AIRCRAFT ACCIDENT REPORT AND EXECUTIVE SUMMARY

				Reference:		CA18/2/3/10391	
Aircraft Registration	ZS-PSZ	**Date of Accident**		23 November 2023		**Time of Accident**	1439Z
Type of Aircraft	Robinson R44 Raven II			**Type of Operation**		Private (Part 91)	
Pilot-in-command Licence Type	Private Pilot Licence (H)			**Age**	39	**Licence Valid**	Yes
Pilot-in-command Flying Experience		**Total Flying Hours**	161.90	**Total Hours on Type**		108.50	
Last Point of Departure	Ultimate Heli in Midrand, Gauteng Province						
Next Point of Intended Landing	Ultimate Heli in Midrand, Gauteng Province						
Damage to Aircraft	Destroyed						

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

Open field approximately 1.5 nautical miles (nm) south of Ultimate Heli at GPS co-ordinates determined to be 26°3´7.22" South 28°7´11.31" East, at 4 800 feet (ft) above mean sea level (AMSL)

Meteorological Information	Surface Wind: 070°; Wind:10kt; Temperature: 31°C; Dew Point: 12°C; Visibility: 9999m						
Number of People On-board	2 + 0	**Number of People Injured**	1	**Number of People Killed**	0	**Other (On Ground)**	0

Synopsis

On Thursday afternoon, 23 November 2023, two pilots on-board a Robinson R44 Raven II helicopter with registration ZS-PSZ were on a private flight from Ultimate Heli in Midrand, Gauteng province, with the intention to land back at the same facility (heliport). Visual meteorological conditions (VMC) by day prevailed at the time of the flight which was conducted under the provisions of Part 91 of the Civil Aviation Regulations (CAR) 2011 as amended.

The pilot flying (PF) stated that there was nothing abnormal with the helicopter during the pre-flight inspection. At 1400Z, the helicopter took off from Ultimate Heli and headed north in the direction of Grand Central Airport (FAGC). The air traffic control (ATC) officer reported that the helicopter was established at 6 000 feet (ft) above mean sea level (AMSL) and the PF was in contact with the ATC officer. The helicopter later headed south in the direction of the general flying (GF) area. After approximately 39 minutes at 5 300ft whilst on its return to Ultimate Heli, the engine stopped without a warning. According to the ATC officer, no distress call was broadcasted, and the PF executed autorotation. However, the helicopter descended uncontrollably and impacted the ground hard on its skid landing gears. The helicopter was destroyed by impact forces. The PF sustained serious injuries and the other pilot was not injured. Post-accident examination of the engine revealed no defects that would have prevented it from operating normally.

Probable Cause

Undetermined engine stoppage followed by an unsuccessful autorotation which resulted in the helicopter descending uncontrollably and, consequently, impacted the ground hard on its skid landing gears.

SRP Date	11 June 2024	Publication Date	12 June 2024

Occurrence Details

Reference Number	**:** CA18/2/3/10391
Occurrence Category	**:** Category 1
Operator Name	**:** Ultimate Heli (Pty) Ltd
Operator Type	**:** Private
Aircraft Registration	**:** ZS-PSZ
Aircraft Make and Model	**:** Robinson Helicopter Company, R44 Raven II
Nationality	**:** South African
Place	**:** Open field south of Ultimate Heli
Date and Time	**:** 23 November 2023 at 1439Z
Injuries	**:** 1 person seriously injured
Damage	**:** Destroyed

Purpose of the Investigation

In terms of Regulation 12.03.1 of the Civil Aviation Regulations (CAR) 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.

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.

Investigation Process

The Accident and Incident Investigations Division (AIID) was notified of the occurrence which involved the Robinson R44 Raven II helicopter on an open field, south of Ultimate Heli in Gauteng province, on 23 November 2023 at 1439Z. The occurrence was classified as an accident according to the CAR 2011 Part 12 and the International Civil Aviation Organisation (ICAO) STD Annex 13 definitions.

Notes:

1. *Whenever the following words are mentioned in this report, they shall mean the following:*
   Accident — this investigated accident
   Aircraft — Robinson R44 Raven II 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 were taken from different sources and may have been adjusted from the original for the sole purpose of improving clarity of the report. Modifications to images used in this report were limited to cropping, magnification, file compression; or enhancement of colour, brightness, contrast; or addition of text boxes, arrows, or lines.*

Disclaimer

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Abbreviation	Description
°C	Degree Celsius
A/C	Aircraft
ACCID	Accident
AGL	Above Ground Level
AIID	Accident and Incident Investigations Division
AIP	Aeronautical Information Publication
AMM	Aircraft Maintenance Manual
AMO	Aircraft Maintenance Organisation
AMSL	Above Mean Sea Level
ATC	Air Traffic Control
C of A	Certificate of Airworthiness
C of R	Certificate of Registration
CAA	Civil Aviation Authority
CAR	Civil Aviation Regulations
CVR	Cockpit Voice Recorder
FAGC	Grand Central Aerodrome
FCU	Fuel Control Unit
FDR	Flight Data Recorder
hPa	Hectopascal
IAW	In Accordance With
Km	Kilometres
Knots	Knots
M	Metre
MHz	Megahertz
MM	Maintenance Manual
MPI	Mandatory Periodic Inspection
N/A	Not Applicable
NDB	Non-directional Beacon
NM	Nautical Miles
POH	Pilot's Operating Handbook
PPL	Private Pilot Licence
QNH	Query: Nautical Height
RPM	Revolutions per Minute
SACAA	South Africa Civil Aviation Authority
SAWS	South African Weather Service
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
Z	Zulu (Term for Universal Co-ordinated Time - Zero Hours Greenwich)

1. FACTUAL INFORMATION

1.1. History of Flight

1.1.1. On Thursday afternoon, 23 November 2023, two pilots on-board a Robinson R44 Raven II helicopter with registration ZS-PSZ were on a private flight from Ultimate Heli in Midrand, Gauteng province, with the intention to land back at the same facility (heliport). Visual meteorological conditions (VMC) by day prevailed at the time of the flight which was conducted under the provisions of Part 91 of the Civil Aviation Regulations (CAR) 2011 as amended.

1.1.2. According to available information, the pilot conducted a pre-flight inspection on the helicopter, which was parked on the helipad at Ultimate Heli; nothing abnormal was found. The helicopter's technical logs revealed no outstanding defects and the flight folio page serial number 1605 showed that the helicopter had 175 litres (l) of Avgas 100LL fuel in the tanks. Before departure, the pilot flying (PF) who was seated on the right front seat, broadcasted her intentions to the Grand Central Aerodrome (FAGC) air traffic control (ATC) officer on very high frequency (VHF) 122.80-Megahertz (MHz). The PF's intentions were acknowledged.

