AIRCRAFT ACCIDENT REPORT AND EXECUTIVE SUMMARY

				Reference:	CA18/2/3/9503		
Aircraft registration	ZS-SDJ	**Date of accident**	2 December 2015		**Time of accident**	0329Z	
Type of aircraft	Robinson R44 Raven II		**Type of operation**		Private (Part 91)		
Pilot-in-command licence type	Commercial		**Age**	30	**Licence valid**	Yes	
Pilot-in-command flying experience	Total flying hours		1 058,7		Hours on type	1 024,5	
Last point of departure	Farm Uitenpas near the town of Musina, Limpopo province						
Next point of intended landing	Farm Ehrenbreitstein, Limpopo province						
Location of the accident site with reference to easily defined geographical points (GPS readings if possible)							
Portion 66 of the farm Musina (GPS position; 22°20.242' South 030°02.891' East), elevation 1780 ft AMSL							
Meteorological information	Surface wind: Light and variable; Temperature: 22°C; CAVOK						
Number of people on board	1 + 1	**No. of people injured**	0	**No. of people killed**	2		

Synopsis

The pilot, accompanied by a passenger took off from the farm Uitenpas, just outside the town of Musina, on a private flight to another farm approximately 20 nautical miles (nm) to the south-west. Three of the four doors had been removed from the helicopter and two 25-litre containers of Avgas loaded in the cabin. Shortly after the helicopter became airborne, the pilot flew over the town and executed a left turn. According to a witness standing outside his house, approximately 1 nm to the south of the helipad from which the helicopter took off, the helicopter was flying at a low level in a south-easterly direction. The witness stated that when the helicopter approached his property while flying very low, the engine pitch suddenly changed as if it was losing power. The helicopter immediately pitched nose-down. He then lost sight of it when it disappeared behind trees that obscured his vision. He ran towards the accident scene and contacted one of the owners of the helicopter on his cellphone, who in turn notified the emergency services. At the scene, the pilot was lying on a sand embankment about 20 m from the point of impact. The pilot was seriously injured. While the witness waited for the paramedics, the helicopter owner arrived on the scene and advised him that there had been another person on board. The emergency personnel located the body of the other person underneath the main wreckage. The pilot succumbed to his injuries shortly after the accident. The helicopter was destroyed during the impact sequence. The accident was reported to the authorities by the police and an official investigation began on the same day.

Probable cause

Unsuccessful forced landing following an undetermined loss of engine power shortly after take-off.

SRP date	28 March 2017	Release date	05 April 2017

AIRCRAFT ACCIDENT REPORT

Name of Owner	**:** Central Africa Transport (Pty) Ltd
Name of Operator	**:** Private (Part 91)
Manufacturer	**:** Robinson Helicopter Company
Model	**:** R44 Raven II
Nationality	**:** South African
Registration	**:** ZS-SDJ
Place	**:** Musina
Date	**:** 2 December 2015
Time	**:** 0329Z

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 establish legal 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 The helicopter had been securely parked in a hangar on the farm Uitenpas, just outside the border of Musina. Also available at the hangar was a refuelling trailer, which contained Avgas for refuelling the helicopter. The trailer was parked in a secure area.

1.1.2 The pilot and his passenger were on a private flight to another farm, Ehrenbreitstein, approximately 20 nm south-west of Uitenpas.

The passenger was seated in the left front seat. Both front doors and the right aft door of the helicopter had been removed before the flight. The doors were found inside the hangar at Uitenpas. Also on board were two 25-litre containers of Avgas.

1.1.3 According to a witness, the owner of the property where the helicopter accident occurred, he was standing outside his house when he saw a helicopter approaching from the direction of the mine dump to the north of his property. The helicopter was flying very low, below the height of the mine dump.

As the helicopter crossed the boundary of his property, the witness noted that the engine pitch suddenly changed as if it was losing power, and the helicopter immediately pitched nose down. He then lost sight of the helicopter as it disappeared behind some trees, which obscured his vision. When he heard the crash, he ran towards the scene of the accident to see if he could render assistance. He also called one of the owners of the helicopter on his cellphone and informed him of the accident, asking him to contact the emergency services. The helicopter had crashed onto a shooting range. He could see the ground impact marks and the main wreckage, which was being propelled over the backstop sand embankment of the shooting range.

The witness observed a male person (the pilot) lying on the south side of the main backstop. It was clear that he had been thrown from the helicopter during the impact sequence. The witness saw that the pilot had sustained serious injuries. He decided not to move him, fearing internal injuries, and to wait for emergency medical personnel (paramedics) to arrive.

The owner of the helicopter arrived shortly thereafter and told the eyewitness/property owner that there might have been another person on board the helicopter. The body of the second person was found underneath the wreckage when the emergency rescue services arrived and started clearing the vegetation.

1.1.4 During an interview, the eyewitness stated that he was familiar with the helicopter and the sounds associated with it as it regularly flew in the area. The helipad on the farm Uitenpas from which the helicopter had taken off was 1 nm to the north of the accident scene.

1.1.5 The pilot had suffered serious chest trauma and succumbed to his injuries in the doctor’s rooms in town before he could be airlifted to a private hospital.

1.1.6 The accident occurred during daylight conditions (early morning) at a geographical position that was determined to be 22°20.242' South 030°02.891' East, at an elevation of 1 780 feet above mean sea level (AMSL).

1.2 Injuries to persons

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

1.3 Damage to aircraft

1.3.1 The helicopter was destroyed during the impact sequence.

Figure 1. The main wreckage as it came to rest

1.4 Other damage

1.4.1 No other damage was caused.

1.5 Personnel information

1.5.1 Pilot-in-command (PIC)

According to available information, the pilot had started flying helicopters on 17 January 2012 at an aviation training organisation (ATO) that was based at Rand Aerodrome. He passed his flying skills test for his private pilot licence on 6 February 2012. During his training period, he had flown both the Robinson R22 and R44 type helicopters and had accumulated a total of 54.1 flying hours.

