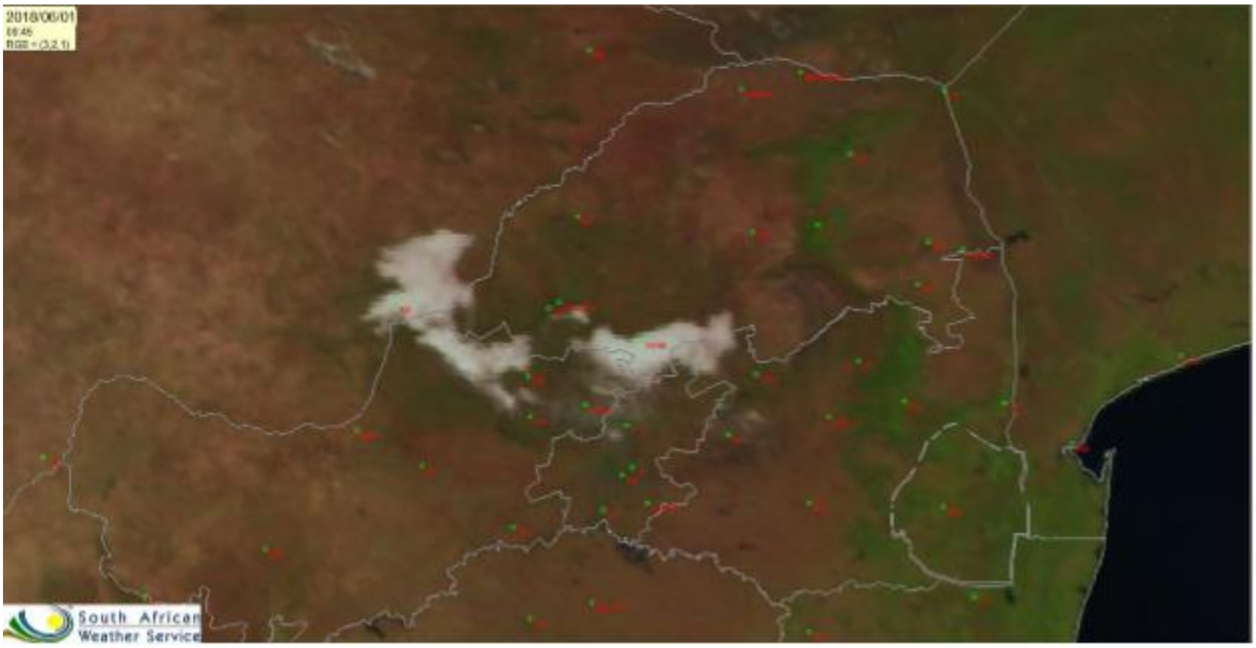

Figure 5: Day natural colour satellite image at 0945Z on 1 June 2018, showing dissipating stratus clouds.

By 1000Z, only FEW to SCT clouds could be observed to the south of the accident location.

1.8 Aids to Navigation

1.8.1 The helicopter was equipped with standard navigational equipment as approved by the Regulator (SACAA) for the aircraft type. There were no defects reported with the navigational equipment prior to the flight.

1.9 Communication

1.9.1 The helicopter was equipped with standard communication equipment as approved by the Regulator (SACAA) for the aircraft type. There were no defects reported with the communication equipment prior to the flight. The helicopter took off from an unmanned airfield; the communication frequency in the unmanned airspace is 122.4 Megahertz (MHz).

1.10 Aerodrome Information

1.10.1 The accident did not occur at an aerodrome. The accident occurred approximately 8 nautical miles (nm) south-west of Zebula Golf Estate & Spa Aerodrome, at a geographical position determined to be S24°52'07.71" E027°52'27.97" and an elevation of 3 904ft.

1.11 Flight Recorders

1.11.1 The helicopter was not equipped with a flight data recorder (FDR) or a cockpit voice recorder (CVR), and not any of these recorders were required by the relevant aviation regulations.

1.12 Wreckage and Impact Information

1.12.1 The helicopter crashed in Lumarie Game Farm, about 187m from the position of the eyewitnesses. According to the fuselage position and damages, it is evident that the helicopter impacted the ground with the right-hand side of the cabin and then bounced to the left-hand side before coming to rest in an upright position, facing south. This also resulted in both the left and the right skip separating from the fuselage.

Figure 6: The final position of the helicopter after the accident.

1.12.2 The main wreckage contained the main fuselage, flight deck, mast, tail boom and engine. The wreckage displayed severe damage from a high-energy vertical impact. The main gearbox and the mast were still attached to the main wreckage and were resting on its right-hand side. The main gearbox attachment points were found separated from the frame as a result of impact forces. One of the rubber stops was crushed, indicative of mast bumping during impact sequence. The main gearbox housing was cracked at the bottom, indicative of internal components that came into contact with a housing due to high rate of descent (RoD). All three hydraulic servo actuators were still attached to the main gearbox. The outside condition was good and there were no visible signs of leaks which might have occurred prior to impact.

Figure 7: Wreckage distribution.

Figure 8: Right view of the main wreckage.

1.12.3 The directions of fracture at the cross-tube or strut assembly and skid connection points indicated that impact loads were in upward and aft directions. As depicted by the picture below, the skid gear damages indicate that the helicopter impacted with the ground at high RoD. The skid gear broke off from the cross section and was found on the right-hand side of the main wreckage.

Figure 9: Left- and right-hand skids.

1.12.4 Both eyewitnesses stated that the helicopter moved forward for approximately 100m and then turned left in a nosedive attitude. One of the helicopter MR blades impacted a tree stem and the other blade was fragmented into pieces and was scattered a few metres around the main wreckage. The less damaged blade was found resting on the farm perimeter fence. It could not be confirmed which of the two blades impacted the tree. The front tip and the main spar of the destroyed blade could not be found at the accident site and the blade root was still attached to the main rotor hub.

Figure 10: Image shows the split tree and a MR blade root cover.

1.12.5 The separated MR blade was found approximately 63m away from the main wreckage. The other small piece of the complete blade was found next to the tree which was approximately 10m away from the main wreckage.