1.1.3. The PF stated that the engine started without difficulty and was left to run for a few minutes until all the parameters were within the acceptable limits (green arch). At 1400Z, the helicopter took off and headed north in the direction of FAGC and, later, south in the direction of the general flying (GF) area. The ATC officer reported that the helicopter was established at 6 000 feet (ft) above mean sea level (AMSL) and the PF was in contact with the ATC officer. After approximately 39 minutes whilst on its return to the departure heliport at 5 300ft, the engine stopped without warning. According to the ATC officer, no distress call was broadcasted, and the PF executed autorotation. However, the helicopter descended uncontrollably and impacted the ground hard on its skid landing gears. The helicopter was destroyed by impact forces. The PF sustained serious injuries and she was airlifted to a private hospital in Johannesburg. The other pilot was not injured, he was transported by road to the hospital for medical examination. After the accident, the PF stated that it felt as if the engine switched off in-flight.

1.1.4. The accident occurred during daylight on an open field, approximately 1.5 nautical miles (NM) south of Ultimate Heli at Global Positioning System (GPS) co-ordinates determined to be 26°3´7.22" South 28°7´11.31" East, at about 4 800 feet (ft) above mean sea level (AMSL).

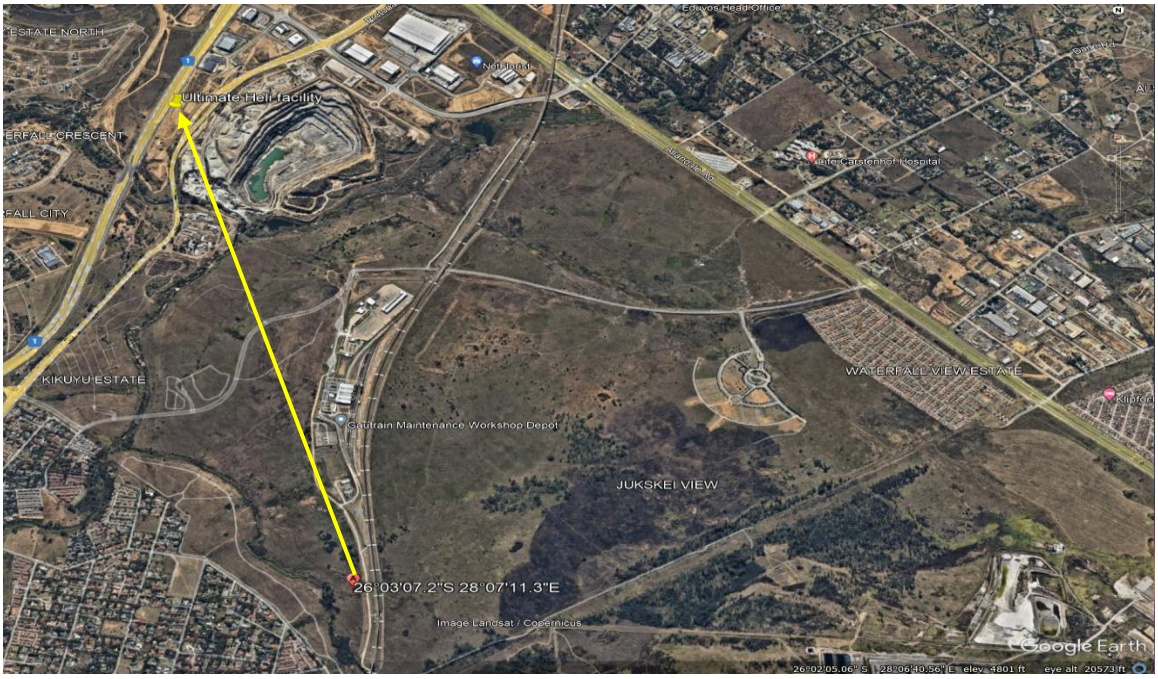

Figure 1: Aerial view of the accident site and Ultimate Heli. (Source: Google Earth)

1.2. Injuries to Persons

Injuries	Pilot	Crew	Pass.	Total On-board	Other
Fatal	-	-	-	-	-
Serious	1	-	-	1	-
Minor	-	-	-	-	-
None	1	-	-	1	-
Total	**2**	**-**	-	**2**	**-**

Note: Other means people on the ground.

1.3. Damage to Aircraft

1.3.1. The helicopter was destroyed on impact.

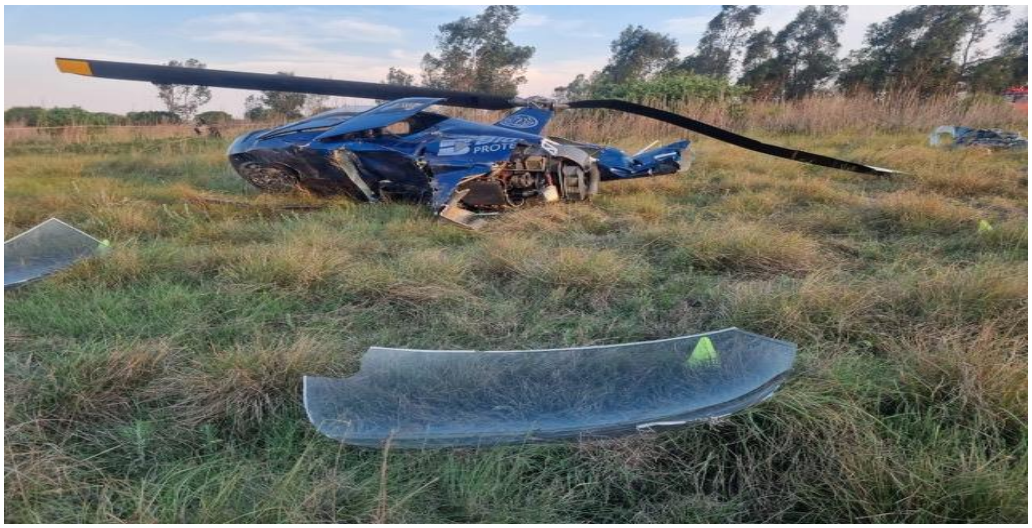

Figure 2: The helicopter at the accident site. (Source: Operator)

1.4. Other Damage

1.4.1 None.

1.5. Personnel Information

Nationality	South African	Gender	Female	Age	39
Licence Type	Private Pilot Licence (PPL)				
Licence Issue Date	11 January 2023	Licence Expiry Date	31 December 2024		
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Night rating				
Medical Class	Class 2				
Medical Issue Date	4 March 2022	Medical Expiry Date	4 March 2025		
Limitations	None				
Previous Accidents	None				

Flying Experience:

Total Flying Hours	161.90
Total Hours Past 24 Hours	0
Total Hours Past 7 Days	0
Total Hours Past 90 Days	2.90
Total Hours on Type Past 90 Days	2.90
Total Hours on Type	108.50

1.5.1 The PF was initially issued a Private Pilot Licence (PPL) on 11 January 2022. Her last licence validation test was conducted on 14 December 2022 after which a licence was issued on 11 January 2023 with an expiry date of 31 December 2024.