It was noted that shortly after he obtained his private helicopter pilot licence, he flew a Robinson R44 helicopter in Mozambique for a year. On his return to South Africa, he had accumulated sufficient flying hours to obtain his commercial helicopter pilot licence. He conducted his flight test on 15 February 2013 with a flight instructor from the same ATO where he had done his private pilot training, and passed.

On 22 May 2014, the pilot started flying the accident helicopter (ZS-SDJ) on a full-time basis, and he continued to do so until the accident flight. He conducted his game/cull rating on this helicopter on 27 May 2014, flying 6.3 hours with a flight instructor in order to obtain the rating.

Nationality	South African	Gender	Male	Age	30
Licence number	0271072431	Licence type	Commercial		
Licence valid	Yes	Type endorsed	Yes		
Ratings	Night and Game/Cull rating				
Medical expiry date	28 February 2016				
Restrictions	None				
Previous accidents	None				

Flying experience:

Total hours	1 058.7
Total past 90 days	134.6
Total on type past 90 days	134.6
Total on type	1 024.5

The pilot held a valid commercial fixed-wing pilot licence. According to available information, he had two separate logbooks. The only logbook that was made available to the Investigator was his helicopter flying logbook.

*NOTE: The flying hours entered in the table above therefore only apply to his helicopter flying.

The last entry in the helicopter pilot's logbook was dated 24 November 2015. One of the owners of the helicopter (also a pilot rated on the Robinson R44) had flown with him the day before the accident flight. He stated that they flew for one hour and thirty minutes and that no defects on the helicopter had been detected during the flight.

According to the pilot's logbook, the pilot had flown 884.7 hours on the accident helicopter over a period of approximately eighteen months.

1.6 Aircraft Information

1.6.1 The Robinson R44 Raven II is a four-seat light helicopter produced by the Robinson Helicopter Company. The helicopter is equipped with a single horizontally opposed reciprocating engine, with a semi-rigid two-bladed main rotor system and a two-bladed tail rotor system. It also features hydraulically assisted flight controls and is equipped with a spring and yield skid-type landing gear. It has an enclosed cabin with two rows of seats side-by-side, with the pilot flying from the right front seat.

Figure 2. A Robinson R44 in hover flight (photograph was obtained from the internet)

Airframe:

Type	Robinson R44 Raven II	
Serial number	12073	
Manufacturer	Robinson Helicopter Company	
Year of manufacture	2008	
Total airframe hours (at time of accident)	936.1 (total airframe hours 3019.2)	
Last MPI (hours & date)	900.1	4 November 2015
Hours since last MPI	36.0	
C of A (issue date)	3 April 2008	
C of A (expiry date)	2 April 2016	
C of R (issue date) (present owner)	21 May 2014	
Operating categories	Standard Part 127	

*NOTE: This helicopter had been subjected to a major overhaul. The helicopter manufacturer allows an operational life of 2 200 hours, whereafter a major overhaul of the airframe and engine becomes mandatory. The total airframe hours in the table above were flown after the major overhaul and correlated with the Hobbs meter installed in the helicopter.

The airframe hours at the time of the maintenance inspection were 2983.2. A further 36 hours were flown with the helicopter after the inspection was certified, bringing the total airframe hours to 3019.2.

Engine:

Type	Lycoming IO-540-AE1A5
Serial number	L-28803-48A
Hours since new	936.1
Hours since overhaul	T.B.O. not yet reached

1.6.2 Weight and balance

The helicopter was last weighed on 15 May 2014 and the empty weight was 1 583.5 pounds (lbs) or 718 kg. According to the pilot's operating handbook (POH) the maximum certified take-off weight for this helicopter was 2 500 lbs (1 134 kg).

The weight of the pilot was 78.6 kg (174 lbs) and that of the passenger 64.4 kg (142 lbs) according to the medico-legal autopsy reports. The two 25-litre containers of Avgas on board amounted to a combined weight of 79 lbs or 36 kg. The location of the containers inside the helicopter could not be determined.

The last entry in the flight folio was dated 24 November 2015, when 77 litres of Avgas was uplifted. The Hobbs meter reading at the time was entered as 927.1. At the time of the accident, the Hobbs reading was 936.1. The helicopter had therefore been flown for a period of nine (9) hours with no documented evidence available to support these flights, nor any records pertaining to fuel uplifts or possible defects to the helicopter.

The take-off weight of the helicopter was calculated as reflected in the table below. Due to the absence of proper record-keeping, no flight folio entry was available to reflect the fuel status before the accident flight. The calculation in the table below reflects the take-off weight of the helicopter AS IF both fuel tanks were filled to capacity before take-off. The calculation indicates that the helicopter was operated within its maximum take-off weight limitations.

Item	Weight (lbs)
Helicopter empty weight	1 583.5
Pilot (78.6 kg)	174

Passenger (64.4 kg)	142
Baggage 2 x 25L containers (Avgas)	79
Total weight (with zero useable fuel)	**1 978.5**
Fuel useable main tank	184
Fuel useable auxiliary tank	110
Total weight (with take-off fuel)	**2 272.5**

1.7 Meteorological information

1.7.1 An official weather report was requested from the South African Weather Services. The information entered in the table below was obtained from the report with the source reference being the surface observations at the Venetia Mine, which was located 47 nm (88 km) west of Musina. The surface data entered in the table below was captured on 2 December 2015 at 0333Z.

Wind direction	319°	Wind speed	6 kts	Visibility	+ 10 km
Temperature	22°C	Cloud cover	Nil	Cloud base	Nil
Dew point	14°C				

1.7.2 Fine weather conditions prevailed when the accident investigator arrived on the scene later on the same day. The estimated temperature was in the mid thirty degree Celsius range, with no wind and scattered cirrus clouds.