Figure 11: Shows the blade root still attached to the main rotor hub

1.12.6 This MR blade had significant compression loads on the top surface for the entire length, which suggests impact with object while not turning at full revolutions per minute (rpm). The damage found approximately 1m on the inner surface of the MR blade was consistent with impact by the blade.

Figure 12: The MR blade as found at the accident site.

Figure 13: Left view of the main wreckage.

1.12.7 Components of the engine were scattered in different directions. The upper sheath broke off from the drive shaft, indicative of sudden stoppage damage on a rotating component. The lower sheath was found 3m from the main wreckage and having rotational impact marks on the surface. The upper bearing was still intact in the middle shaft and was turning freely. The middle shaft was fractured due to impact forces. The outer flexible coupling was broken at two attachment points while the inner flexible coupling broke off in all attachment points. The last flexile coupling was still intact with the tail gearbox input shaft.


Figures 14 & 15: Images show damage to the engine and drive train.

1.12.8 The tail gearbox was still intact, had freedom of movement and did not reveal any signs of overheating. One of the tail rotor blades revealed signs of high rotation impact with the ground and it sheared off from the root as seen in Figures 16 and 17. The tail fin and horizontal stabiliser had impact compression loads, indicative of contacting the ground. The tail rotor guard was crushed and flattened, indicative of high RoD.


Figure 16 & 17: Images show broken tail rotor blade and a damaged horizontal stabiliser.

1.12.9 The position of the hydraulic switch was found in an off position after the accident. It is possible that it might have been moved during the recovery process.

Figure 18: Shows a hydraulic switch

1.12.10 Note: Hydraulic system failure.

Source: Robinson R44 POH

- Hydraulic system failure is indicated by heavy or stiff cyclic and collective controls. Loss of hydraulic fluid may cause intermittent and/or vibrating feedback in the controls. Control will be normal except for the increase in stick forces.
  1. HYD Switch – verify ON.
  2. If hydraulics not restored, HYD Switch – OFF.
  3. Adjust airspeed and flight condition as desired for comfortable control.
  4. Land as soon as practical.

1.13 Medical and Pathological Information

1.13.1 The medico-legal post mortem report indicate that both the pilot and the passenger died because of multiple blunt force injuries sustained during impact.

1.14 Fire

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

1.15 Survival Aspects

1.15.1 The accident was considered not survivable due to the impact damage sustained by the helicopter on the cabin and cockpit which caused fatal injuries to both occupants. Both occupants were wearing their safety harnesses and none of the safety harnesses failed.

1.16 Tests and Research

1.16.1 On 20 June 2018, Failure Analysis & Investigation Laboratory/CrashLab was requested to assist with investigation of the MR blades (P/N C016-5) and engine serial number L-32638-48E for a possible cause of blade failure and/or engine failure. Engine inspection did not reveal any abnormalities. The report revealed that there was a possibility of MR blade delamination, however, it could not confirm beyond reasonable doubt. (See full MR blades report in Appendix 2)

1.16.2 Transverse Flow Effect

As the helicopter accelerates in forward flight, induced flow drops to near zero at the forward disk area and increases at the aft disk area. These differences in lift between the fore and aft portions of the rotor disk are called transverse flow effect. This increases the angle of attack (AOA) at the front disk area causing the rotor blade to flap up, and reduces the AOA at the aft disk area causing the rotor blade to flap down. Because the rotor acts like a gyro, maximum displacement occurs 90° in the direction of rotation. The result is a tendency for the helicopter to roll slightly to the right as it accelerates through approximately 20 knots or if the headwind is approximately 20 knots. Transverse flow effect is recognised by increased vibrations of the helicopter at airspeeds just below effective translational lift (ETL) on take-off and after passing through ETL during landing. To counteract transverse flow effect, a cyclic input to the left may be needed. Source: *Helicopter Flying Handbook, FAA-H-8083-21A*

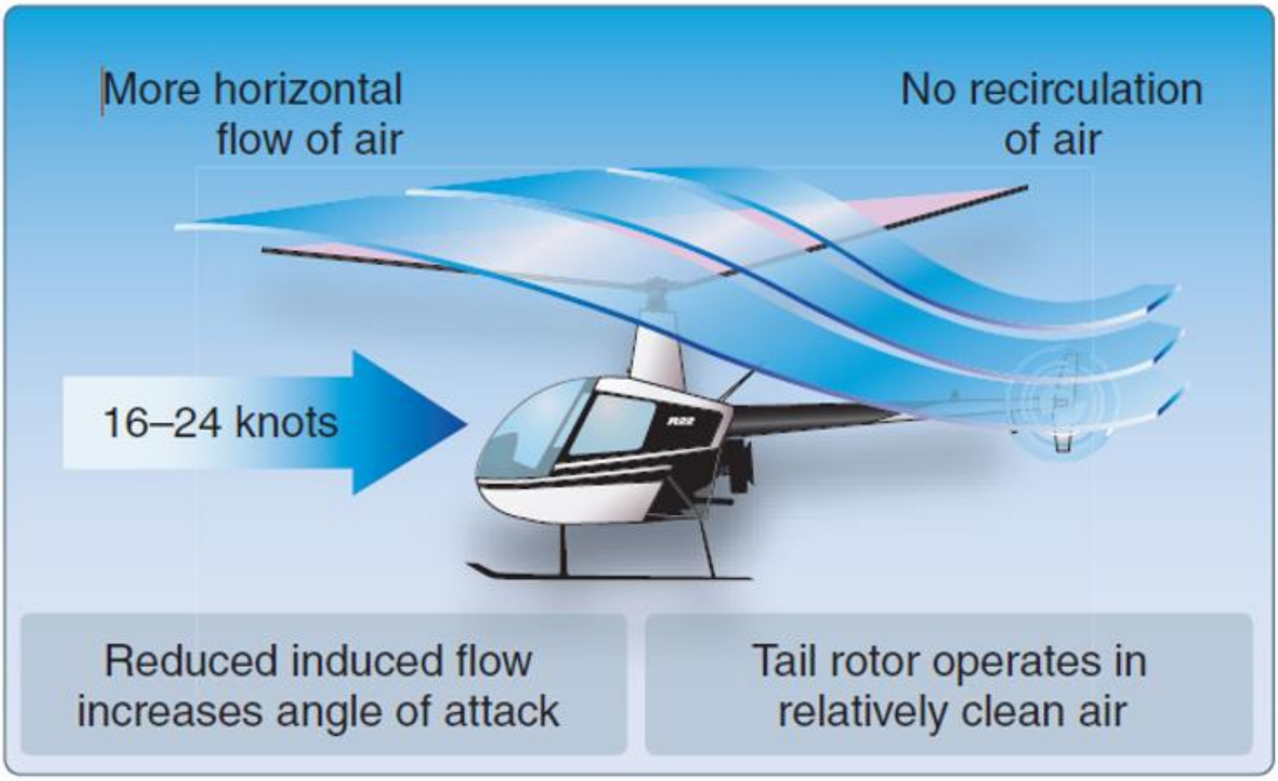

Figure 19: Shows an effective translation lift is easily recognized in actual flight by transient Induced aerodynamic vibrations and increased performance of the helicopter.

