HELICOPTER ACCIDENT REPORT AND EXECUTIVE SUMMARY

						Reference:	CA18/2/3/9618
Helicopter Registration	ZS-HFF	**Date of Accident**	19 May 2017			**Time of Accident**	1512Z
Type of Helicopter	Robinson R44 Raven II		**Type of Operation**			Private (Part 91)	
Pilot-in-command Licence Type		PPL	**Age**	47		**Licence Valid**	Yes
Pilot-in-command Flying Experience		Total Flying Hours	561			Hours on Type	512.20
Last point of departure	Nampo Park near Bothaville, Free State Province						
Next point of intended landing	De Hoop private farm near Frankfort, Free State Province						

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

On Ongegund Farm near Heilbron, Free State Province (GPS S27°17’28.85” E027°51’45.12” at an elevation of 4 745 ft)

Meteorological Information	Wind: 045° at 4 kt, temperature: 23.3°C, visibility: CAVOK				
Number of people on board	1 + 3	**No. of people injured**	2	**No. of people killed**	2

Synopsis

On Friday 19 May 2017 at approximately 1430Z, the pilot, accompanied by three passengers comprising an adult male and 3 passengers took off from Nampo Park (S27°13’936” E026°39’958”) near Bothaville in Free State Province on a private flight destined for De Hoop private farm near Frankfort in Free State Province. The flight was conducted under visual meteorological conditions (VMC) during daylight hours.

According to an eyewitness at Ongegund private farm, the helicopter was approaching from the west direction towards Heilbron (Free State Province) when he heard a sudden change in the engine tone followed by the helicopter descending rapidly in a nose-down attitude. The pilot appeared to execute autorotation, as the nose of the helicopter was observed pitching up shortly before the helicopter crashed into the ground. The main rotor severed the tail boom on impact**.** The eyewitness immediately notified the South African Police Service (SAPS) in the area, who also notified the Emergency Medical Services (EMS).

It was established that the helicopter hit the ground heavily during the high-velocity impact sequence. The pilot and the passengers were fatally injured during the impact sequence. The adult male passenger and the other 14-year-old male passenger survived the accident with serious injuries and were transported to the Union Life Hospital in Alberton by road ambulance. Investigation of the engine and components and associated flight controls showed no malfunction.

The investigation concluded that the helicopter impacted the ground at a high rate of descent following undetermined engine stoppage.

Probable Cause

The helicopter experience engine stoppage, the pilot executed autorotation, however the helicopter was observed pitching nose up and impacted the ground in high velocity the main rotor severed the tail boom on impact.

Contributory Factor:

Undetermined engine failure.

SRP Date	14 November 2017	Release Date	21 May 2018

HELICOPTER ACCIDENT REPORT

Name of Owner	**:** Wenzel Boerdery Trust
Name of Operator	**:** D.S. Wenzel
Manufacturer	**:** Robinson Company
Model	**:** R44 Raven II
Nationality	**:** South African
Registration Marks	**:** ZS-HFF
Place	**:** Ongegund farm, Heilbron (Free State Province)
Date	**:** 19 May 2017
Time	**:** 1512Z

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 interests of the promotion of aviation safety and the reduction of the risk of aviation accidents or incidents and ***not to establish blame or liability****.*

Disclaimer:

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

1. FACTUAL INFORMATION

1.1 History of Flight:

1.1.1 On 19 May 2017 at approximately 1430Z, the pilot, accompanied by three passengers, took off from Nampo Park (near Bothaville in the Free State Province) where an agricultural show was being hosted, on a private flight to the De Hoop private farm near Frankfort, also located in the Free State Province. The flight was conducted under visual meteorological conditions (VMC) during daylight hours.

1.1.2 According to the only eyewitness, on the Ongegund private farm, the helicopter was approaching from the west towards Heilbron (Free State Province) when he heard a sudden change in the engine tone, followed by the helicopter descending rapidly in a nose-down attitude. The pilot appeared to execute an autorotation, as the nose of the helicopter was observed pitching up shortly before the helicopter crashed into the ground. The rotor severed the tail boom during the accident sequence. The eyewitness immediately reported the accident to the South African Police Service (SAPS) in the area that also notified the Emergency Medical Services (EMS), which rushed to the accident scene.

1.1.3 Post-wreckage examination established that the helicopter hit the ground heavily during a high-velocity impact sequence. Three of the occupants appeared to have been thrown out of the helicopter upon impact. The pilot, who was found outside the wreckage, and one of the 14-year-old male passengers, found inside the wreckage, were both fatally injured during the impact sequence.

1.1.4 The adult male passenger and the other 14-year-old male passenger were found outside the wreckage, having sustained serious injuries. Due to the nature of injuries sustained during the accident sequence, the adult male was hospitalised for 14 days and the 14-year-old male for approximately 62 days, in two different hospitals.

1.1.5 During the on-site investigation, the investigation team established that the helicopter impacted the ground at a high rate of descent, collapsed both skids, nosed over and came to rest on its left-hand side. The helicopter was destroyed during the impact sequence.