1.8 Aids to navigation

1.8.1 The helicopter was equipped with standard navigational equipment as approved by the Regulator for the helicopter type. No defects that rendered the navigation system unserviceable were recorded before or during the flight.

1.9 Communication

1.9.1 The helicopter was equipped with standard communications equipment as approved by the Regulator for the helicopter type and there were no recorded defects before or during the flight.

1.9.2 The VHF frequency 124.8 MHz was selected on the radio. It could not be established if the pilot had indeed broadcast on the frequency, as he was flying outside controlled air space.

1.10 Aerodrome information

1.10.1 The accident did not occur at or near an aerodrome but on private property.

1.11 Flight recorders

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

1.12 Wreckage and impact information

1.12.1 The accident site was 1 nm south of the helipad on the farm Uitenpas, from where they took off, from as can be seen on the Google Earth overlay in Figure 3.

1.12.2 The helicopter crashed into the ground in a south-easterly direction after it cleared an elevated irrigation system, which was supported by 5 m high wooden poles (Figure 4 and 5).

Figure 3. Google Earth overlay indicating take-off location and accident site (ZS-SDJ)

Figure 4. View from point of impact looking towards irrigation system and mine shaft

Figure 5. View of elevated irrigation system and impact area

1.12.3 The first ground impact marking was caused by the tail stinger and lower vertical stabiliser (Figure 6). From that point, it was observed that the helicopter had crashed heavily into the ground in a slight right skid low, upright attitude, with the right skid gear imprint visible in the soil at the point of impact, followed by the left skid. From this point onwards (looking forward), the airframe was destroyed, with the skid gear assembly breaking off and objects from inside the cockpit/cabin being propelled forward, until the helicopter hit the backstop sand embankment of the shooting range.

Figure 6. First point of ground impact

1.12.4 The main wreckage (the airframe with the engine and main rotor transmission, including the main rotor blades) as seen in Figure 11 bounced over the backstop sand embankment. There was no evidence that the main wreckage had made contact with the embankment between the site of first impact with the ground (western side) until it came to rest. Assessment of the condition of the main rotor blades indicated that very little inertia (rotor rpm) remained in the main rotor blades on impact. Both tail rotor blades were found severed near the blade cuffs, close to the tail rotor assembly, which was still attached to the aft tail boom structure (Figure 9). The aft tail boom structure had separated from the tail boom during the impact sequence. Most of the tail boom structure remained attached to the main fuselage.

1.12.5 The left aft door was accounted for (Figure 7, 8). Both 25-litre containers of Avgas ruptured on impact when they were propelled from the cabin. The instrument panel as a unit (Figure 7) was located approximately 20 m to the right of the point of impact.

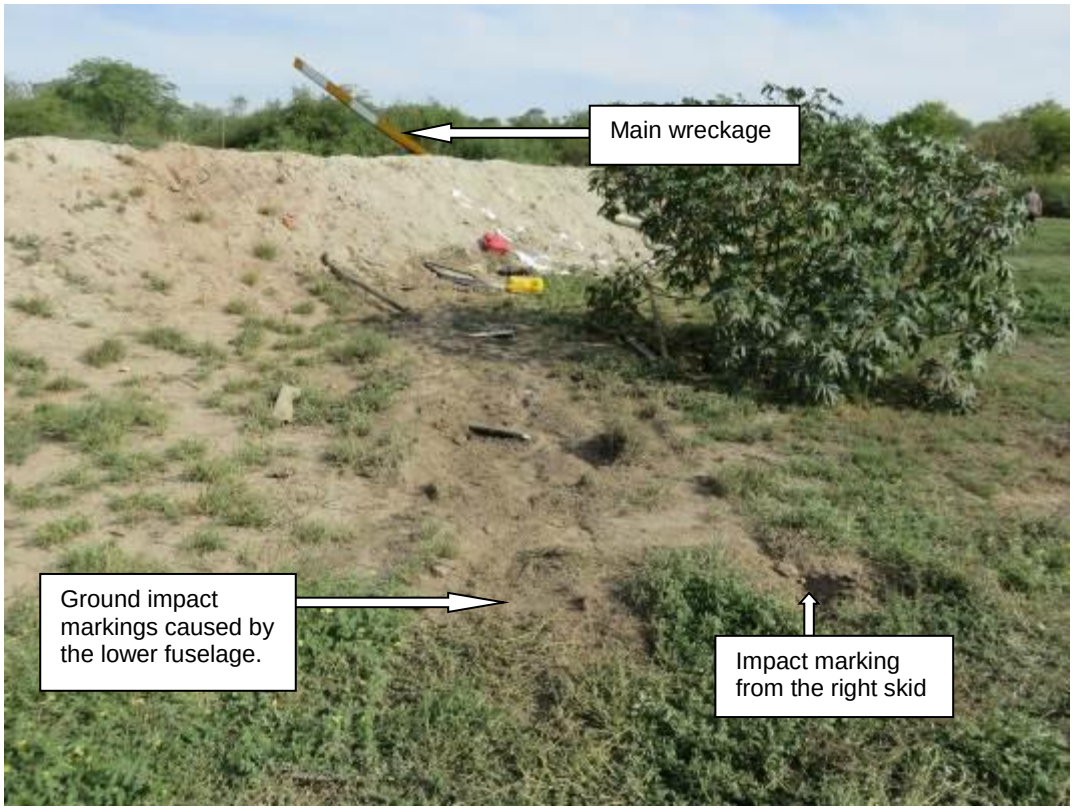


Figure 6: Ground impact markings

Figure 7. Debris spread across the side backstop wall

Figure 8. Debris spread – different angle

Figure 9. Tail rotor assembly still attached to aft tail boom structure

1.12.6 The position of both fuel tanks can be seen in Figure 10. The main tank, which is also the tank that supplies fuel to the engine via gravity flow, was partially ripped out of the fuselage structure. The tank was ruptured and did not contain any fuel. The auxiliary tank remained attached and contained some fuel. This tank also had some rupture holes which would have allowed fuel to leak out.