1.17 Organisational and Management Information

1.17.1 This was a private flight conducted under the provisions in Part 91 of the Civil Aviation Regulations of 2011.

1.18 Additional Information

1.18.1 None.

1.19 Useful or Effective Investigation Techniques

1.19.1 None.

2. ANALYSIS

2.1. General

From the evidence available, the following analysis was made with respect to this accident. These shall not be read as apportioning blame or liability to any particular organisation or individual.

2.2. Analysis

2.2.1 The pilot was qualified and rated on the helicopter. His last skills test was carried out on 8 November 2017 and he was found competent.

2.2.2 The last mandatory periodic inspection (MPI) had been certified on 8 September 2017 by an approved AMO at 576.7 total hours. The helicopter had a total of 653.6 hours at the time of the accident. The helicopter had flown 76.9 hours since the last MPI.

2.2.3 After the accident, both the main rotor blades were recovered and subjected to examination and metallurgical test at an approved laboratory. Investigation pointed towards a possible debonding of the blade skin(s) from one of the main blade spars during flight. This would have resulted in alteration of the aerofoil profile, loss of effectiveness (lift) and severe destabilisation of the MR blade; however, this possibility could not be conclusively proven.

2.2.4 The two eyewitnesses observed the helicopter approaching from a southerly direction. One of the eyewitnesses stated that he got out of the car to observe the helicopter and saw it hovering at a very low height of less than 150ft AGL. He further stated that the helicopter moved forward for approximately 100m and rolled to the left before impacting terrain.

2.2.5 It is probable that during forward movement, the helicopter entered a transverse flow effect which resulted in the helicopter rolling to the right. To correct the roll, the pilot moved the cyclic control to the left but he over compensated, resulting in the loss of control and the subsequent crash.

2.2.6 The hydraulic switch was found in an off position after recovery of the helicopter. If the switch had been off during flight, it would have been difficult to operate the helicopter and the pilot would have landed on the road. It is unlikely that the pilot moved the hydraulic switch to the off position.

2.2.7 The weather on the day of the accident did not contribute to the cause of this accident.

3. CONCLUSION

3.1. General

From the evidence available, the following findings, causes and contributing factors were made with respect to this accident. These shall not be read as apportioning blame or liability to any particular organisation or individual.

To serve the objective of this investigation, the following sections are included in the conclusions heading:

- Findings – are statements of all significant conditions, events or circumstances in this Accident. The findings are significant steps in this Accident sequence but they are not always causal or indicate deficiencies.
- Causes – are actions, omissions, events, conditions, or a combination thereof, which led to this Accident.
- Contributing factors – are actions, omissions, events, conditions, or a combination thereof, which, if eliminated, avoided or absent, would have reduced the probability of the accident or incident occurring, or mitigated the severity of the consequences of the accident or incident. The identification of contributing factors does not imply the assignment of fault or the determination of administrative, civil or criminal liability

3.2 Findings

3.2.1 The pilot was issued with a PPL on 8 November 2017, with an expiry date of 30 November 2018. His aviation medical certificate was issued on 4 July 2017, with an expiry date of 31 July 2019 with no restrictions. His last skills test was carried out on 8 November 2017.

3.2.2 The helicopter was issued with a certificate of airworthiness (CoA) on 29 November 2011, with an expiry date of 30 November 2018. Its certification of registration (CoR) was issued on 8 May 2018.

3.2.3 The last MPI had been carried out on 8 September 2017 by an approved AMO and the helicopter had flown a further 76.9 hours until the accident. It was issued with a certificate of release to service on 8 September 2017 with an expiry date of 7 September 2018 or at 676.7 hours, whichever occurs first.

3.2.4 The helicopter was operated as a private flight conducted under visual meteorological conditions (VMC) by day.

3.2.5 Both the helicopter's MR blades were subjected to metallurgical inspection. Investigation pointed towards a possible debonding of the blade skin(s) from one of the main blade spars during flight. This would have resulted in alteration of the aerofoil profile, loss of effectiveness (lift) and severe destabilisation of the MR. This probability, however, could not be conclusively proven.

3.2.6 It is probable that during forward movement, the helicopter entered a transverse flow effect which resulted in the helicopter rolling to the right. To correct the roll, the pilot moved the cyclic control to the left but he over compensated, resulting in the loss of control and the subsequent crash.

3.2.7 The weather on the day of the accident did not contribute to the cause of this accident.

3.2.8 The helicopter was destroyed and both occupants were fatally injured during the accident sequence.

3.3 Probable Cause/s

3.3.1 The helicopter entered a transverse flow effect during forward movement, and in an effort to recover the aircraft, the pilot lost control, resulting in a crash.

4. SAFETY RECOMMENDATIONS

4.1 General

The safety recommendations listed in this report are proposed according to paragraph 6.8 of Annex 13 to the Convention on International Civil Aviation and are based on the conclusions listed in heading 3 of this report; the AIID expects that all safety issues identified by the investigation are addressed by the receiving States and organisations.

4.1.1 It is recommended that the SACAA, through the relevant division(s), ensures that all operators of Robinson R44 and R22 helicopters comply with AD 2014-23-16, which must be carried out strictly before every first flight of the day. In addition, the inspection must be entered into the aircraft records to show compliance.