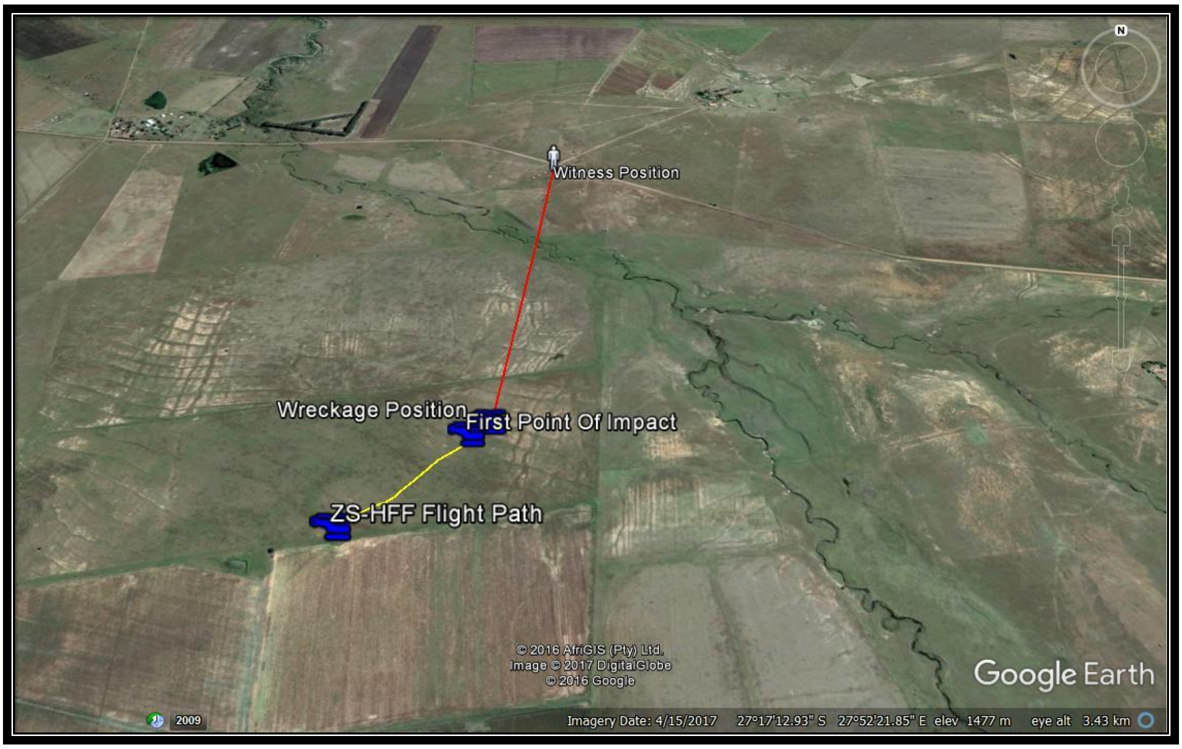


Figure 1: Google Earth overlay of the accident site

1.1.6 The wreckage was found resting on its left-hand side in the southerly direction, with the tail boom twisted slightly. The main rotor head cowling assembly was resting on its left-hand side.

1.1.7 According to the adult male who survived the accident, the pilot was busy manipulating the cyclic control before the accident occurred, but he cannot remember all the events due to his medical condition.

1.1.8 The 14-year-old male who survived the accident stated that he had been occupying the left-hand front seat when he heard a loud bang, whereafter the pilot mentioned that there was a problem with the helicopter. He did not hear any warning sound in the headset or inside the cockpit, but could remember noticing the clutch light illuminating. He further stated that the pilot pushed the cyclic control forward while the helicopter was descending to the ground and, before the impact, the pilot pulled back on the cyclic and applied the collective fully.

1.1.9 The accident occurred during daylight conditions at a geographical position determined to be S27°17'28.85" E027°51'45.12", at an elevation of 4 745 ft above mean sea level (AMSL).

1.2 Injuries to Persons

Injuries	Pilot	Crew	Pass.	Other
Fatal	1	-	1	-
Serious	-	-	2	-
Minor	-	-	-	-
None	-	-	-	-

1.3 Damage to Helicopter

1.3.1 The helicopter was destroyed by impact forces.

Figure 2: The helicopter as it came to rest after the impact sequence

Figure 3: The main wreckage after the impact sequence

1.4 Other Damage

1.4.1 None.

1.5 Personnel Information

1.5.1 Pilot-in-command:

Nationality	South African	Gender	Male	Age	47
Licence Number	0270295892	Licence Type	PPL (Helicopter)		
Licence valid	Yes	Type Endorsed	Yes		
Ratings	None				
Medical Expiry Date	30 September 2017				
Restrictions	None				
Previous Accidents	None				

1.5.2 Pilot-in-command Flying Experience:

Total Hours	561
Total Past 90 Days	14.7
Total on Type Past 90 Days	14.7
Total on Type	510.2

Note: The pilot's flying experience hours were obtained from the summary period entry in the pilot's log book that was endorsed on 30 April 2017. There were no further entries made in the logbook.