Figure 10. Main wreckage as it came to rest

1.12.7 The battery of the helicopter was propelled approximately 45 m from the point of impact and landed on the shooting range (Figure 11). During normal operations the battery is mounted inside the engine compartment on the left side. The instrument panel (Figure 12) had been separated from its installation and was located approximately 20 m to the right of the point of impact.

Figure 11. Battery of helicopter

Figure 12. Instrument panel as found on site

1.12.8 The main fuselage (Figure 13) was severely disrupted. All failures, which include the push-pull tubes of the flight control system, were associated with the impact sequence. The drive system was inspected and no evidence could be found of a malfunction of the system, which includes both gearboxes (main rotor and tail rotor) as well as the clutch actuator which raises the upper drive sheave. The V-belt sheave that was bolted directly to the output shaft of the engine was intact, and the three V-belts were accounted for. The forward tail rotor drive shaft flexible coupling had fractured in the torsional overload. The primary components of the hydraulic system were accounted for, including the pump, the three servo actuators, connecting lines and the reservoir, which is mounted on a steel tube frame behind the main rotor gearbox. The emergency locator transmitter (ELT) was also found intact. Figure 13 displays the damage to the lower fuselage and the lower engine during the impact sequence.

Figure 13: Engine still within fuselage. Photograph taken during recovery

1.12.9 In Figure 14, the destruction of the cockpit/cabin area can be seen, with the floor structure on the pilot's side (on the right side when looking at the helicopter from behind) completely destroyed/missing. The fuel shut-off valve, which was located in the cabin between the two front seats, was in the ON position.

Figure 14. The cockpit/cabin area, photographed during recovery

1.13 Medical and pathological information

1.13.1 The medico-legal autopsy report stated that the pilot succumbed to blunt force chest injuries sustained during the impact sequence.

1.13.2 The medico-legal autopsy report stated that the passenger succumbed to multiple blunt force injuries because of the accident.

1.14 Fire

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

1.15 Survival aspects

1.15.1 Due to the severity of the impact forces and the destruction of the cockpit/cabin area, the accident was not considered survivable.

1.15.2 The helicopter was equipped with an ELT. The unit was installed behind the main rotor gearbox on a support beam, and remained intact after the crash. However, the unit did not activate during the impact sequence.

1.16 Tests and research

1.16.1 The engine, a Lycoming IO-540-AE1A5, Serial No. L-28803-48A, was removed from the wreckage and taken to an approved engine maintenance facility, where a teardown inspection was performed. The engine had sustained substantial impact damage and could not be bench-tested. The engine teardown report is attached as Annexure A.

1.17 Organizational and management information

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

1.17.2 Aircraft maintenance organisation (AMO) No. 1210 had certified the last mandatory periodic inspection on the helicopter before the accident flight. This inspection was carried out on 4 November 2015 at 900.1 airframe hours. The maintenance organisation was in possession of a valid AMO approval certificate.

1.18 Additional information

1.18.1 Hangar facility for the helicopter

The helicopter was parked in a hangar on the farm Uitenpas on the night before the accident flight. Also available was an Avgas fuel trailer, which was parked in its own secure location (Figure 15). During an inspection of the hangar facility, three of the four helicopter doors were found stored inside the hangar.

Figure 15. The hangar and the fuel trailer, parked in its own secure area

An inspection of the fuel trailer was also conducted and it was found to be equipped with a proper fuel filter mechanism. The fuel filter contained a transparent housing with a water trap at the lowest point. No evidence of dirt or contamination could be detected in the fuel in the filter (Figures, 17).

Figure 16 Avgas fuel trailer

Figure 17. Electric fuel pump, refuelling nozzle and fuel filter in the aft fuel trailer

1.18.2 Safety Notice SN-10

Source: POH, Section 10, Safety Tips

"Fatal accidents caused by low rotor rpm

"A primary cause of fatal accidents in light helicopters is failure to maintain rotor rpm. To avoid this, every pilot must have his reflexes conditioned so he will instantly add throttle and lower the collective to maintain rpm in any emergency.

"The helicopter demonstrates excellent crashworthiness as long as the pilot flies the aircraft all the way to the ground and executes a flare at the bottom to reduce his airspeed and rate of descent. Even when going down into rough terrain, trees, wires and water, he must force himself to lower the collective to maintain rpm until just before impact. The ship may roll over and be severely damaged, but the occupants have an excellent chance of walking away from it without injury.

"Power available from the engine is directly proportional to rpm. If the rpm drops 10%, there is 10% less power. With less power, the helicopter will start to settle, and if the collective is raised to stop it from settling, the rpm will pull down even lower, causing the ship to settle even faster. If the pilot not only fails to lower collective, but instead pulls up on the collective to keep the ship from going down, the rotor will stall almost immediately. When it stalls, the blades will either 'blow back' and cut off the tail cone or it will just stop flying, allowing the helicopter to fall at an extreme rate. In either case, the resulting crash is likely to be fatal.

"No matter what causes the low rotor rpm, the pilot must first roll on throttle and lower the collective simultaneously to recover rpm **before** investigating the problem. It must be a conditioned reflex. In forward flight, applying aft cyclic to bleed off airspeed will also help recover lost rpm."

1.18.3 Pilot's Operating Handbook, Section 3

Definitions

Land immediately – Land on the nearest clear area where a safe normal landing can be performed. Be prepared to enter autorotation during the approach, if required.

Land as soon as practical – Land at the nearest airport or other facility where emergency maintenance can be performed.