4.1.2 It is also recommended that operators who are still flying helicopters fitted with MR blades P/N C016-5 include the daily inspection on their checklist until such blades are replaced.

5. APPENDICES

5.1 Appendix 1 – SAWS report
5.2 Appendix 2 – Metallurgical report
5.3 Appendix 3 – FAA Airworthiness Directive AD 2014-23-16

5.1 Appendix 1 - South African Weather Service official report

In FAER the winds were even lighter at just 2kt from south-west, with a dry atmosphere.

```
FAER 010900Z AUTO 22002KT //// // ////// 22/11 Q1021=
FAER 011000Z AUTO 26002KT //// // ////// 25/11 Q1020=
```

NO any other significant weather can be discerned from these surface observation over Rustenburg, Ellisrus and Pilanesburg observation stations.

(iii) Synoptic Analysis

On this day a large cold front was moving along the south west coast and adjacent interior. Stable weather conditions were prevailing over the larger part of South Africa in the central, north and eastern parts. Zonal upper level circulation and a dominating high pressure system in the north-east resulted in mostly cloud free conditions except stratus clouds over the area of interest in the morning, but this cloud also dissipated as the day progressed as indicated by satellite image figure 8. Offshore winds along the east coast guaranteed clear weather.

(iv) Model Analysis

The air profile extending from ground level to 2000ft over the accident area showed no presence of any significant weather (Figure 9). Winds were light north-westerly's (5kt), with no moisture or possible turbulence. This is well in agreement with the satellite observations and METARs. The only marked change in wind occurs at least at 10 000ft, where winds became south-westerly's at 30kt. And typically, a jet stream was present at 35000ft, with no impact on surface weather conditions.

(v) Significant Weather Chart

The significant weather chart valid for 0900Z (Figure 10) indicate the forecasted presence of broken low-level stratus clouds and reduced visibility of 3000m in mist over the area, including the location of accident. As attested by the satellite images, these conditions had cleared by 0930Z leading up to the time of accident and beyond. Subsequent chart valid from 1200Z and there on showed clear skies and no significant over the area of accident.

(vi) Conclusions

In the absence of low level cloud or any clouds at all over the area closest to the time of accident, it is unlikely that weather was responsible for the accident. Low level stratus clouds and possible fog/mist were prevalent over the general region in the preceding times up to 0900Z, where rapid clearance occurred. As at 0945Z there is no indication of the low clouds over the area. No any other significant weather is evident in surface observations and model data. Furthermore, no forecast product anticipated bad weather at the time of accident.

FINAL WORDS ON THE INFLUENCE OF THE WEATHER ON THIS ACCIDENT

In my analysis of available data, actual and model, I have found no significant weather or hazard over the area and at time of accident.

ATTACHMENTS

Figure 1: Day Natural Colours satellite image at 0900Z on 01 June 2018 showing areas of low level stratus clouds. Accident site is marked ZS-MZS. Note the precise location marked with a blue dot is clear of any clouds.

Figure 2: HRV Cloud Enhance satellite image at 0900Z on 01 June 2018 showing areas of low level stratus clouds. Accident site is marked ZS-MZS.

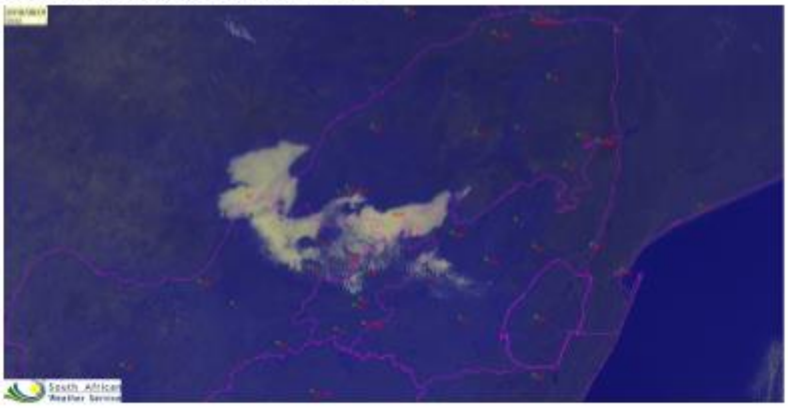

Figure 3: Day Natural Colour satellite image at 0945Z on 01 June 2018 showing dissipating stratus clouds

5.2 Appendix 2 - Metallurgical report

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ITEM:	MAIN ROTOR ASSEMBLY, ROBINSON R44 RAVEN II HELICOPTER, AIRCRAFT NUMBER ZS-MZS

1. **INTRODUCTION & BACKGROUND INFORMATION**

1.1. Parts from the recovered Main Rotor Assembly (Photo 4) of a Robinson R44 Raven II Helicopter (Photo 1), aircraft number ZS-MZS, serial number 12180, was submitted to determine the following:

(a) Most probable failure sequence of events.
(b) Indications of possible pre-impact failure/s.

1.2. The aircraft was involved in a CAT 5 accident on the 1st of June 2018 (Photo 2). Results from the Wreckage Analysis indicated an unrecoverable high Rate of Descend prior to impact. No clear signs relating to probable causational factor/s explaining the high RoD were detected.

Photo 1: Robinson R44 Helicopter (File Photo)[1]

Photo 2: ZS-MZS 2018 Accident Site[2]

Photo 3: Recovered remains of Main Rotor Blade B, as supplied (digital)

[1] Courtesy Starlite
[2] Courtesy SACAA

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Photo 4: Main Rotor Blade A and Head assy., as supplied (digital)

1.3. This report is divided into the following sections:

- Introduction & Background Information Par. 1
- Applicable Documents Par. 2
- Investigative Personnel Par. 3
- Apparatus & Investigative Methodologies Par. 4
- Investigation Results Par. 5
- Conclusions & Discussion Par. 6
- Recommendations Par. 7
- Declarations Par. 8