1.6 Aircraft Information

Figure 4: Complete helicopter (picture copied from the internet)

1.6.2 Airframe:

Type	Robinson R44 Raven	
Serial Number	12629	
Manufacturer	Robinson Helicopter Company	
Date of Manufacture	6 April 2009	
Total Airframe Hours (At time of Accident)	909.6 (Hobbs meter)	
Last MPI (Date & Hours)	20 March 2017	890.1
Hours since Last MPI	19.5	
C of A (Issue Date and Expiry)	3 July 2009	2 July 2017
C of R (Issue Date) (Present owner)	26 June 2009	
Operating Categories	Standard Part 91	
Retro fitment of bladder tanks	In August 2013 an approved aircraft maintenance organisation (AMO) retrofitted the ZS-HFF helicopter with the improved bladder tanks.	

Note: On 20 December 2010, the manufacturer issued R44 Service Bulletin 78 (SB-78) requiring that R44 helicopters with all-aluminium fuel tanks be retrofitted with bladder-type tanks as soon as practical, but no later than 31 December 2014. The background information to the service bulletin stated: “To improve the R44 fuel system’s resistance to a post-accident fuel leak and had to be completed as soon as possible.”

The manufacturer advised that, compared with the all-aluminium tanks, the bladder-type tanks provided improved resistance to post-accident fuel leaks due to their improved cut and tear resistance and the ability of the bladders to sustain large deformations without rupture.

SB-78 also incorporated the fitment of:

- reinforced fuel filler caps, to increase their ability to retain fuel under internal pressure loads
- roll-over vent valves, designed to minimise fuel spillage should the helicopter come to rest at an attitude that permitted fuel to reach a fuel tank vent opening.

1.6.3 Engine:

Type	Lycoming IO-540
Serial Number	L-33346-48E
Hours since New	909.6
Hours since Overhaul	TBO not reached

1.6.4 Main gearbox:

Part number	C006-5
Serial Number	5571
Hours since New	909.6
Hours since Overhaul	TBO not reached

1.6.5 Main rotor blades:

Part number	C016-5	
Serial Numbers	5954	5948
Hours since New	909.6	
Hours since Overhaul	TBO not reached	

1.6.6 Tail gearbox:

Part number	C021-1
Serial Numbers	4970
Hours since New	909.6
Hours since Overhaul	TBO not reached

1.6.7 Weight and balance:

According to available information, the pilot lifted a full load of fuel before departure from De Hoop farm to Nampo, namely about 50 US gallons of Avgas LL100.

Fuel Uplift	50 US gallons	Fuel used
De Hoop farm to Nampo	218km	15 US gallons
Nampo to crash site	126km	7 US gallons
Fuel remaining	28 US gallons	
Fuel leaked	23.5 US gallons	
Fuel drained in the main tank	4.5 US gallons	

Weight before impact	Weight (lb)
Empty weight	1 548

Pilot and front passenger	253 + 119
Aft passengers	216 + 110
Baggage	0
Fuel on board	26.86
Total mass	**2 272.86**
Maximum take-off weight	**2 500**
Access weight	**227.14**

1.7 Meteorological Information

1.7.1 An official weather report was obtained from the South African Weather Service (SAWS). The closest SAWS automatic weather station to the accident scene where data were recorded was at Frankfort, which was 62 km east of Heilbron.

Wind direction	45°–54°	Wind speed	4 kt	Visibility	CAVOK
Temperature	23.3°C	Cloud cover	Unknown	Cloud base	Unknown
Dew point	–6.4°C				

1.8 Aids to Navigation

1.8.1 The helicopter was equipped with standard navigational equipment as required by the regulator for the helicopter type. No defects that rendered the navigation system unserviceable were recorded prior to or during the flight.

1.9 Communications

1.9.1 The helicopter was equipped with standard communication equipment as required by the regulator. No defects that rendered the communication system unserviceable were recorded prior to or during the flight.

1.10 Aerodrome Information

1.10.1 The accident occurred at Ongegund farm near Heilbron in the Free State Province at a geographical position determined to be S27°17’28.85” E27°51’45.12”, at an elevation of 4 745 ft above mean sea level (AMSL).

1.11 Flight Recorders

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

1.12 Wreckage and Impact Information

1.12.1 Following an unsuccessful autorotation, the helicopter impacted the ground hard, resulting in both skids collapsing, and the helicopter nosing over and coming to rest on its left-hand side. After the impact, the helicopter bounced and skidded for about 50 m before it came to rest in an almost inverted position with the fuselage twisted, resting on its left side with the nose facing a southerly direction. On-site investigation revealed that the helicopter appeared to have been autorotating after an undetermined engine stoppage.

1.12.2 The witness mark observed on the ground was of the tail rotor guard, the main rotor blade and the belly of the aircraft, with skids gear marks next to it. As a result of high descent speed at impact, the skids opened wide and broke off while separating, with the cross tube, from the aircraft; this resulted in the belly of the helicopter coming into contact with the ground. The left and right front pieces of the skids broke off on the midsection. The main rotor blades severed the tail boom during impact with the ground, and one blade came into contact with the ground. The damage that was observed on the main and tail rotor blades indicated wear that can be attributed to damage sustained when not turning at full RPM. The windshield disintegrated and shattered in the direction of impact. Pieces of helicopter parts were scattered at an angle of 90° in the direction of impact, which was in an easterly direction at a radius of 50 m from the main wreckage.