Power Failure – General

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

CAUTION

Aft cyclic is required when collective is lowered at high speed and forward CG.

CAUTION

Avoid using aft cyclic during touchdown or during ground slide to prevent possible blade strike to tailcone.

1.19 Useful or effective investigation techniques

1.19.1 No new methods were applied.

2. ANALYSIS

2.1 Man (Pilot)

The pilot was the holder of a valid commercial helicopter pilot licence and met the regulatory requirements to fly the helicopter. He had accumulated 884.7 (documented) flying hours on this helicopter (ZS-SDJ) over a period of approximately eighteen months and was therefore well acquainted with it.

The intended flight was nothing out of the norm for the pilot and he opted to remove three of the four doors for the flight. Two additional 25-litre Avgas containers were also transported on board, which he most probably would have used to add fuel to the helicopter tanks as the flying for the day progressed.

The helicopter was parked overnight in a secure hangar on the farm Uitenpas. The pilot, accompanied by a passenger, took off from the farm early in the morning and was flying in a south-westerly direction over the town (built-up area) of Musina. It would appear that shortly after take-off, while still flying at a low level, there was an emergency on board (the nature of such an emergency could not be determined) and that the pilot made the decision to turn left, most probably with the intention to return to the helipad or to land on an open area on a nearby mine. The emergency most probably required him to land immediately or as soon as practical. However, while he was trying to find an open area, he presumably could not enter into hover flight or a hover taxi as the main rotor rpm started to decay rapidly. Because he was flying at a low level, he had no altitude available to arrest the main rotor rpm by lowering the collective pitch lever. He did manage to clear the elevated irrigation structure ahead of them at that stage, but the main rotor blade rpm was already substantially depleted and the helicopter crashed heavily into the ground in an upright position. Safety notice SN-10 states: “it will just stop flying, allowing the helicopter to fall at an extreme rate”. The evidence found on the site correlates with what the pilot’s operating handbook states in Safety Notice 10.

2.2 Machine (Helicopter)

The helicopter was maintained in accordance with the approved maintenance schedule and a further 36 hours had been flown with it since the last maintenance inspection was certified on 4 November 2015. The last documented entry in the flight folio was dated 24 November 2015. Following the maintenance inspection on 4 November 2015, no defects were entered into the flight folio until the last entry was made on 24 November 2015. During the period 25 November until 2 December 2015, including the accident flight, a further nine (9) hours were flown with the helicopter. No documented evidence of these flights could be found; therefore one has to presume that there no defects with the helicopter before the accident flight on the morning of 2 December 2015, as the pilot would not have compromised the safe operation of the helicopter by flying with a defect or defects that would have impaired the performance of the helicopter.

The witness did state that he was familiar with the helicopter as it was flying on a regular basis in the area, with the hangar where it was parked located approximately 1 nm north of his property. He stated that as the helicopter approached his property, “the motor pitch changed suddenly as if losing power, and the helicopter nose-dived almost immediately thereafter.”

During the post-field investigation, the engine was removed from the wreckage and a teardown inspection was conducted at an approved engine overhaul facility. The teardown inspection did not reveal any evidence of a mechanical defect or associated failure that would have prevented normal engine operation. It was evident from the pilot’s actions that there was an on-board emergency as he made the decision to turn left shortly after becoming airborne, most probably with the intention to return to the helipad (point of take-off). The situation changed hastily and he had to land immediately but was over a built-up area.

The witness stated that the motor pitch had changed suddenly as if losing power. However, the cause of the change in the pitch of the engine as the witness described it could not be determined as no mechanical malfunction was observed during the engine teardown inspection. All engine operational signs observed could be associated with normal engine operation.

From the ground impact markings, it was evident that the helicopter crashed heavily into the ground, destroying the skid gear and then the cockpit/cabin area. The pilot and the cargo in the cabin were forced from the cockpit/cabin area on impact. The main wreckage bounced over the backstop sand embankment of the shooting range and came to rest in an upright position on the other side. Apart from one of the main rotor blades that was bent, the blades displayed evidence associated with low inertia during the helicopter crash. The helicopter therefore stopped flying and fell to the ground at an extreme rate.

All components associated with the drive system, including the engine to main rotor transmission, were accounted for and all failures were associated with impact damage.

Evidence of poor record-keeping was observed. A period of nine (9) flight hours before the accident flight could not be accounted for owing to a lack of documentation to support these flights. In addition, there were no records pertaining to fuel uplifts or possible defects to the helicopter.

There was no evidence of any pre- or post-impact fire. Fuel was evident in the auxiliary fuel tank, which was still secured to the airframe although it contained several rupture holes. The main fuel tank from which fuel is supplied to the engine suffered such severe impact damage that it broke out of the fuselage frame structure.

The take-off weight of the helicopter was calculated based on an assumption that both fuel tanks were filled to capacity before take-off, and was found to be within the operating limitations of the helicopter. The presence of two 25-litre containers filled with Avgas on board supports the assumption that the pilot had planned to fly a certain number of hours for the day and carried additional fuel should it be required. It was highly unlikely that he would have carried additional fuel without ensuring that the fuel tanks were also filled to capacity before take-off.

2.3 Environment

Fine weather conditions prevailed at the time of the accident flight, and were not considered to have had any bearing on the accident.

Following take-off, the helicopter was observed flying in a south-westerly direction over the town (built-up area) of Musina, when the pilot executed a left turn. The reason for the turn was most probably an on-board emergency that caused the pilot to decide to turn back. The type of emergency could not be determined.

The landing area that was selected by the pilot might have appeared to be an open or clear area from some distance away, but when he came closer, he would have seen the elevated irrigation structure. The structure was found to blend in with the environment as most of the wooden poles were light grey, blending in with the white sand.

The pilot probably stretched the glide to its maximum to clear these obstructions, as he would have realised the consequences if the helicopter collided head-on with one of the support structure poles.