1.4. **List of Acronyms:**

AAI	Aircraft Accident Investigation	NDI	Non-Destructive Inspection
AC	Advisory Circular	NDT	Non-Destructive Testing
AISI	American Iron and Streel Institute	OEM	Original Equipment Manufacturer
AME	Aircraft Maintenance Engineer	OHSA	Occupational Health and Safety Act
AMO	Aircraft Maintenance Organization	POD	Probability of Detection
ASI	Air-Speed Indication/or	QMS	Quality Management System
ASTM	American Society for Testing and Materials	RC	Rockwell C-scale
EBSD	Electron Back-Scatter Diffraction	RoD	Rate of Descend
ECSA	Engineering Counsel of SA	RT	Radiographic Testing
EDS	Energy-Dispersive X-ray Spectroscopy	SABS	South African Bureau of Standards
FAA	Federal Aviation Authority	SACAA	South African Civil Aviation Authority
HSS	High-Strength Steels	SB	Service Bulletin
ICAO	International Civil Aviation Authority	SEM	Scanning Electron Microscope
IG	Inter-Granular	TG	Trans-Granular
IR	Infra-Red or Thermal Testing	UT	Ultra-Sonic Testing
MAUW	Maximum All-Up Weight	VSI	Vertical Speed Indication/or
NDE	Non-Destructive Evaluation	MR	Main Rotor
MGB	Main Rotor Gearbox	TR	Tail Rotor
LE	Leading Edge	TE	Trailing Edge
AID	Accident Investigation Division	IIC	Investigator-In-Charge
RHC	Robinson Helicopters		

2. **APPLICABLE DOCUMENTS**

(a) Robinson Helicopters IPC
(b) Robinson Helicopters Maintenance Manuals
(c) Robinson Helicopters Service Bulletins
(d) Federal Aviation Authority AD's
(e) SACAA Accident Reports
(f) F.A.I.L. Laboratory report No AAI-001-07-2018
(g) ATSB TRANSPORT SAFETY REPORT Occurrence Investigation Report AO-2009-002

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3. **INVESTIGATIVE PERSONNEL**

(a) The investigative member and compiler of this report is Mr C.J.C. Snyman, ID number 6406105057080. Mr Snyman is a qualified Physical Metallurgist (H.N.Dip Metallurgical Engineering, ECSA Registration: Prof. Eng. Tech. No 201670194), Radiation Protection Officer (RPO, NNR, No 281) and Aircraft Accident Investigator (SCSI).

4. **APPARATUS AND METHODOLOGY**

(a) The apparatus employed for this investigation are Low- and High-magnification instruments, SEM and measuring equipment and Digital Camera.

(b) The methodology included a layout of the supplied parts (post-recovery) and visual examination of relevant systems.

5. **INVESTIGATION**

5.1. **Visual Inspection Results.**

5.1.1. **General Condition**

All referred orientations and nomenclature as depicted by Diagrams 1, 2, 3 and 4.

The visual inspection revealed the Main Rotor Blades (**Blade A Serial No 5699, Blade B Serial No 5688, Part No's C016-5**) to be in a conspicuously contrasting post-impact condition (Combined Pictures 1 and 2, Photo 5).

MR Blade A was located at a distance from the final impact position (Photo 9; Diagram 5) and proved to relatively intact when compared to Blade B (Combined Photographs 1 and 2, Photo 5). This combined with the unusual separation at the MR blade root (Photo 6, A side), led to the initial hypothesis by the AID IIC that Blade A was the first failure in the sequence of events culminating with the final impact.

The Main Rotor Hub assembly revealed severe impact damages (Photo's 7 and 8, red arrows). Although it could not be conclusively confirmed, the severity of the damages can most probably be attributed to impact forces and not in-flight fluctuations of the assembly

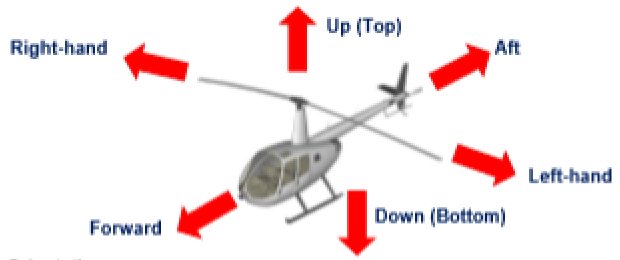

Diagram 1: Orientations

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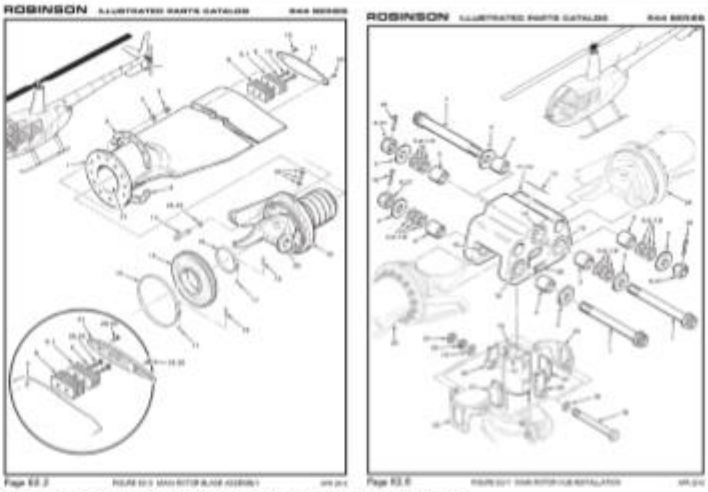

Diagram 2: Main Rotor Blade and MR Hub assemblies[3]

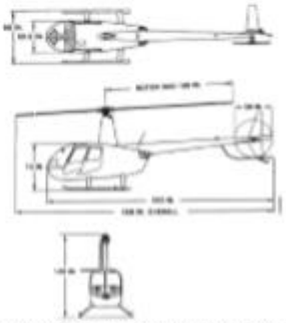

Diagram 3: Three views of the R44 helicopter[4]

[3] RHC IPC, Chapters 62 & 63
[4] RH Maintenance Manuals

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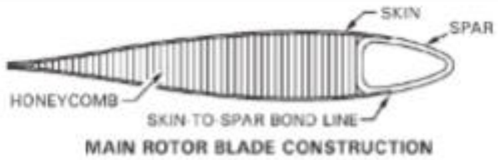

Diagram 4: Main Rotor Blade construction[5]

Combined Picture 1: Main Rotor Blades, Top view (digital)

Combined Picture 2: Main Rotor Blades, Bottom view (digital)