1.5.2 The PF was issued a Class 2 aviation medical certificate on 4 March 2020 with an expiry date of 4 March 2025.

1.6. Helicopter Information

1.6.1. Helicopter Description (Source: Pilot's Operating Handbook [POH])

The Robinson R44 Raven II is a four-seat helicopter powered by a six-cylinder fuel injected engine rated at 205 brake horsepower (BHP). It is certified for visual flight rules (VFR) operations only. The flight controls are actuated by a conventional system of push-pull rods and bellcranks. Power is transmitted from the engine to the main rotor gearbox by four rubber V-belts, mounted on two sheaves (pulleys). The lower sheave is bolted directly to the engine output shaft. The V-belts transmit power from the lower sheave to the upper sheave, which in turn transmits power forward to the main rotor and aft to the tail rotor, via a main rotor and tail rotor gearbox.

1.6.2 *The transmission is engaged and disengaged by means of a clutch, which is operated by a two-position guarded switch on the instrument panel. The main rotor flight controls are hydraulically boosted to eliminate cyclic and collective feedback forces. The system is designed to enhance the pilot's comfort by reducing vibration from the rotor head to the controls and reduces the required input forces the pilot has to make. The system is controlled by a HYD/OFF switch on the pilot's cyclic control and can be deactivated by placing the switch to OFF position. The hydraulic system operates at a pressure between 450 – 500psi. The helicopter is equipped with 15 warning lights on the instrument panel to warn the pilots of conditions requiring attention. Eight of these lights are on the top of the instruments panel and 7 are in the middle panel. The fuel system comprises of two crashworthy bladder fuel tanks, the main tank has the capacity of 120l and the auxiliary tank 70l.*

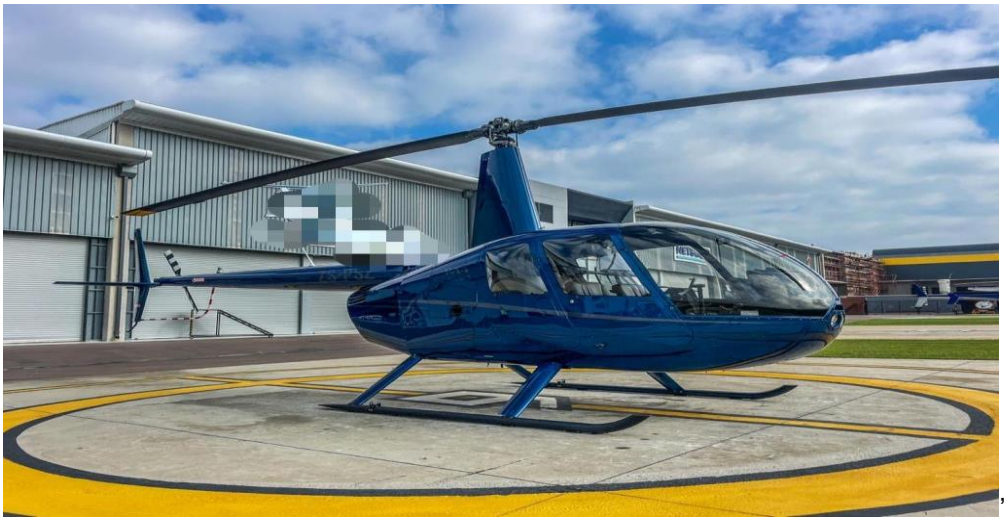

Figure 3: The helicopter before the accident. (Source: Operator).

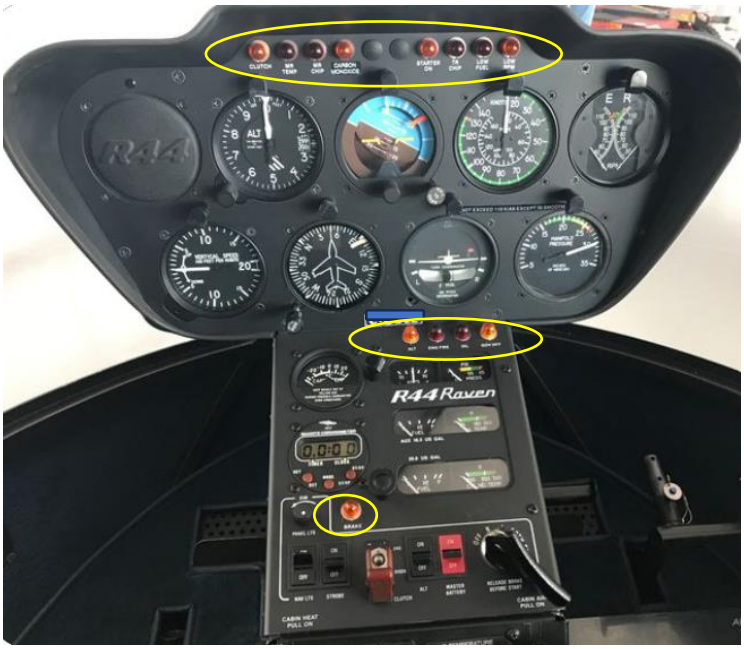

Figure 4: The Robinson R44, Raven II instrument panel showing warning lights.

Airframe:

Manufacturer/Model	Robinson Helicopter Company/R44 Raven II	
Serial Number	11169	
Year of Manufacture	2006	
Total Airframe Hours (At Time of Accident)	4 702.0	
Last Annual Inspection (Date & Hours)	20 November 2023	4 685.9
Hours Since Last Inspection	16.1	
CRS Issue Date	13 November 2023	
Certificate of Airworthiness (Issue Date & Expiry Date)	2 July 2015	31 July 2024
C of R (Issue Date) (Present Owner)	25 June 2021	
Type of Fuel Used	Avgas 100LL	
Operating Category	Private (Part 91)	
Previous Accidents	Nil	

Engine:

Manufacturer/Model	Lycoming / IO-540-EA1A5
Serial Number	L-31018-48A
Part Number	Unknown
Hours Since New	4 784.2
Hours Since Overhaul	1 044.8

Propeller:

Manufacturer/Model	Robinson Helicopter Company / C016-2
Serial Number	8242
Part Number	Unknown
Hours Since New	946.5
Hours Since Overhaul	Time between overhaul (TBO) not reached

1.7. Meteorological Information

1.7.1 The weather information below was obtained from the South African Weather Service (SAWS).

Wind Direction	070º	Wind Speed	10kt	Visibility	9999m
Temperature	31ºC	Cloud Cover	CAVOK	Cloud Base	NIL
Dew Point	12ºC	QNH	1022 hPa		

1.8. Aids to Navigation

1.8.1. The helicopter was equipped with standard navigational equipment as approved by the Regulator (SACAA). There were no records indicating that the navigational equipment was unserviceable prior to the flight.