1.12.3 According to the configuration that was observed on-site, the helicopter was fitted with dual controls. The destruction of the aircraft rendered performance of a continuity test on the flight control difficult. The pilot cyclic handle broke off and separated, consistent with the pilot handling control of the aircraft. The collective was applied fully with the throttle in the off position and the governor switch was in the 'on' position.

Figure 5: Impact by the belly of the helicopter

1.12.4 The tail drive shaft flex plate broke off, consistent with sudden stoppage of the tail rotor drive system on impact. The engine was still secured on the fuselage although rear engine mounting struts were broken off. The ring gear made teeth marks on the side of the oil cooler, which indicates signs of no rotation at impact. The alternator that provides alternating current to the helicopter electrical system revealed signs of no rotation on the pulley.

Figure 6: The fuselage lying on its left-hand side

1.12.5 The tail rotor gearbox, still attached with the tail rotor blades, broke off and separated from the tail cone, falling 10 m from the main wreckage. The damage on the tail rotor blades root was consistent with the high rotation velocity impact (Figure 7). The tail cone piece also separated and was projected 100 m from the first impact mark.

1.12.6 The engine cowling separated from the fuselage, ending 10 m from the helicopter. The muffler came off and separated from the engine. The air pipes that provide cooling air to the systems of the helicopter disintegrated and broke off; pieces thereof lying 2 m from the right-hand side of the helicopter. A direct drive squirrel cage cooling fan mounted on the engine output shaft, which supplies cooling air to the oil cooler and cylinders, was still intact on the engine, but a quarter of it was buckled due to impact forces. The alignment marks for the squirrel cage cooling fan were still in line with the securing nut. There were no signs of cooling fan rotation at the time of impact, although the damage incurred can be attributed to impact. The engine and its accessories were recovered and subjected to a teardown inspection. Although the engine was physically damaged, it was not possible to perform bench testing on a test cell.

1.12.7 The drive system didn’t reveal any sign of pre-impact damage or malfunction, the main gearbox was still attached to the fuselage, and the mast and the main rotor head didn’t show any signs of malfunction or mast bumping. The clutch assembly was still attached, although it was bent as a result of impact. The swash plate and the pitch change links were accounted for and still intact except one pitch link that was bent due to impact. The flex plate that link drive from the v-belts to the main gearbox was still intact. The v-belts didn't show any signs of breakage or malfunction. According to available information, there was fuel leaking from the damaged pipes of the main tank, however the fuel tanks were still intact and the bladder tanks sustained no damage. The damage observed was due to impact forces.

Figure 7: The tail rotor gearbox and the blades assembly

1.12.8 The instrument panel separated from the helicopter and fell 15 m from the wreckage. The auxiliary panel was still attached to the instrument panel with its components still attached. None of those components showed signs of malfunction before impact. The chronometer was indicating the time when it stopped running, which can be considered the time of impact referenced with the time the accident was reported. The Hobbs meter was still intact and indicated operation before impact; it stopped at 0909.6. The magneto switch key was selected on both magnetos.

Figure 8: The instrument panel with its gauges and warning lights

Figure 9: The auxiliary instrument panel with arrows indicating the Hobbs meter, chronometer and magneto switch

1.12.9 The main rotor blades were still attached on the main rotor hub and mast assembly, although one of the blades severed the tail boom and the other blade came into contact with the ground during the impact sequence. This was consistence with the manner in which the main rotor blade was bent and deformed in an upward, curly position, and the tip cover was missing from the blade. The main rotor blades revealed signs of low inertia damage. The blade tip cover was located 2 m closer to the impact mark from where the main rotor blade came into contact with the ground.

1.12.10The fuselage, a structure of welded steel tubing and riveted aluminium sheeting, was destroyed. The cabin section lateral beams broke off when the helicopter impacted the ground with its right side before coming to rest on its left side. The left cockpit door came off with its post and was lying forward of the fuselage. The right-hand cockpit door was still attached with the right side of the fuselage although most of the front part of the cockpit and cabin structure was destroyed. The tail boom was still secured to the airframe although the tail cone that was severed by the main rotor projected 50 m from the main wreckage.

1.13 Medical and Pathological Information

1.13.1 The cause of death for both the pilot and the passenger, according to post-mortem analysis, was determined to be unnatural multiple injuries. A toxicology was performed on a blood specimen from the pilot and the analysis result for the concentration of alcohol was 0.00 g per 100 mL, and for sodium fluoride was >3.0 g per 100 mL.

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 not considered to be survivable due to the cockpit structure of welded steel tubing and riveted aluminium sheeting, which was destroyed. The helicopter was equipped with safety harnesses, but due to the damage on the seats, it could not be confirmed if the harnesses were used by the occupants. However the two passengers seated on the left-hand side of helicopter managed to survive this accident albeit with serious injuries.

1.16 Tests and Research

The following components were removed from the wreckage and were sent for testing and analysis at various approved AMOs.