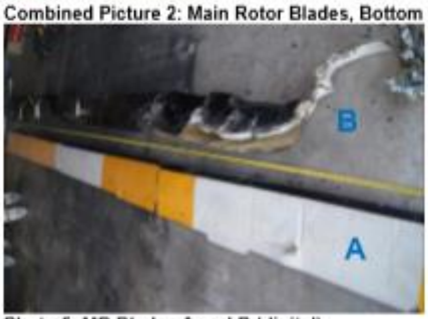

Photo 5: MR Blades A and B (digital)

[5] RH Section 7 Systems Description

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Photo 6: MR Hub assembly, as supplied (digital)

Photo 7: Impact damages to MR Hub assembly (digital)

Photo 8: Impact damages to MR Hub assembly (digital)

5.1.2. **Main Rotor Blade A (Serial No 5699)**

Note: *For ease of reference, the MR blades were divided in Sections 1, 2 and 3 coinciding with the change in paint scheme (Combined Picture 1, red brackets; Diagrams 2 and 4).*

Section 1, Top Side: No clear indications of LE impact damages except slight scraping marks were noted (Photo 10). Following the removal of the Blade Tip Cover, no clear indications of blade skin debonding were detected as per RHC SB-72 (Photo 11, blue arrow, Extract 1). No indications of blade skin debonding were noted at the skin/main spar bond-line (Photo 11, red arrow).

Section 2, Top Side: No clear indications of LE impact damages or scraping marks were noted (Combined Picture 1).

Section 3, Top Side: No clear indications of LE impact damages or scraping marks were noted (Combined Picture 1). Blade A was exposed to a downward force (Photo 12, gray

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arrow) prior to the Blade Main Spar (LE) fracturing at its weakest point (Photo 13, red square). The failure sequence is in correlation with a high RoD, Horizontal impact attitude (refer to Report No AAI-001-07-2018). This most probably resulted in the separation of MR Blade A after contacting hard ground at the primary impact position and thus relocated to the as-found position due to inertia forces/energy.

Section 1, Bottom Side: Clear scraping marks were noted (Photo 14) indicating rotation on impact, albeit at an angle supporting impacting with hard ground while in a (forced) downward orientation relative to the position of the MR Hub assembly at the moment of impact. No indications of blade skin debonding were noted at the skin/main spar bond-line.

Section 2: Bottom Side: No indications of blade skin debonding were noted at the skin/main spar bond-line up to the 135"/3.43m position (Combined Picture 1, RHC SB-72).

Section 3, Bottom Side: All indications concur with those of Section 3, Top Side.

Photo 9: (digital)[6]

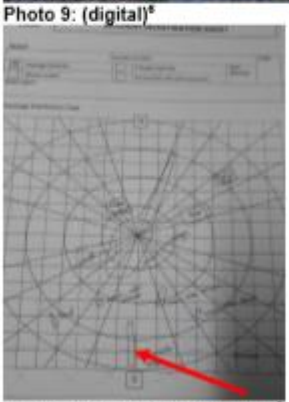

Diagram 5: Accident site layout[7]

[6] Courtesy SACAA
[7] Courtesy AIID (SACAA)

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Photo 10: Blade A, Section 1, impact damages (digital)

Photo 11: Blade A, blade tip, cover removed (digital)

Photo 12: Blade A, Section 3, direction of failure (digital)

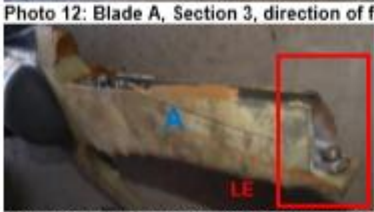

Photo 13: Blade A, Main Spar fracture position and orientation (digital)

Photo 14: Blades A and B, impact scraping marks (digital)

5.1.3. **Main Rotor Blade B (Serial No 5688)**

Note: *For ease of reference, the MR blades were divided in Sections 1, 2 and 3 coinciding with the change in paint scheme (Combined Picture 1, red brackets).*

Most of the parts originating from MR Blade B were located at, or close to, the final impact position (Diagram 5). MR Blade B proved to be extensively more damaged when compared to Blade A (Combined Photographs 1 and 2, Photo 5).

Section 1, Top Side: *The Main Spar (LE), Blade Tip and Cover segments from this section of Blade B were not recovered from the accident site and thus not available for investigation.*

The remainder of section 1 proved to be extensively impact damaged (Photo 15). No clear indications of scraping marks were noted.

Section 2, Top Side: A large segment of the top side blade skin separated (Photo 16) as well as the Main Spar segment from this section. The damage attributes to the now exposed honeycomb structure on the LE end (Photo 17, yellow square) suggest that the top side blade skin remained attached to the Main Spar during the failure sequence while to bottom blade skin separated from it.

Section 3, Top Side: *A significant portion of section 3, both top and bottom sides, was not recovered from the accident site and thus not available for investigation.*

The Main Spar from Blade B fractured +-600mm from the blade root (Photo 18, red arrow). The Blade B Main Spar fracture geometry conforms favorably with that of Blade A (Photo 18, yellow arrow) signifying a comparable exposed downward force during impact in correlation with a high RoD, Horizontal impact attitude (refer to Report No AAI-001-07-2018).

The Main Spar fracture surface revealed no clear indications of pre-impact fracture initiations and/or other discrepancies.

Damages to the inner honeycomb structure (Photo 20, yellow square) suggest that the Main Spar was still in relative position, albeit fractured as discussed above, on final impact.

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Section 1, Bottom Side: No comparable indications (to Blade A, Photo 14) of scraping marks were noted that may suggest similar rotational impact orientation as of Blade A.

The LE impact damages to the bottom blade skin (Photo 21, red square) relates to a direct impact with hard ground/objects. This suggest that the Main Spar was not in the original position as manufactured allowing the inner blade structure to be exposed to the brunt of the impact forces.

Section 2, Bottom Side: Comparable impact damages to Section 1 relating to the blade inner structure were noted (Photo 22).

Section 3, Bottom Side: *A significant portion of section 3, both top and bottom sides, was not recovered from the accident site and thus not available for investigation.*

All other indications concur with those of Section 3, Top Side.