1.9. Communication

1.9.1. The helicopter was equipped with a standard communication system as approved by the Regulator. There were no recorded defects with the communication system prior to the flight.

1.10. Aerodrome Information

1.10.1. The accident occurred during daylight on an open field approximately 1.5nm south of Ultimate Heli at GPS co-ordinates determined to be 26°3´7.22" South 28°7´11.31" East, at about 4 800ft AMSL.

Aerodrome Name	Ultimate Heli
Aerodrome Location	Midrand, Gauteng Province
Aerodrome Co-ordinates	S25º 59'.11" E028º8'.24"
Aerodrome Elevation	5 327 feet AMSL
Runway Dimensions	1 830 x 23
Runway Designations	17/35
Runway Used	N/A
Runway Surface	Asphalt
Aerodrome Status	Licensed
Approach Facilities	Runway lighting and non-directional beacon (NDB)

1.11. Flight Recorders

1.11.1. The helicopter was neither equipped with a flight data recorder (FDR) or a cockpit voice recorder (CVR), nor was it required by regulation to be fitted to the helicopter type.

1.12. Wreckage and Impact Information

1.12.1. Examination of the wreckage revealed that all damage to the airframe and systems had resulted from impact with the ground. There was no evidence to suggest that the helicopter had not been structurally intact prior to the accident. The helicopter impacted the ground hard with the skids landing gear which broke off. The helicopter's fuselage bounced after impact and came to rest approximately 10 metres (m) from the initial point of impact. The helicopter

battery separated from the battery box. The vertical stabiliser, tail rotor guard and tail skid were damaged and disrupted.

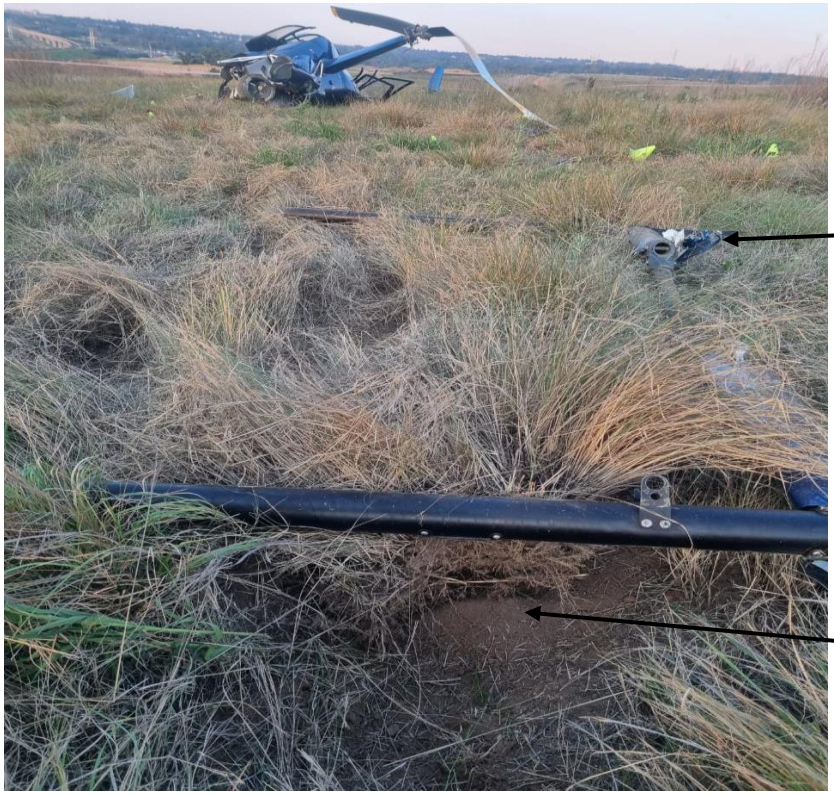

Figure 5: The wreckage and the broken skids landing gear.

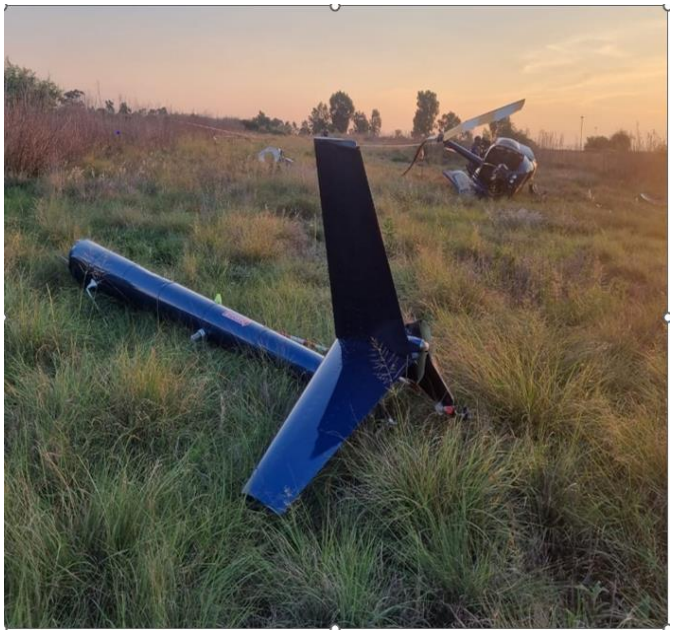

Figure 6: The main wreckage and the severed tail boom.

1.12.2 The accident site was examined by the investigation team, assisted by a team of engineers from the operator's facility. Examination of the wreckage and the components that broke due

to impact at the accident site indicated that the helicopter was intact prior to the accident. The fuel bladder cells were intact and contained sufficient fuel which was consistent with Avgas 100LL. There was no evidence of fuel leaks.

1.12.3 Examination of the cockpit revealed the rotor brake in a 'pulled' position. None of the circuit breakers (CBs) popped. The fuel shut-off selector knob was found intact and free when rotated, the valve position was consistent with the fuel selected to the ON position. The auxiliary tank was correctly interconnected with the main tank. The inter-tank flexible hose assembly was found clear of obstructions.

