HELICOPTER ACCIDENT REPORT AND EXECUTIVE SUMMARY

			Reference:		CA18/2/3/9809	
Aircraft Registration	**ZS-HGY**	**Date of Accident**	30 July 2019		**Time of Accident**	0915Z
Type of Aircraft	Bell 47G-3B-1		**Type of Operation**		Game Culling (Part 137)	
Pilot-in-command Licence Type	Private Pilot Licence (H)		**Age**	69	**Licence Valid**	Yes
Pilot-in-command Flying Experience	Total Flying Hours		12685.7		Hours on Type	316.9
Last Point of Departure	Tshwarelano Game Lodge: Limpopo Province					
Next Point of Intended Landing	Tshwarelano Game Lodge: Limpopo Province					
Location of the accident site with reference to easily defined geographical points (GPS readings if possible)						
Tshwarelano game farm at GPS co-ordinates determined to be 22˚41´52˝S, 029˚22´44˝E and at an elevation of 2516ft						
Meteorological Information	Wind direction: 330˚; Wind speed: 04kts; CAVOK; Temperature: 22˚C; Q940hPA					
Number of People On-board	1+1	**No. of People Injured**	1	**No. of People Killed**	1	
Synopsis						

On 30 July 2019 at approximately 0900Z, the pilot and a passenger on-board a Bell 47G-3B-1 helicopter took off from Tshwarelano Game Lodge in Alldays, Limpopo Province. The purpose of the flight was to conduct game culling. The passenger stated that while the helicopter was flying at approximately 20-30 knots (kts) at 200 feet (ft) above ground level (AGL), they felt a vibration coming from the tail rotor section for approximately 5 seconds. He further stated that the helicopter started spinning clockwise about six times before losing height and impacting the ground. The helicopter came to rest in an upright position facing west.

The passenger managed to remove his safety harness and got out of the helicopter. The passenger noticed that the pilot, who was still on-board the helicopter, was unconscious, and that the helicopter had caught fire. He then assisted the pilot out of the helicopter. A post-impact fire erupted shortly thereafter. The pilot and the passenger sustained serious injuries. They were both transported to a nearby medical facility. The pilot succumbed to his injuries at the medical facility in Alldays. The helicopter was destroyed by post-impact fire.

The investigation revealed that during the flight, the pilot lost control of the helicopter due to the tail rotor failure, resulting in the helicopter spinning uncontrollably before impacting the ground.

Contributing factor: Lack of lubrication.

SRP Date:	8 September 2020	Publication Date	9 September 2020

ABBREVIATION	DEFINITION
AGL	Above Ground Level
AIID	Accident and Incident Investigations Division
ATF	Authority to Fly
CAA	Civil Aviation Authority
CAR	Civil Aviation Regulations
CRS	Certificate of Release to Service
ft	Feet
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions
CAVOK	Ceiling and Visibility Okay
S	South
E	East
PPL	Private Pilot Licence
AME	Aircraft Maintenance Engineer
AMO	Aircraft Maintenance Organisation
NTCA	Non-Type Certified Aircraft
TCA	Type Certified Aircraft
S/N	Serial Number
MPI	Mandatory Periodic Inspection
SACAA	South African Civil Aviation Authority
SAWS	South African Weather Service
NM	Nautical Miles
N/A	Not Applicable
m	Metre
rpm	Revolutions Per Minute

Reference Number	**:** CA18/2/3/9809
Name of Owner/Operator	**:** Gauteng 45 Business Management (PTY) LTD
Manufacturer	**:** Westland Aviation LTD
Model	**:** Bell 47G-3B-1
Nationality	**:** South African
Registration Marks	**:** ZS-HGY
Place	**:** Tshwarelano Game Lodge in Alldays, Limpopo Province
Date	**:** 30 July 2019
Time	**:** 0915Z

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 (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****.*

Investigations process:

The accident was notified to the Accident and Incident Investigations Division (AIID) on 30 July 2019 at about 1100Z. The investigators went to Tshwarelano Game Lodge on 31 July 2019. The investigators co-ordinated with all authorities on site by initiating the accident investigation process according to CAR Part 12 and investigation procedures. The AIID of the South African Civil Aviation Authority (SACAA) is leading the investigation as the Republic of South Africa is the State of Occurrence.