Photo 15: Blade B, Section 1, impact damages (digital)

Photo 16: Blade B, Section 2, impact damages (digital)

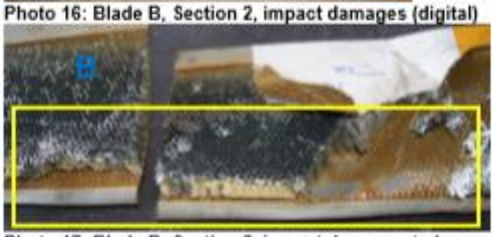

Photo 17: Blade B, Section 2, impact damages to honeycomb structure, loss of skin (digital)

Photo 18: Blade B, Section 3, failure direction and position (digital)

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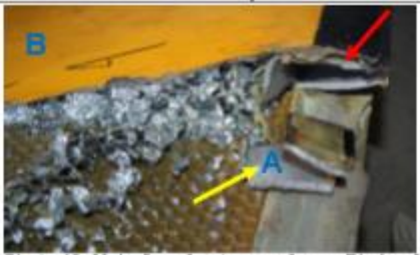

Photo 19: Main Spar fracture surfaces, Blades A and B (digital)


Photo 20: Blade B, Section 3, impact damages to honeycomb structure (digital)


Photo 21: Blade B, Section 1, impact damages (digital)


Photo 22: Blade B, Section 2, impact damages (digital)

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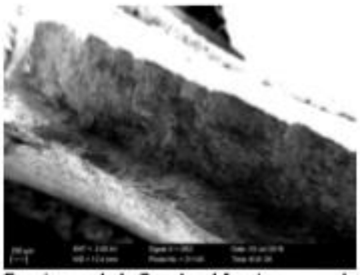
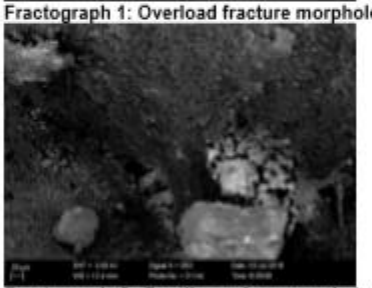
5.2. **Microscope Inspection**

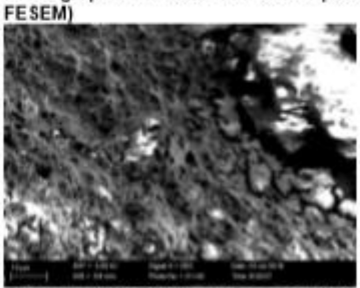
Inspection at higher magnifications of the Main Spar fracture surfaces revealed no clear indications of pre-existing fracture or other material discrepancies (Fractographs 1, 2, 3 and 4).



Fractograph 1: Overload fracture morphology (x120, SE2, FESEM)



Fractograph 2: Ductile surface morphology with foreign deposits – post-impact (x300, SE2, FESEM)



Fractograph 3: Ductile surface morphology (x1500, SE2, FESEM)

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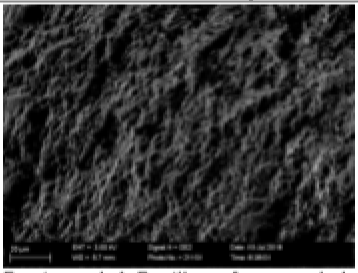


Fractograph 4: Ductile surface morphology (x1500, SE2, FESEM)

7. **DISCUSSION AND CONCLUSIONS**

The conclusions are based on the investigation results obtained from the supplied parts/components and information only.

7.1. The visual inspection revealed the following indications relating to the MR Assembly:

7.1.1. Blade A (Serial No 5699, Part No C016-5):

Blade A seperated from the blade root due to an applied downward force on impact. The residual rotational energy resulted in the seperated segment to be relocated to some distance from the main impact position.

No clear indications of blade skin debonding associated with historic failures (as depicted by an OEM Service Bulletin and representative Investigation Report/s – refer to Extract 1), or other pre-existing failure/s were detected.

No clear indications supporting in-flight seperation were noted.

7.1.2. Blade B (Serial No 5688, Part No C016-5):

Large sections including the Blade Tip and Cover were not recovered from the accident site and consequently not available for this investigation.

The Main Spar fractured at +-600mm from the blade root with comparable direction and mode as the Main Spar fracture from Blade A suggesting that Blade B was exposed to similar impact related forces.

The outer section (Section 1) revealed clear indictions of impact damages to the inner honeycomb structure and the top- and bottom blade skins. The position and orientation of the noted damages suggest that the Main Spar segment was not in the original position at the moment of impact. This may be an indication that the top and/or bottom blade skins **debonded** from the main spar during flight/rotation and prior to final impact. Furthermore, impact damaged segments from Section 2 correlates with the latter finding.

7.1.3. Main Rotor Hub:

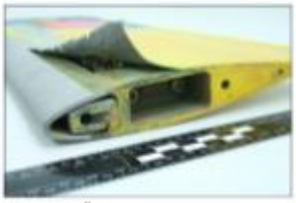
Impact related damages were noted. This investigation could not conclusively confirm the posibilities of other damage/s being inflicted during the final phase of flight and/or during the recovery process.

7.2. The Investigation Results point toward **possible debonding** of the blade skin/s (Top and Bottom) from the Main Spar of **Blade B (Serial No 5699)** during flight. This would have resulted in the altering of the aerofoil profile, loss of effectivenes (lift) and severly destabilizing the MR controlability. The following findings support this notion:

(a) It can be assumed that the determined aircraft attitude and high RoD on impact would have exposed both MR blades to comparable impact loads and subsequint damage profiles. The variations in the noted damage profiles, considering the similarity of the Main Spar fractures, support the notion that Blade B was in a dissimilar condition, or structural composition, than Blade A at the moment of impact.

(b) The noted impact damages to the blade skins and inner honecomb structure of the outer segment (Section 1) of Blade B suggest the absence of the Main Spar 'protection' at the LE boundary during impact.

(c) Research results from similar Robinson Helicopter (R22 and R44) MR blade damages following impacts with hard ground or other objects infer that the Main Spar rarely seperates from the blade skins in total, as with the unit under investigation. In the majority of cases the MR blade segmented as an assembly during impact.