1.12.4 The right-side throttle/twistgrip was in a position close to idle. The pilot and co-pilot throttles/twist grips both moved in unison when the pilot's (right side) throttle was activated. The collective pitch lever was found in the UP position and the governor switch was selected to the ON position, consistent with a normal flight.

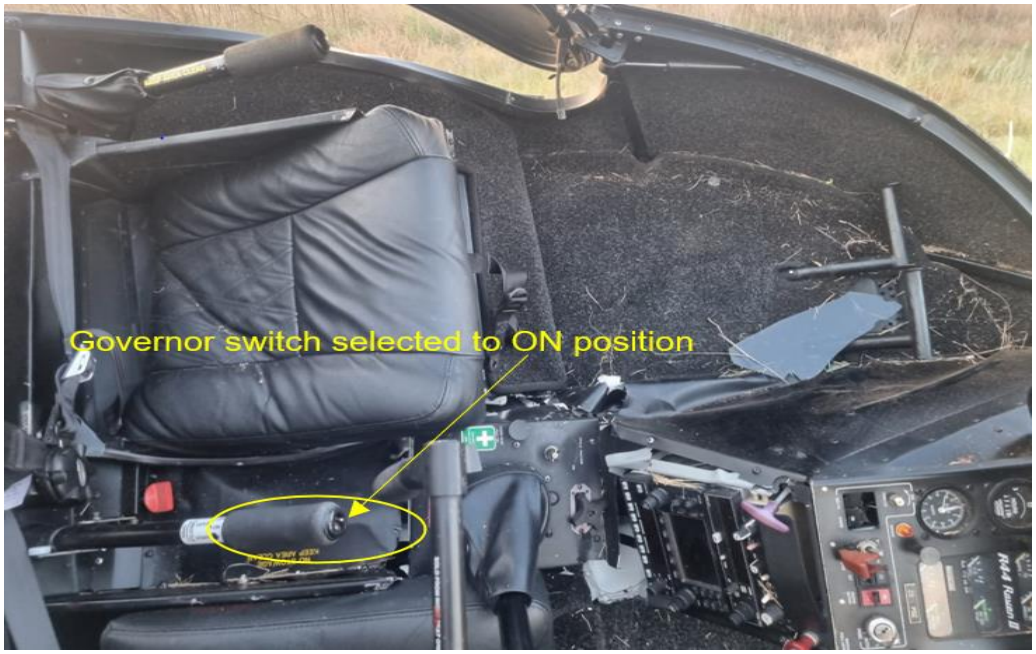

Figure 7: The pilot's collective pitch control stick in the UP position and the governor switch in the ON position.

1.12.5 The movement of the collective pitch levers was limited due to the damaged right-side collective pitch control lever. Continuity of the throttle control cable was confirmed from the collective jackshaft to the throttle bell crank assembly and was securely attached. The hydraulic switch on the pilot's (right side) T-bar cyclic control stick broke during the accident sequence.

1.12.6 The anti-torque pedals could not be activated due to restrictions caused by impact damage. The mixture control was depressed (OFF position), it appeared to have been disturbed during the accident sequence. The flight control continuity to the main rotor head and tail rotor could

not be established due to impact damage. The wiring beneath the centre console was examined and no disconnection was noted.

1.12.7 All warning and caution lights were inspected, and electrical continuity was confirmed. The filaments of the low rotor, low fuel, alternator and governor warning lamps were subsequently inspected under a microscope; none was found stretched or broken.

1.12.8 The engine and the main transmission remained mounted on the airframe and all the main rotor blades were secured to their respective grips, which remained attached to the main rotor head and mast. The ignition harnesses from both magnetos to their respective spark plugs remained intact. The magnetos were secured to their respective mounting pads.

1.12.9 Drive train to the main and tail rotors could not be established. The main gearbox housing was intact and attached to the bottom of the main rotor mast and the centre frame. The main gearbox rotated freely and exhibited continuity from input to the main rotor drive shaft, and the free-wheeling sprag clutch operated as expected. One of the pitch links broke at the adjusting course area; it displayed signatures consistent with compression loads emanating from impact. The main rotor blades showed little to no damage along their respective spans towards the blade tips, which was consistent with low rotor revolutions per minute (RPM) at the time of impact. The main rotor blade with serial number 7282 had dents and scratches on the leading-edge inboard area (white painted portion), which indicated impact damage with the tail boom structure.

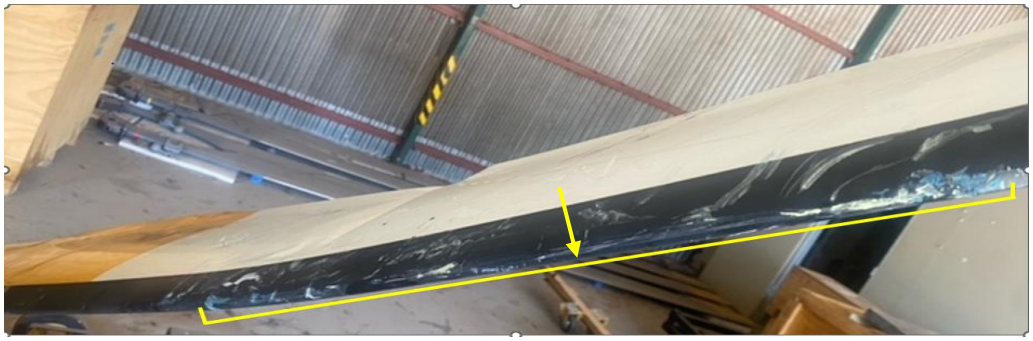

Figure 8: The main rotor blade leading edge area showing the impact print.

1.12.10 The white markings inside the engine cooling fan were aligned, and there was no slippage to the cooling fan retention nut alignment mark which indicated that the engine was producing little to no power at the time of impact.

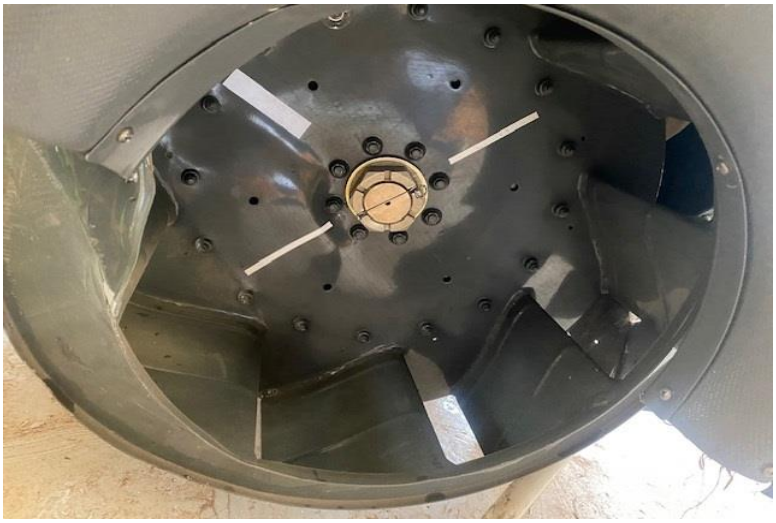

Figure 9: The engine cooling fan.