2.4 Survivability

The property owner, who witnessed the helicopter approaching his land, was not

aware that there was a second occupant on board the helicopter. One of the owners of the helicopter who arrived on the scene after he was notified of the accident told the witness about the second person.

The body of the person was found by emergency services personnel were it was trapped underneath the main wreckage. She was still secured by the helicopter equipped safety harness. This accident was not considered survivable due to the excessive impact forces associated with it, which led to severe trauma for both occupants.

3. CONCLUSION

3.1 Findings

3.1.1 The pilot was the holder of a valid commercial pilot licence and he had the helicopter type endorsed on his licence. He was also the holder of a valid commercial fixed-wing pilot licence.

3.1.2 The pilot was in possession of a valid aviation medical certificate that was issued by a CAA-approved medical practitioner.

3.1.3 The last entry in the pilot logbook was dated 24 November 2015. According to one of the owners of the helicopter, he had flown with him the day before the accident; the duration of the flight was one hour and thirty minutes (1.5 hours).

3.1.4 This was a private flight; the pilot was accompanied by a passenger.

3.1.5 The helicopter was in possession of a valid certificate of airworthiness and had been maintained in accordance with the regulations.

3.1.6 Three of the four doors were removed before the flight and there were two 25-litre containers on board filled with Avgas.

3.1.7 Refuelling was conducted from a fuel trailer that was parked in a secure location at the hangar on the farm Uitenpas.

3.1.8 No documented evidence (flight folio) was available for the last nine (9) hours of flight with the helicopter before the accident flight, including records pertaining to fuel uplifts and any possible defects of the helicopter.

3.1.9 The teardown inspection of the engine did not reveal any pre- or post-impact mechanical failure that would have prevented the engine from normal operation.

3.1.10 A small amount (a few millilitres) of fuel was still present in the fuel injector servo during the engine teardown inspection.

3.1.11 The weight and balance calculation indicates that the helicopter was within its maximum weight limitation on take-off.

3.1.12 Due to the high impact forces and the destruction of the cabin/cockpit area, the accident was considered not to be survivable.

3.1.13 The pilot was propelled from the cockpit during the impact sequence and succumbed to his injuries, which were associated with severe chest trauma.

3.1.14 The property owner who witnessed the accident was not aware that there was a second occupant on board until he was informed of such a person by one of the owners of the helicopter. The body of the person was found underneath the main wreckage by emergency services personnel that arrived on the scene.

3.1.15 Fine weather conditions prevailed at the time of the accident, and were not considered to have had any bearing on the accident.

3.2 Probable cause

3.2.1 Unsuccessful forced landing following an undetermined loss of engine power shortly after take-off

3.3 Contributory factors

3.3.1 An on-board emergency situation occurred shortly after take-off while they were still flying at low level. The lack of altitude did not allow the pilot to recover the main rotor's rpm as he could not lower the collective pitch lever.

3.3.2 The area identified by the pilot for the forced landing was covered by an elevated irrigation system. He most probably became aware of this hazard once he was in close proximity to it, whereupon he attempted to obtain the maximum glide distance

in order to clear the irrigation structure.

3.3.3 The elevated irrigation structure was found to have blended in with the surrounding environment and the obstruction/risk associated with it only became apparent when the pilot was in close proximity to it.

4. SAFETY RECOMMENDATIONS

4.1 None.

5. APPENDICES

5.1 Annexure A (Engine teardown report)

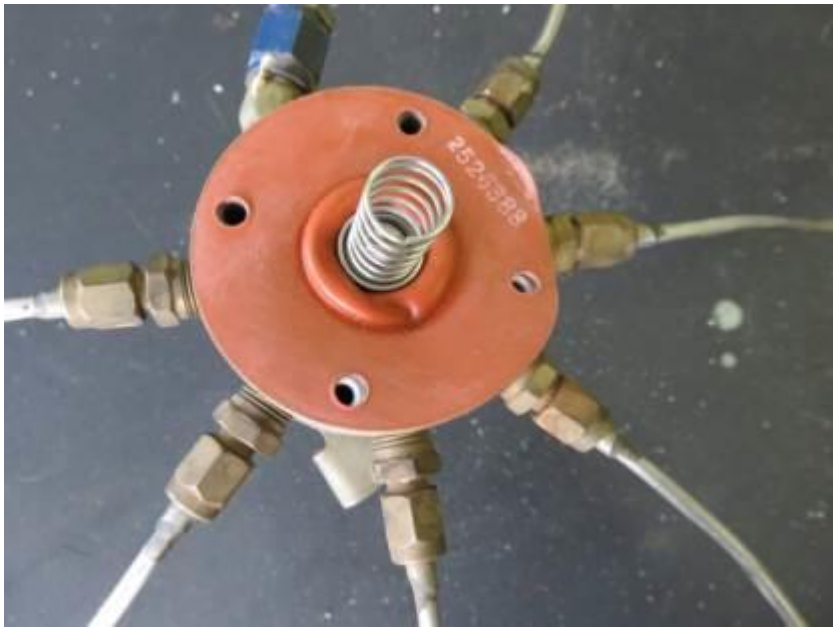
ANNEXURE A

The engine, a Lycoming IO-540-AE1A5, Serial No. L-28803-48A, was removed from the wreckage after recovery and taken to an approved engine maintenance facility (Figure A1), where a teardown inspection was performed on Wednesday, 17 February 2016. The engine sustained substantial impact damage and could not be bench-tested (Figure A2). The purpose of the teardown inspection was to assess the mechanical integrity of the engine. The following observations were made:

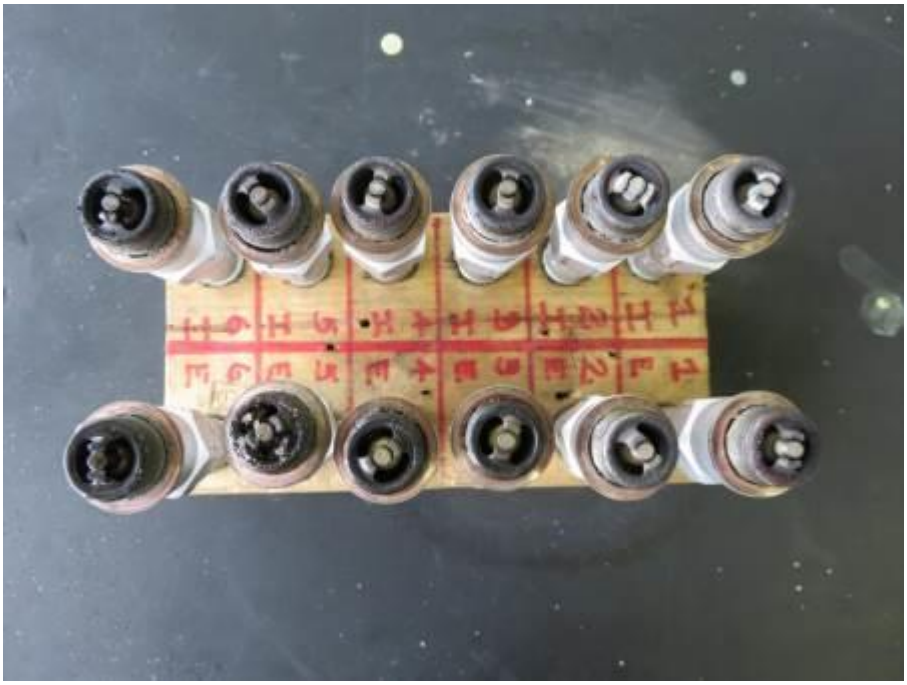
Figure A1: Engine before teardown inspection

Figure A2: Impact damage visible to bottom of engine

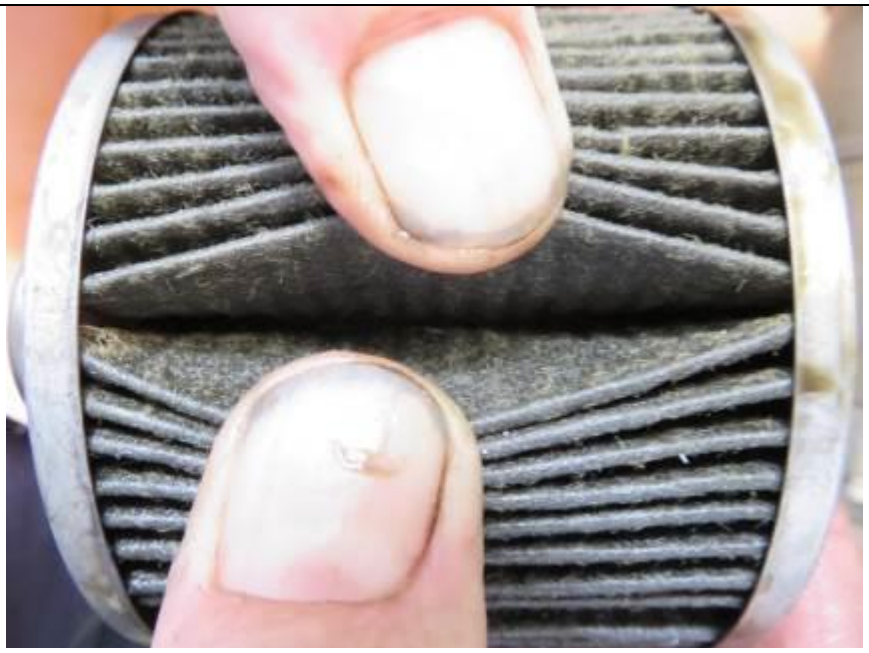
Engine Model	**Lycoming IO-540-AE1A5**
Serial No.	**L-28803-48A**
Fuel injector servo: Precision Part # 2576630-4 Serial # 70050201	The fuel injector servo sustained minor impact damage and was found to be in an overall good condition. A small amount of fuel (a few millilitres) was drained from the unit after it was removed from the engine. All linkages were secured and no anomalies were noted that would have restricted normal operation. The fuel filter that forms part of the unit was removed and was found to be free of any contamination.

	
Fuel pump	The fuel pump was undamaged and was removed from the engine.
Fuel flow divider: Part # LW-2576526-1 Serial # 2576526-1	The six fuel lines that attached to the fuel flow divider were found to be intact and the fuel lines were secured to the fuel nozzles. The wire lockings were cut and the unit opened. The unit did not display any internal damage or dirt and the diaphragm was found to be intact (see photograph). 

Fuel nozzles/ Injector nozzles	All six fuel nozzles were removed from the engine and were inspected; they were found to be clean (free from any obstructions as can be viewed in the second photo below).  
Spark plugs: Champion REM-38E	The spark plugs were removed from the cylinders and found to be in good overall condition, displaying a light brownish colour, which were associated with normal engine operation. The lower spark plug on cylinder 5 displayed evidence of oil and a small amount of sand on the electrodes.

	
HT harness: Slick	The high-tension harnesses were in good overall condition and were secured to both magnetos and all the spark plugs.
Magnetos: Alpha Systems #66B21784 (right side), #66B21783 (left side)	Both magnetos were still attached to the engine. The units did not sustain any damage and it was possible to bench-test both. The units were removed from the engine and subjected to a bench test at an approved electrical maintenance facility. During the bench test, both magnetos were found to function satisfactorily, providing spark over the entire rpm range tested. The photograph on the next page displays one of the magnetos being bench-tested.