1.16.1 Clutch Actuator:

The actuator was retrieved from the wreckage and was sent to an approved AMO for functional and integrity testing, and inspection. The tests and research revealed the following points:

a. The worm wheel of the actuator, which activates when the current runs through the circuit, was energised and the worm wheel started to rotate in the direction of polarity. A reverse polarity was initiated and the worm wheel was turning in the opposite direction. The rotation of the worm wheel was satisfactory and consistent with proper operation according to the manufacture’s specification.
b. All the micro-switches were accounted for and tested for continuity and operation in accordance with the Robinson wiring diagram. The test revealed that they proved to be serviceable at the time of impact. However, one of the micro-switches was severely damaged by impacted forces, which posed difficulty in testing it.

1.16.2 The Magnetos:

The magnetos that provide spark during engine operation (right-hand and left-hand magnetos serial numbers (S/N): E08FA262 and E08EA185, respectively) proved to be in a good physical condition. The magnetos were removed from the engine and were subjected to the test bench to test for operation. Both magnetos were run at low and high RPM and were both firing sparks in all points provided.

1.16.3 The Engine – Lycoming IO 540 AE-1A5:

The engine was retrieved from the wreckage and subjected to a teardown inspection. The damage on the engine rendered difficulty to do bench test on a test cell, however a teardown inspection was conducted on Wednesday 26 July 2017 by an approved AMO; this comprised engine disassembly and a detailed inspection of rotating and non-rotating components. The engine teardown didn't reveal any engine malfunction.

a. The sparkplugs were removed and inspected; the points didn't show any signs of malfunction.
b. The engine fuel nozzles were removed and inspected; there were no signs of blockages although some of the nozzles were damaged due to impact. The the majority of the nozzles were fine.
c. The pistons and the rings were accounted for. The pistons show no signs of malfunction, the conrods were not damaged and the bearings showed no signs of damage on either of the inner and outer surfaces.
d. The camshaft was removed and inspected, and was still intact. The cam lubes show no signs of roughness or scoring. The roller lifters were all accounted for and showed good signs of operation.
e. The fuel divider was removed and inspected, and although the fuel delivery pipes were damaged, the fuel divider was not blocked. Compressed air was used to blow through the divider and there was freedom of movement of the air. The engine fuel pipes were also inspected and no blockages were found except for damage sustained from the impact forces.
f. The fuel pump was removed and disassembled. The diaphragm proved to be in good condition. The plunger, which provides movement for the suction and delivery of fuel, was operating freely without any difficulty.
g. The fuel injector was recovered and subjected to the bench test. The flow of fuel was continuous, without interruptions or blockages, at any given operational RPM by the test bench.

1.16.4 The Main and Tail Gearboxes:

The main and tail gearboxes were recovered and subjected to teardown inspection. The physical appearance of the two gearboxes proved to be in good condition. The main gearbox was disassembled and the pinion gear was observed to have impact marks on four of the teeth, consistent with sudden stoppage, and all the gear teeth were accounted for. The bearing, which provides smooth rotation of the pinion gear, was damaged by impact. The bevel gear was still intact, the bearing didn't reveal any signs of roughness and all the teeth were accounted for, although three of the teeth had sudden stoppage marks on them. The tail gearbox was disassembled and the gear teeth were intact and moving freely, with no signs of pre-impact failure.

1.16.5 The Lateral and Longitudinal Servo Actuators:

The main servo actuators were removed and inspected; their physical appearance was in good condition with no leaks. The servos were subjected to testing and pressurised with hydraulic fluid. All three servos were in good condition and showed no signs of malfunction during the test.

1.16.6 The Garmin Aera 500 Navigational GPS:

A portable navigational GPS was found on the accident site in the vicinity of the cabin area. This GPS was retrieved and send for memory download at an approved AMO. The information on the GPS that was downloadable was up to 9 March 2017; the information pertaining to the accident was not available due to the memory being full.

1.17 Organizational and Management Information

1.17.1 According to available information this was a private flight. The pilot was returning back to base at De Hoop private farm near Frankfort from the Nampo agricultural show.

1.17.2 The last maintenance inspection prior to the accident flight was certified on 20 March 2017 by an AMO that was in possession of a valid AMO approval certificate. No mechanical defect with the helicopter was recorded on the flight folio prior to the accident flight.

1.18 Additional Information

1.18.1 Power Failure:

The Robinson POH describes power failure as follows:

- A power failure may be caused by either an engine or drive system failure and will usually be indicated by a low RPM horn.
- An engine failure may be indicated by a change in engine noise level, nose left yaw, oil pressure light or decreasing engine RPM.
- A drive system failure may be indicated by unusual noise or vibration, nose right or left yaw or decreasing rotor RPM while engine RPM is increasing.
- Allow airspeed to drop below power-off Vne or below.

Caution

Aft cyclic is required when collective is lowered at high speed and forward CG (centre of gravity)

Caution

Avoid using aft cyclic during touch-down or during ground slide to prevent possible blade strike to tail cone

1.18.2 Autorotation:

The Robinson POH describes autorotation as follows:

Power failure between 8 ft and 500 ft AGL:

- Take-off operation should be conducted as per height velocity diagram.
- If power failure occurs, lower collective immediately to maintain RPM.
- Adjust collective to keep RPM in the green arc or apply full down collective if light weight prevents attaining above 97%.