1.12.11 The V-belts on the engine output shaft were in place and intact. The long tail rotor drive shaft was severed; however, the tail rotor gearbox shaft was intact and it rotated freely. The tail rotor gearbox housing was also intact. The inspection sight gauge (glass) indicated a sufficient lubrication oil level.

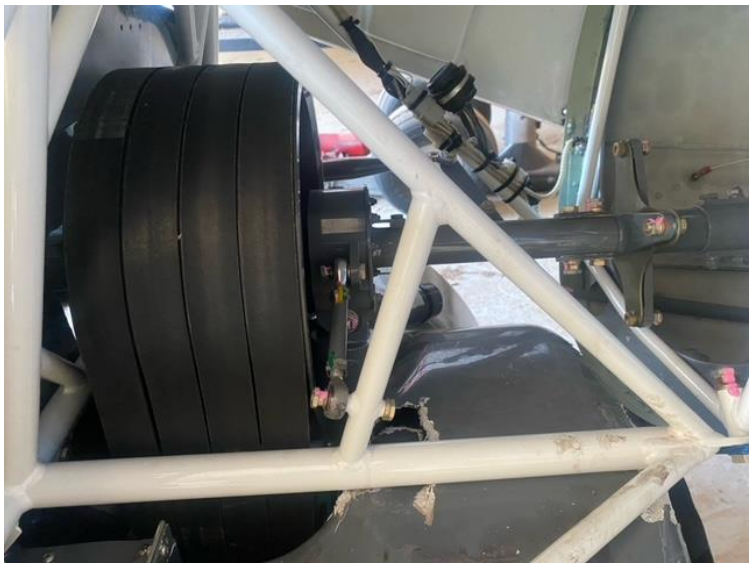

Figure 10: The V-Belts on the engine output shaft.

1.13. Medical and Pathological Information

1.13.1. Not applicable.

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 considered survivable because the cockpit structure had remained intact. The occupants had made use of the aircraft's safety harnesses.

1.16. Tests and Research

1.16.1 Post-accident examination of the engine casing and components indicated nothing abnormal. The engine remained attached to the cradle and firewall. About 160l of fuel was drained from the tanks at the accident site, and it was of the correct grade (Avgas 100LL) and free of contaminants. Fuel was found inside the gascolator (fuel strainer), and it was free of contaminants. The gascolator drain valve was locked (closed) and showed no evidence of fuel leak. No evidence of fuel supply pipe disconnection was noted.

1.16.2 The investigator-in-charge (IIC) had examined fuel records at the operator's facility. Fuel sample from the batch used to refuel the aircraft had passed the normal fuel quality examination. The fuel was certified for fuel density. There were no reports of fuel defects or challenges from other pilots (other aircraft) that had refuelled from the same fuel batch before and after the accident.

1.16.3 The engine oil cap and dipstick were properly secured, and the sump plug was relatively clean. The engine dipstick was pulled out, and it indicated 7 quarts of oil, which was sufficient for the planned flight. The magnetos and ignition harnesses were properly fitted and were in a good condition. All the engine air pipes/hoses were free of blockages. The air filter also showed no signs of blockages. All the engine components, bolts and wire locking were intact and in place.

1.16.4 The wreckage of the helicopter was recovered from the accident site and transported to FAGC where a detailed examination was conducted in the hangar. There was no obvious external damage on the engine casing and components. The engine was examined by the IIC, assisted by two engineers who were rated and experienced on the Robinson R44 helicopter model. The fuel supply and metering system integrity was confirmed; there were no leaks under the boost pump pressure.

1.16.5 The fuel injection system nozzles were free of contaminants and delivered the minimum flow rate as per the engine maintenance manual requirements. Fuel was drained from the fuel control unit (FCU) return line and it was free of contaminants. The rigging on the engine controls was checked and found to be appropriate. The fuel filter element was free of contaminants.

1.16.6 On Monday, 17 November 2024, the engine was taken to Lycoming's approved component repair and overhaul facility for further investigation. A detailed receiving inspection was performed and nothing abnormal was detected. The FCU was removed from the engine and

placed on a test rig. Functional test was performed on the FCU in accordance with (IAW) the maintenance manual (MM); it demonstrated positive fuel flow.

1.16.7 The FCU was later removed from the test rig and refitted to the engine. The engine output shaft was removed from the engine to allow the fitment of a three-blade propeller. The engine was later secured to a test cell for examination. The ignition key was turned on and the engine started without difficulty. The engine was warmed up before power was increased in stages. No adjustments or troubleshooting/s were performed during the engine test run. The engine met all the parameters IAW the engine maintenance manual (EMM). A hot engine start was also performed, and no irregularities were found. The magneto check was conducted during the tests and the engine RPM remained the same. No evidence of pre-existing defects was noticed that would have prevented the engine from operating normally.