Extract 1: Historic indications of delamination[8]

8. RECOMMENDATIONS

8.1. To complete and prove, or disprove, the investigation results, it is recommended that the remaining segments of Blade B (Serial No 5699) are recovered.

9. DECLARATION

9.1. All digital images have been acquired by the author and displayed in an un-tampered manner, unless stated otherwise.

[8] ATSB TRANSPORT SAFETY REPORT Occurrence Investigation Report AO-2009-002

5.3 Appendix 3 - Airworthiness Directive AD 2014-23-16

FAA
Aviation Safety

AIRWORTHINESS DIRECTIVE

www.faa.gov/aircraft/safety/alerts/
www.gpoaccess.gov/fr/advanced.html

2014-23-16 Robinson Helicopter Company: Amendment 39-18032; Docket No. FAA-2013-0159; Directorate Identifier 2012-SW-010-AD.

(a) Applicability

This AD applies to Model R22, R22 Alpha, R22 Beta, and R22 Mariner helicopters with main rotor blade (blade), part number (P/N) A016-2 or A016-4; and Model R44 and R44 II helicopters with blade, P/N C016-2 or C-016-5, certificated in any category.

(b) Unsafe Condition

This AD defines the unsafe condition as blade skin debonding, which could result in blade failure and subsequent loss of control of the helicopter.

(c) Affected ADs

This AD supersedes AD 2011-12-10, Amendment 39-16717 (76 FR 35330, June 17, 2011); corrected March 5, 2012 (77 FR 12991).

(d) Effective Date

This AD becomes effective January 9, 2015.

(e) Compliance

You are responsible for performing each action required by this AD within the specified compliance time unless it has already been accomplished prior to that time.

(f) Required Actions

(1) Before the first flight of each day, visually check for any exposed (bare metal) skin-to-spar joint area on the lower surface of each blade. The actions required by this paragraph may be performed by the owner/operator (pilot) holding at least a private pilot certificate and must be entered into the aircraft records showing compliance with this AD in accordance with 14 CFR 43.9(a)(1) through (4) and 14 CFR 91.417(a)(2)(v). The record must be maintained as required by 14 CFR 91.417, 121.380, or 135.439.

(2) If there is any bare metal in the area of the skin-to-spar bond line, before further flight, inspect the blade by following the requirements of paragraph (f)(3) of this AD.

(3) Within 10 hours time-in-service (TIS), and at intervals not to exceed 100 hours TIS or at each annual inspection, whichever occurs first, inspect each blade for corrosion, separation, a gap, or a dent by following the Compliance Procedure, paragraphs 1 through 6 and 8, of Robinson R22 Service Bulletin SB-103, dated April 30, 2010 (SB103), or Robinson Service Bulletin SB-72, dated April 30, 2010 (SB72), as appropriate for your model helicopter. Although the Robinson service information limits the magnification to 10X, a higher magnification is acceptable for this inspection. Also, an appropriate tap test tool which provides similar performance, weight, and consistency of tone may be

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substituted for the "1965 or later United States Quarter-dollar coin," which is specified in the Compliance Procedure, paragraph 2, of SB72 and SB103.

(4) Before further flight, refinish any exposed area of a blade by following the Compliance Procedure, paragraphs 2 through 6, of Robinson R22 Service Letter SL-56B or R44 Service Letter SL-32B, both dated April 30, 2010, as appropriate for your model helicopter.

(5) Before further flight, replace any unairworthy blade with an airworthy blade.

(6) Within 5 years of the effective date of this AD:

(i) For Model R22 series helicopters, replace blade P/N A016-2 or A016-4 with a blade, P/N A016-6.

(ii) For Model R44 series helicopters fitted with hydraulically boosted main rotor flight controls, replace blade P/N C016-2 or C016-5 with a blade, P/N C016-7.

(iii) For Model R44 series helicopters without hydraulically boosted main rotor flight controls, replace blade P/N C016-2 or C016-5 with a blade, P/N C016-7. Prior to installing a blade P/N C016-7, verify the helicopter has been modified as required by Robinson R44 Service Letter SL-37, dated June 18, 2010, Compliance Procedures, paragraphs 1. through 10.

(iv) Installing blades, P/N A016-6 or P/N C016-7, is terminating action for the inspection requirements of paragraphs (f)(1) through (f)(4) of this AD.

(7) As an option for complying with paragraph (f)(3) of this AD, you may perform a blade inspection by following the corresponding provisions of SB-103A or SB-72A, both dated July 19, 2012, as appropriate for your model helicopter.

(g) Special Flight Permits

Special flight permits will not be issued.

(h) Alternative Methods of Compliance (AMOCs)

(1) The Manager, Los Angeles Aircraft Certification Office, FAA, may approve AMOCs for this AD. Send your proposal to: Fred Guerin, Aviation Safety Engineer, Los Angeles Aircraft Certification Office, Transport Airplane Directorate, FAA, 3960 Paramount Blvd., Lakewood, CA 90712; telephone (562) 627-5232; email fred.guerin@faa.gov.

(2) For operations conducted under a 14 CFR part 119 operating certificate or under 14 CFR part 91, subpart K, we suggest that you notify your principal inspector, or lacking a principal inspector, the manager of the local flight standards district office or certificate holding district office before operating any aircraft complying with this AD through an AMOC.

(3) AMOCs approved for AD 2011-12-10 (76 FR 35330, June 17, 2011); corrected March 5, 2012 (77 FR 12991), are approved as AMOCs for the corresponding requirements in paragraph (f) of this AD.

(i) Additional Information

The Robinson letter titled "Additional Information Regarding Main Rotor Blade Skin Debonding," dated May 25, 2007, which is not incorporated by reference, contains additional information about the subject of this AD. For service information identified in this AD, contact Robinson Helicopter Company, 2901 Airport Drive, Torrance, CA 90505; telephone (310) 539-0508; fax (310) 539-5198; or at http://www.robinsonheli.com/servelib.htm. You may review a copy of this information at the FAA, Office of the Regional Counsel, Southwest Region, 2601 Meacham Blvd., Room 663, Fort Worth, Texas 76137.

(j) Subject

Joint Aircraft Service Component (JASC) Code: 6210: Main Rotor Blades.