- Maintain airspeed until ground is approached, then begin cyclic flare to reduce rate of descent and forward speed.
- At 8 ft AGL, apply forward cyclic to level ship and raise collective just before touch down to cushion the landing. Touch down with skid level and nose straight ahead.

1.19 Useful or Effective Investigation Techniques

1.19.1 None.

2. ANALYSIS

2.1 Man (Pilot):

The pilot was appropriately qualified and type-rated to conduct the flight as per the provisions contained in the Civil Aviation Regulations (CARs) of 2011. He held a valid private pilot licence and the helicopter type was endorsed in it. The pilot held a valid aviation medical certificate with no restrictions. The pilot was en-route back to De Hoop farm. This was a direct forward flight for the pilot. Following an undetermined engine failure, the pilot entered an autorotation which was eventful: the flaring for the autorotation was too early, resulting in the rotor speed decaying and aircraft impacting hard with the ground. Toxicology was performed on the blood specimen for the pilot and the result for the concentration of alcohol in the blood specimen was 0.00 g per 100 mL.

2.2 Aircraft (Machine):

The helicopter was maintained in accordance with the approved maintenance schedule and there were no reported defects documented prior to the flight that could have contributed or have caused the accident. What was out of the ordinary was the position of the collective stick, which was fully applied, with the throttle in the ‘off’ position and the governor switch was in the ‘on’ position. Scrutiny of the wreckage revealed astonishing signs of the engine not operating at full RPM during impact. The damage on the main and tail rotor blades revealed signs of low inertia damage. The fan wheel (cooling fan duct) was still attached to the engine with alignment marks aligned with the castellated nut that secure the fan wheel in position. The ring gear made teeth marks on the side of the oil cooler, which indicated that the engine was not turning at impact. The auxiliary fuel tank was found to be filled with fuel and about 4.5 US gallons were drained; however, fuel leaked from the broken main tank pipes after impact. The auxiliary fuel tank is interconnected with the main tank and is located somewhat higher than the main tank, so it will empty while fuel remains in the main tank. The helicopter was fitted with dual control. Test and research was conducted on the engine, clutch actuator, main servo actuators, main and tail gearboxes as well as the Garmin Aera 500 GPS. The tests revealed no mechanical anomalies that could be the cause of the accident. The Garmin Aera 500 GPS memory was downloaded but information pertaining to the accident flight was not available due to the memory being full. Due to the manner in which the helicopter was destroyed, there was high probability of a post-impact fire. However, the helicopter was retro-fitted with the bladder-type fuel tanks, which reduced the risk of fuel tank rupture.

2.3 Environment (Weather):

The prevailing weather conditions at the time had no influence on this accident. The surface wind was reported by SAWS to be 045° at 4 kt at Frankfort, which was nearest to the place where the accident took place; the wind was well within the operating limitations of this helicopter type. The terrain where the accident took place was flat and there was ample space available for an unscheduled or forced landing.

2.4 Crash Survivability**:**

The pilot incurred serious head injuries during the impact sequence. He was not wearing a flying helmet at the time of the accident. Flying with an approved flying helmet could have provided him with the necessary protection to such a degree that he could have survived the accident. The two occupants who were seated on the left side of the helicopter survived the accident. The injuries sustained by the passengers who occupied the left seats of the helicopter were due to the destruction of the cabin structure as well as the lower fuselage structure, which was manufactured from glass fibre.

2.5 Conclusion:

This was a direct flight flown by the pilot. According to available information, a loud noise was heard followed by the helicopter nose pitching up, whereafter the helicopter started descending and impacted the ground heavily. The noise/bang that came from the helicopter attracted the eyewitness' attention. He saw the aircraft flying at medium height before it descended. Before touch-down, he saw the nose of the helicopter pitching up and tail rotor striking the ground first before the impact. The eyewitness was approximately 1.5 km away when he heard the engine noise/bang; the statement of the eyewitness about the noise can be considered inconclusive due to the distance between the aircraft and the eyewitness.

A surviving passenger, who was sitting on the left front seat, was interviewed and he conveyed that he also heard a bang and can recall seeing the clutch light illuminated. He then saw the pilot manipulating the cyclic forward. Before touch-down, he witnessed the pilot flaring. The 14-year-old surviving passenger could not recall hearing a horn or seeing any pressure drop on the instrument panel.

The weight of the helicopter was well within the prescribed weight limitation in accordance with POH, and was well within the performance boundary to safely execute an autorotation in a clear area and land safely. The entry point for the autorotation was with the direction of the wind and not against the wind as stipulated on the POH. Although the surface wind in the area was calm, the effect was negligible. It is probable that the cushioning to arrest the descent was executed too late or too early, and as a result the aircraft impacted the ground at very high speed.

3. CONCLUSION

3.1 Findings:

3.1.1 The pilot was the holder of a valid private pilot licence on helicopters and the helicopter type was endorsed on his licence.

3.1.2 The pilot was the holder of a valid aviation medical certificate that was issued by a designated medical examiner, with no restrictions.

3.1.3 The helicopter Certificate of Airworthiness was valid at the time of the accident.

3.1.4 The last maintenance inspection prior to the accident flight was certified on 20 March 2017 at 890.1 airframe hours.