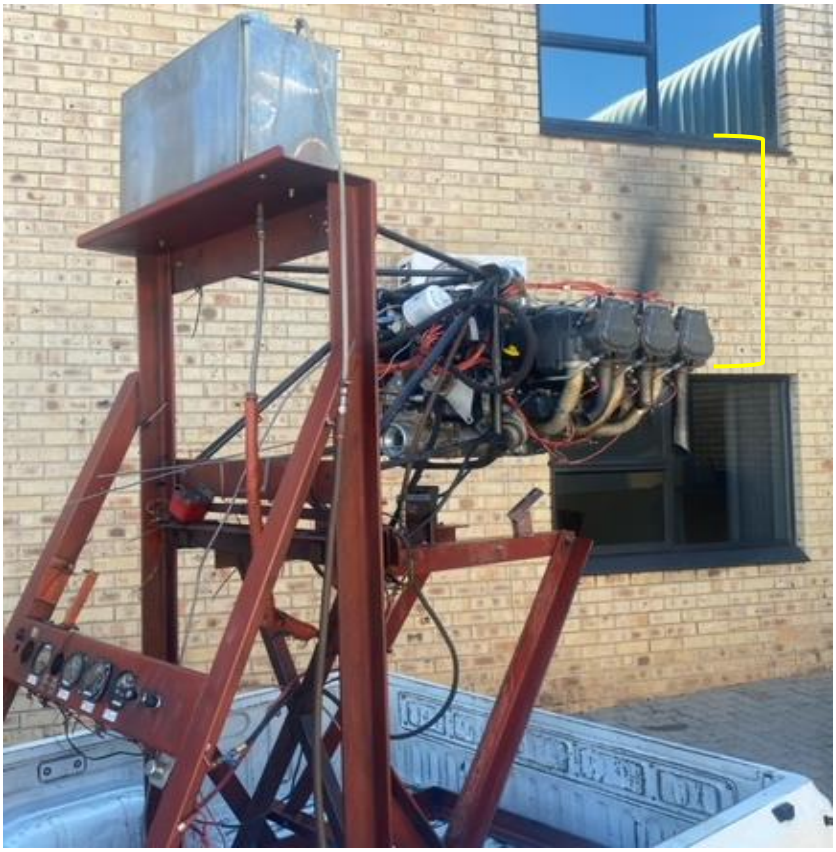

Figure 11: The engine during a test run.

1.17. Organisational and Management Information

1.17.1 This was a private flight conducted under the provisions of Part 91 of the CAR 2011 as amended.

1.17.2 The 100-hour mandatory periodic inspection (MPI) that was conducted on the helicopter prior to the accident flight was certified on 20 November 2023 at 4 685.9 airframe hours. The accident occurred at 4 702.0 total airframe hours, which meant that the helicopter was flown a further 16.1 airframe hours since the last inspection.

1.17.3 The aircraft maintenance organisation (AMO) which conducted the last MPI on the helicopter had an approval certificate that was issued on 16 May 2023 with an expiry date of 31 May 2024.

1.17.4 The helicopter was issued the Certificate of Release to Service (CRS) on 20 November 2023 with an expiry date of 19 November 2024 or at 4 784.9 airframe hours, whichever occurs first.

1.18. Additional Information

1.18.1. Autorotation (Source: Pilot's Operating Handbook [POH])

Autorotation permits a helicopter to descend in a controlled manner after engine power loss or other catastrophic mechanical failure and still permits the pilot to carry out a safe landing. A critical aspect of autorotation is the entry manoeuvre immediately following the loss of engine power because the pilot must react quickly to conserve rotor RPM. Of the other factors affecting autorotative flight, the existence of sufficient altitude at the time of the loss of engine power is critical to a successful descent and landing. The no-engine landing after an autorotative descent is a challenging manoeuvre for any pilot since it involves skills not frequently practiced.

Following a loss of engine power, the pilot must lower the collective pitch control full down in an effort to prevent loss of rotor RPM (Nr) and obtain sufficient airflow to turn the main rotor. During flight, the engine provides the power needed to drive the rotors. When the engine fails or the clutch system suffers a mechanical breakdown, some other force must be used to drive the rotors so that the flight can descend safely to the ground. This force, generated when sufficient air flows through the main rotor during descent to overcome blade drag, is provided by the potential energy stored by the helicopter. In other words, as the helicopter's altitude decreases, potential energy in the form of loss in altitude is traded off to place kinetic energy in the rotor system.

The Robinson R44 POH describes, as follows, the recommended procedure for an autorotation at an altitude greater than 500ft AGL:

- *Lower collective immediately to maintain main rotor RPM and enter normal autorotation;*
- *Establish a steady glide at approximately 70 knots;*
- *Adjust collective to keep rotor RPM in the green arc (or lower the collective completely if the weight of the helicopter prevents the pilot from attaining more than 97% RPM);*

- *Select landing area and, if altitude permits, maneuver so landing is into wind;*
- *At 40ft AGL, begin cyclic flare to reduce rate of descent and forward airspeed;*
- *At 8ft AGL, apply forward cyclic to level the ship and raise collective before touchdown to cushion the landing. Touchdown in a level attitude with the nose straight ahead.*

1.18.2 Safety Notice SN-24: Low RPM rotor stall can be fatal (Issued: Sep 86 Rev: Jun 94)

Rotor stall due to low RPM causes a very high percentage of helicopter accidents, both fatal and non-fatal. Frequently misunderstood, rotor stall is not to be confused with retreating tip stall which occurs only at high forward speeds when stall occurs over a small portion of the retreating blade tip. Retreating tip stall causes vibration and control problems, but the rotor is still very capable of providing enough lift to support the weight of the helicopter. Rotor stall on the other hand, can occur at any airspeed and when it does, the rotor stops producing the lift required to support the helicopter and the aircraft literally fall out of the sky. Fortunately, rotor stall accidents most often occur close to the ground during take-off or landing and the helicopter falls only four or five feet. The helicopter is wrecked but occupants survive. However, rotor stall also occurs at higher altitudes and when it happens at heights above 40 or 50 feet AGL, it is most likely to be fatal. Rotor stall is very similar to the stall of an airplane wing at low airspeeds. As the airspeed of airplane gets lower, the nose-up angle or angle of attack, of the wing must be higher for the wing to produce the lift required to support the weight of the airplane. At a critical angle (about 15 degrees), the airflow over the wing will separate and stall, causing a sudden loss of lift and a very large increase in drag. The airplane pilot recovers by lowering the nose of the airplane to reduce the wing angle of attack below stall and adds power to recover the lost airspeed. The same thing happens during rotor stall with a helicopter except it occurs due to low rotor RPM instead of low airspeed. As the RPM of the rotor gets lower, the angle of attack of the rotor blades must be higher to generate the lift required to support the weight of the helicopter. Even if the collective is not raised by the pilot to provide the higher blade angle, the helicopter will start to descend until the upward movement of air to the rotor provides the necessary increase in blade angle of attack. As with the airplane wing, the blade aerofoil will stall at a critical angle, resulting in a sudden loss of lift and a large increase in drag. The increase drag on the blades acts like a huge rotor brake causing the rotor RPM to rapidly decrease, further increasing the rotor stall. As the helicopter begins to fall, the upward rushing air continues to increase the angle of attack on the slowly rotating blades, making recovery virtually impossible, even with full down collective. When the rotor stalls, it does not do so symmetrically because any forward airspeed of the helicopter will produce a higher airflow on the advancing blade than on the retreating blade. This causes the retreating blade to stall first, allowing it to dive as it goes aft while the advancing blade is still climbing as it goes forward. The resulting low aft blade and the high forward blade become a rapid aft tilting of the rotor disc sometimes referred to as "rotor blow back". Also, as the helicopter begins to fall, the upward flow of air under the tail surfaces tends to pitch the aircraft nose-down. These two effects, combined with aft cyclic by the pilot attempting to

keep the nose from dropping, will frequently allow the rotor blades to blow back and chop off the tail-boom as the stalled helicopter falls. Due to the magnitude of the forces involved and the flexibility of the rotor blades, rotor teeter stops will not prevent the boom chop. The resulting boom chop, however, is academic, as the aircraft and its occupants are already doomed by the stalled rotor before the chop occurs.