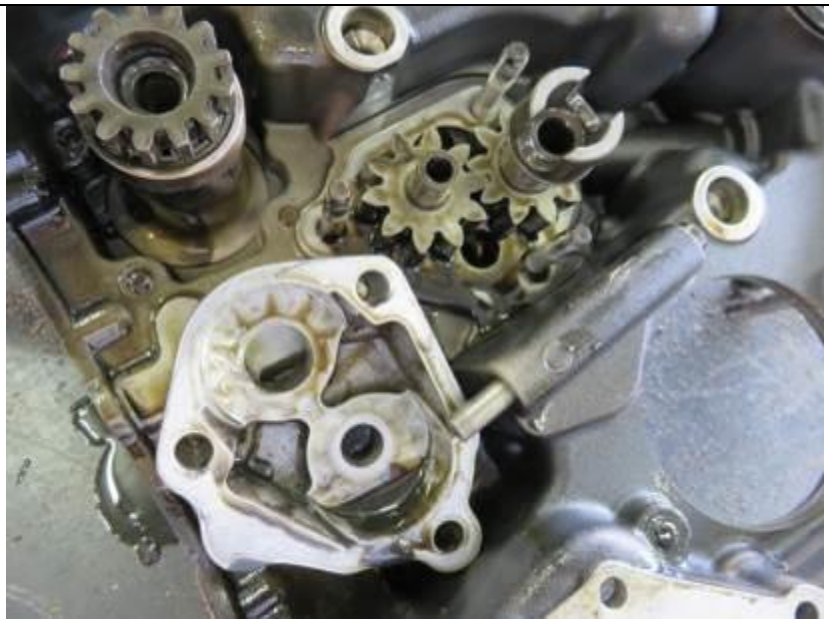
	 
Oil filter	The filter unit was still attached to the engine and sustained minor impact damage. It was removed and the filter housing cut open. No evidence of dirt/debris was found in the filter element.

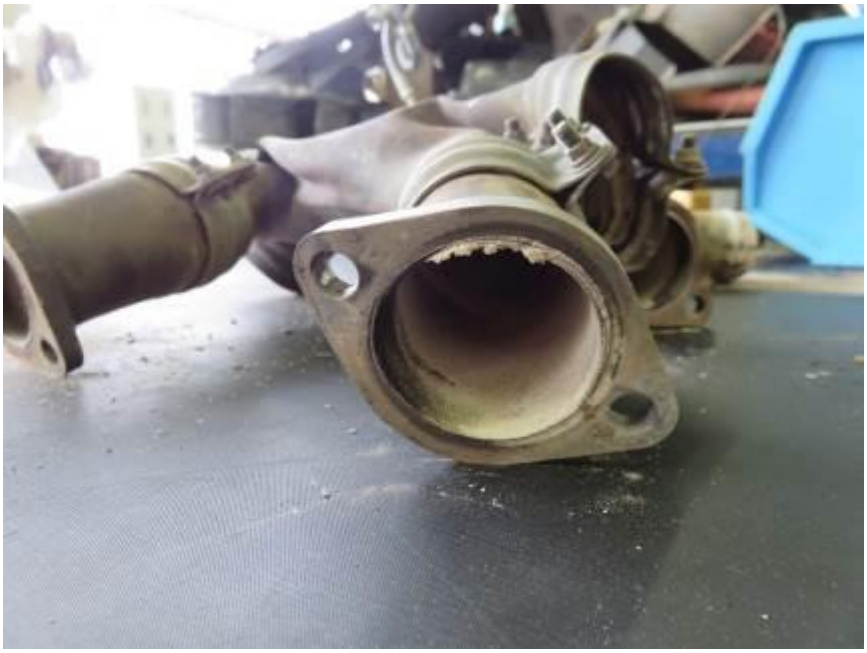
	
Gear drive train	The gear drive train was undamaged (see photograph below). 
Cylinders	All six cylinders were removed and they showed signs of normal engine operation; the carbon deposits were found to be normal on this type of engine. The photograph on the next page displays the inside of the No. 1 cylinder. The other cylinders display a similar operational pattern.

	*NOTE: The spark plugs were removed during the initial teardown examination before the cylinders were removed from the engine. 
Pistons and rings	The pistons were in a good overall condition and displayed evidence of carbon build-up associated with normal engine operation. None of the rings were broken and all of them could be freely rotated. The photograph below is of the No. 1 piston. The other pistons display a similar operational pattern. 
Hydraulic lifters	All the hydraulic lifters were removed. They were found to be in a good overall condition as displayed on the photograph on the next

	page. The other lifters display a similar operational pattern. 
Main bearings and big-end bearings	All the bearings were found to be in good overall condition and displayed evidence of adequate lubrication. 
Crankshaft	The crankshaft was found to be in overall good condition. In the photograph below the connecting rods are still attached to the crankshaft.

	
Camshaft	The camshaft was removed, including the gear drive assembly. All the lobes on the camshaft displayed evidence associated with normal engine operation.
Cylinder head/valve assembly	All the rocker covers were intact. The covers were removed and the valves with their associated valve springs were found to be intact and in good condition.
Oil cooler	The unit sustained minor impact damage.
Oil pump	The oil pump was found undamaged and in good condition. The oil in the engine was drained before disassembly.

	
Oil sump	The sump sustained minor impact damage but no oil leaked from the sump assembly. The oil was drained from the engine before disassembly. The oil pick-up in the sump was intact and free of any obstructions. The colour of the oil was dark (blackish). 
Starter	The unit was attached to the engine and sustained some impact damage.
Alternator	The unit was attached to the engine and sustained some impact damage.

Alternative observations	The exhaust stacks were inspected and were found to display a light brownish colour on the inside, which was associated with normal engine operation. 
Conclusion:	The teardown inspection of the engine did not reveal any pre- or post-impact mechanical failure that would have prevented the engine from normal operation.