3.1.5 The pilot was not wearing a flying helmet when the accident occurred.

3.1.6 According to available information, there was undetermined amount of fuel that leaked out of the damaged fuel pipes. The auxiliary fuel tank contained a considerate amount of fuel. The auxiliary fuel tank is interconnected with the main tank. The fuel tanks were retrofitted with the bladder tanks.

3.1.7 No mechanical malfunctions were detected when the engine was dismantled during the accident investigation test and research. However, the ring gear made teeth marks on the side of the oil cooler during the impact sequence, indicating that the engine was not turning on impact.

3.1.8 The weight of the helicopter was well within the prescribed weight limitation in accordance with the POH (as seen in Annexure A), which was well within the performance boundary to safely execute an autorotation in a clear area and land safely. The entry point for the autorotation was with the direction of the wind and not against the wind as stipulated on the POH, although there was no significant weather at the time of the accident.

3.1.9 The two occupants who were seated on the left side of the helicopter survived the accident but with serious injuries.

3.1.10 The prevailing weather conditions at the time did not contribute to the cause of the accident.

3.2 Probable Cause/s:

3.2.1 The helicopter experience engine stoppage, the pilot executed autorotation, however the helicopter was observed pitching nose up and impacted the ground in high velocity the main rotor severed the tail boom on impact.

3.3 Contributing factor/s:

3.3.1 Undetermined engine stoppage.

4. SAFETY RECOMMENDATIONS

4.1 Safety message: It recommended to the pilots flying light helicopters to make use of aviation-approved flying helmets to increase the chances of survivability from head injuries during accidents.

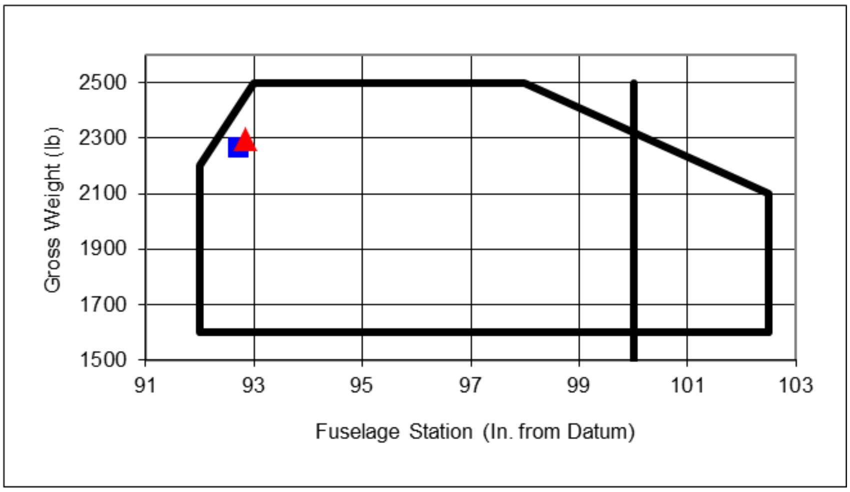
5. APPENDICES

5.1 Annexure A (Weight and balance calculation)

5.2 Annexure B (Aircraft system description)

5.1 Annexure A (Weight and balance calculation)

Weight and balance for aircraft	ZS-HFF	Category	Hire-&-Fly
Robinson R44 Raven II			
	Arm	**Weight**	**Moment**
Item	**in. from datum**	**lb**	**lb-in.**
Basic empty weight as equipped	105.9	1 548.0	163 933
Pilot (R seat)	49.5	253	12 524
Forward passenger (L seat)	49.5	119	5 445
Forward baggage	44.0	0	0
Aft passengers and baggage	79.5	326	28 620
Zero Usable Fuel	**92.7**	**2 271**	**210 522**
Usable fuel at 6 lb/gal (main tank)	106.0	16	1 696
Usable fuel at 6 lb/gal (auxillary)	102.0	10	1 020
MAUW	**85.3**	**2 500**	**213 238**
All up weight (take-off fuel)	**92.8**	**2 297**	**213 238**
	Balance (lb)	**203**	
Fuel (gal)	**To be used**	**Available**	**% Full**
Main tank (6 lb/gal)	18	30.6	59
Auxillary tank (6 lb/gal)	11	18.3	60
Weight conversion	**Kg**	**lb**	
Pilot (R seat)	115	253	
Forward passenger (L seat)	50	110	
Forward baggage	0	0	
Aft passengers and baggage	115	253	
Station	**Lb**	**Main rotor**	
92	1 600	100	2500
92	2 200	100	1500
93	2 500		
98	2 500		
102.5	2 100		
102.5	1 600		
92	1 600		



5.2 Annexure B (Aircraft system description)

1.6.1 The Robinson Pilot Operating Handbook (POH) describes the aircraft systems as follows:

1.6.1.1 The Robinson R44 is a four-seater, single main rotor, single-engine helicopter constructed primarily of metal and equipped with skid-type landing gear. The primary fuselage structure is welded steel tubing and riveted aluminium sheets. The tail cone is a monocoque structure in which aluminium skins carry most primary loads. Fiberglass and thermoplastics are used in various other cabin structures, engine cooling shrouds and various other ducts and fairings.