1.19. Useful or Effective Investigation Techniques

1.19.1. None.

2. ANALYSIS

2.1. General

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

2.2. Analysis

Man (Pilot)

2.2.1 The PF was initially issued a PPL on 11 January 2022. Her last licence validation test was conducted on 14 December 2022 and the licence was reissued on 11 January 2023 with an expiry date of 31 December 2024.

2.2.2 According to the pilot's questionnaire, the pilot had flown a total of 161.90 hours of which 108.50 were on the aircraft type. The pilot had flown 2.90 hours in the past 90 days.

2.2.3 The PF was issued a Class 2 aviation medical certificate on 4 March 2020 with an expiry date of 4 March 2025.

Machine (Helicopter)

2.2.4 Post-accident examination of the technical documentation indicated that the last 100-hour MPI that was conducted on the helicopter prior to the accident flight was certified on 20 November 2023 at 4 685.9 airframe hours. The accident occurred at 4 702.0 total airframe hours, which meant that the helicopter accrued 16.1 airframe hours since the last inspection. The AMO which conducted the last MPI on the helicopter had an approval certificate that was issued on 16 May 2023 with an expiry date of 31 May 2024. The helicopter was issued the CRS on 20 November 2023 with an expiry date of 19 November 2024 or at 4 784.9 airframe hours, whichever occurs first.

2.2.5 The PF reported engine stoppage in-flight whilst en route to Ultimate Heli at 5 300ft. The aircraft fuel, ignition and induction systems were examined post-accident and nothing abnormal was found. The fuel tanks had sufficient fuel which was of the correct grade (Avgas 100LL) and free of contaminants. The rigging on the engine controls was checked and found to be appropriate.

2.2.6 On Monday, 17 November 2024, the engine was taken to a Lycoming's approved component repair and overhaul facility for further investigation. A detailed receiving inspection was performed and nothing abnormal was detected. The FCU was removed from the engine and placed on a test rig. Functional test was performed on it (FCU) IAW the MM and it demonstrated positive fuel flow. The FCU was later removed from the test rig and refitted to the engine. The engine output shaft was removed from the engine to allow the fitment of the propeller. The engine was later secured to a test cell for examination. The engine was started and was allowed to warm up. Power was increased in stages until it was evident that the engine was capable of operating at full power IAW the EMM.

2.2.7 No adjustments or troubleshooting/s were performed during the test run. The magneto check was conducted during the tests (cold and hot start) and the engine RPM remained the same. The investigation found no evidence of any pre-existing defects that would have prevented the engine from operating normally.

Environment

2.2.8 The prevailing weather conditions at the time had no influence on the accident. There were no clouds, and visibility was more than 10 kilometres. The terrain where the accident occurred was flat.

Conclusion

2.2.9 The ATC officer reported that ZS-PSZ helicopter was established at 6 000ft AMSL before it was involved in an accident. The PF reported that after approximately 39 minutes whilst at 5 300ft en route to Ultimate Heli, the engine stopped without warning which was deemed uncommon by the investigation team. The PF reported that she instantly entered autorotation, however, the helicopter descended and impacted the ground hard on the skid landing gears.

2.2.10 The investigation team found the collective pitch control lever in the "UP" position post-accident; this suggested that the PF had tried to arrest the descent rate which originated from the depletion of the main rotor RPM (Nr) that was likely caused by the delayed lowering of the collective pitch control lever.

2.2.11 When the engine fails, some other force must be used to drive the main rotor so that the

helicopter can descend safely to the ground. The main rotor of the Robinson R44 Raven II helicopter is considered a “low-inertia rotor system”. This term refers to its tendency to quickly deplete its stored energy or Nr when it is no longer powered. When the main rotor ceases to be driven by the engine, the pilot must quickly lower the collective pitch control lever to compensate for the rapid decay in Nr and to prevent an aerodynamic stall of the main rotor. Once the main rotor is stalled, recovery is unlikely.

3. CONCLUSION

3.1. General

From the available evidence, 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 organisation or individual.

To serve the objective of this investigation, the following sections are included in the conclusion 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 occurring, or would have mitigated the severity of the consequences of the accident. 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 PF was initially issued a Private Pilot Licence (PPL) on 11 January 2022. Her last licence validation test was conducted on 14 December 2022, and the licence was reissued on 11 January 2023 with an expiry date of 31 December 2024.

3.2.2 The PF was issued a Class 2 aviation medical certificate on 4 March 2020 with an expiry date of 4 March 2025.

3.2.3 The flight was conducted under visual meteorological conditions (VMC) by day and under the provisions of Part 91 of the CAR 2011.

3.2.4 The helicopter was issued a Certificate of Registration (C of R) on 25 June 2021.

3.2.5 The helicopter was issued a Certificate of Airworthiness (C of A) on 11 December 2022 with an expiry date of 31 January 2024.

3.2.6 The last 100-hour mandatory periodic inspection (MPI) that was conducted on the helicopter prior to the accident flight was certified on 20 November 2023 at 4 685.9 airframe hours.

3.2.7 The helicopter was issued a Certificate of Release to Service (CRS) on 20 November 2023 with an expiry date of 19 November 2024 or at 4 784.9 airframe hours, whichever occurs first. The helicopter was flown a further 16.1 airframe hours since the last 100-hour inspection.

3.2.8 The AMO which conducted the last MPI on the helicopter had an approval certificate that was issued on 16 May 2023 with an expiry date of 31 May 2024.

3.2.9 The PF reported engine stoppage in-flight. The investigation found no evidence of any pre-existing defects that would have prevented the engine from operating normally.

3.3. Probable Cause/s

3.3.1 Undetermined engine stoppage followed by an unsuccessful autorotation which resulted in the helicopter descending uncontrollably and, consequently, impacted the ground hard on its skid landing gears.

3.4 Probable Cause/s

3.4.1 It is possible that the PF delayed lowering the collective pitch control lever during an autorotation which led to a decay in the main rotor RPM and, subsequently, the main rotor stalled which rendered ground impact inevitable.

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.

4.2 Safety Message

4.2.1 None.

5. APPENDICES

5.1 None.

This report is issued by:

Accident and Incident Investigations Division
South African Civil Aviation Authority
Republic of South Africa