1.6.1.2 The doors are also constructed of fiberglass and thermoplastics. Four right-side cowl doors provide access to the main rotor gearbox, drive system and engine. A left-side engine cowl door provides access to the engine oil filler and dip stick. For additional access to controls and other components, there are removable panels between the seat cushions and seat backs, on each side of the engine compartment and under the cabin. All four cabin doors may be removed and installed by maintenance personnel or pilots.

1.6.1.3 The main rotor has two all-metal blades connected to the hub by individual coning hinges. The hub is mounted to the shaft with a teeter hinge located above the coning hinges. The main rotor blades have thick stainless-steel leading edges, resistant to corrosion due to weather and erosion due to sand and dust. Blade skins are also stainless steel to resist corrosion. Pitch change bearings for each blade are enclosed in housings at the blade root. Each housing is filled with oil and hermetically sealed with a neoprene boot. The coning and teetering hinges use self-lubricated Teflon bearing. Droop stops for the main rotor blades provide a teeter hinge friction restraint, which normally prevents the rotor from teetering while stopping or starting.

1.6.1.4 The tail rotor has two all-metal blades and a teetering hub with a fixed coning angle. The pitch change bearings have self-lubricated Teflon liners. The teeter hinge bearings are elastomeric. The tail rotor blades are constructed with wrap-around aluminium skins, honeycomb spars and forged aluminium root fittings.

1.6.1.5 A vee-belt sheave is bolted directly to the engine output shaft. The vee-belt transmits power to the upper sheave, which has an overrunning clutch contained in its hub. The inner shaft of the clutch transmits power forward to the main rotor and aft to the tail rotor. After the engine is started, it is coupled to the rotor drive system through vee-belts, which are tensioned by raising the upper drive sheaves. An electric actuator, located between the drive sheaves, raises the upper sheave when the pilot engages the clutch switch. The actuator senses compression load (belt tension) and switches off when the vee-belts are properly tensioned. A caution light illuminates whenever the actuator is operating, either engaging, disengaging or retensioning the belts. The light stays on until the belts are tensioned or completely disengaged. Flexible couplings are located at the main gearbox input and at each end of the long tail rotor drive shaft. The main gearbox contains a single stage spiral bevel gear set that is splash lubricated. Cooling ducts under the box are connected to the top of the engine shroud. The main gearbox is supported by four rubber mounts.

1.6.1.6 The long tail drive shaft has no support bearings but has a lightly loaded damper bearing. The tail gearbox contains a splash lubricated spiral bevel gear set. The tail gearbox output shaft is stainless steel to prevent corrosion.

1.6.1.7 One Lycoming IO-540 six-cylinder, horizontally opposed, overhead-valve, air-cooled, fuel-injected engine with a wet sump oil system powers the helicopter. The engine is equipped with a starter, alternator, shielded ignition, two magnetos, muffler, two oil coolers, oil filter and induction air filter systems. A direct drive, squirrel cage cooling fan mounted to the engine output shaft supplies cooling air to the cylinders and oil coolers via a fiberglass and aluminium shroud.

1.6.1.8 The flight controls are dual flight controls as standard equipment, and all primary controls are actuated through push-pull tubes and bell cranks. Bearings used throughout the control system are either sealed ball bearings or have self-lubricated Teflon liners. Flight controls are conventional. The cyclic stick appears to be different but the grip moves the same as in other helicopters due to the free hinge at the centre pivot. The cyclic grip is free to move vertically, allowing the pilot to rest his forearm on his knee if he chooses. The collective stick is also conventional, with a twist-grip throttle control. When the collective is raised, the throttle is opened by an interconnecting linkage. An electronic governor makes minor throttle adjustments required to maintain revolutions per minute (RPM).

1.6.1.9 The governor maintains engine RPM by sensing changes and applying corrective throttle inputs through a friction clutch, which can be easily overridden by the pilot. The governor is only active above 80% engine RPM and can be switched on or off using the toggle switch on the end of the right seat collective. The hydraulic system boosts the main rotor flight controls and eliminates cyclic and collective feedback forces. The hydraulic system consists of a pump, three servos, a reservoir and interconnecting lines. The pump is mounted on and driven by the main rotor gearbox to maintain hydraulic pressure in the event of an engine failure. A servo is connected to each of the three push-pull tubes that support the main rotor swashplate.

1.6.1.10 Engine controls consist of a twist-grip throttle, one located on each collective stick. They are interconnected and actuate the fuel control butterfly valve through a system of bell cranks and push-pull tubes. The linkage is designed to open throttle as the collective stick is raised. A detent spring, located in the vertical throttle push-pull tube, allows the pilot to roll throttle off beyond the idle stop prior to ground contact (run-on) autorotation landing. Other engine controls include a mixture control on the console face, push-to-start buttons on the pilot’s cyclic and collective, an engine governor switch on the pilot’s collective and a key-type ignition switch. The cyclic start button allows the pilot to maintain cyclic control during an air restart. The fuel system includes main and auxiliary tanks. The auxiliary tank is interconnected with the main tank and located somewhat higher so it will empty while fuel still remains in the main tank. One valve controls flow from both tanks.