Disclaimer:

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

1. FACTUAL INFORMATION

1.1. History of Flight

1.1.1 On Tuesday, 30 July 2019 at approximately 0900Z, the pilot and a passenger (who was involved in game culling) on-board a Bell 47G-3B-1 helicopter with registration ZS-HGY took off from Tshwarelano Game Lodge in Alldays in Limpopo province with the intention to land back at Tshwarelano Game Lodge. The purpose of the flight was to conduct game culling operations. The flight was conducted under the provisions of Part 137 of the Civil Aviation Regulations (CAR) 2011 as amended and under visual flight rules (VFR) by day. Visual meteorological conditions (VMC) prevailed at the time of the accident.

1.1.2 According to the passenger, the helicopter was flying at approximately 20-30 knots (kts) at 200 feet (ft) above ground level (AGL). Approximately 15 minutes into the flight, the tail section of the helicopter started vibrating. The pilot disengaged the fuel pump and then engaged it again, but the helicopter continued to vibrate. Approximately 5 seconds later, the helicopter started spinning to the right (clockwise) with the engine still running. The passenger stated that the pilot lost control of the helicopter and it continued to spin about six times. The helicopter lost height and impacted the ground, coming to rest in an upright position facing west.

1.1.3 The passenger managed to free himself from the helicopter seat harness and got out of the helicopter. After realising that the pilot was still in the helicopter and unconscious, he went back to help him get out of the helicopter. A post-impact fire erupted thereafter, and the helicopter was destroyed. The pilot and the passenger sustained serious injuries. They were both transported to a nearby medical facility by road in a private vehicle and, later, the pilot succumbed to his injuries at the medical facility in Alldays.

1.1.4 The accident occurred at approximately 0915Z during daylight at Global Positioning System (GPS) co-ordinates determined to be 22˚41´52˝S, 029˚22´44˝E which is 15 nautical miles (NM) south of Venetia Mine Airfield and at an elevation of 2516ft.

Figure 1: The take-off point and the accident site, which is a distance of approximately 3.6 kilometres. (Source: Google Earth Maps)

1.2. Injuries to Persons

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

1.3. Damage to Aircraft

1.3.1 The helicopter was destroyed by post-impact fire.


Figure 2 & **3:** The accident helicopter (left) before the accident (Source: Bruce Perkins) and the helicopter as found at the accident site (right).

1.4. Other Damage

1.4.1 The shrubs and the environment sustained damage caused by the rotating main rotor blades, as well as the post-impact fire.

1.5. Personnel Information

Pilot-in-command

Nationality	South African	Gender	Male	Age	69
Licence Number	0270209869	Licence Type	Private Pilot Licence (Helicopter)		
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Culling Rating				
Medical Expiry Date	31 March 2020				
Restrictions	Wear corrective lenses				
Previous Accidents	None				

Flying Experience:

Total Hours	12685.7
Total Past 90 Days	Unknown
Total on Type Past 90 Days	Unknown
Total on Type	316.9

- According to the pilot's file, he was initially issued a Private Pilot Licence (PPL) on 7 July 1989. He did his last renewal skills test on 24 March 2019 and was reissued a licence with an expiry date of 31 March 2020. He carried out his medical examination on 25 February

2019 and was reissued a Class 2 aviation medical certificate with an expiry date of 25 February 2020, with restrictions to wear corrective lenses.

- According to the pilot's son; the pilot's logbook and the helicopter flight folio were in the helicopter during the accident. Thus, it could not be determined if the documents were on-board the helicopter due to the post-impact fire that erupted after the accident. Information in the table above was taken from the pilot's file dated from July 1989 to 25 March 2019.

Aircraft Maintenance Engineer (AME) experience:

- The aircraft maintenance engineer (AME) was initially issued a licence on 26 October 1981. He did his revalidation and was reissued a licence with Bell helicopter series endorsed on it. The licence was issued on 29 January 2018 with an expiry date of 16 May 2020.

1.6. Aircraft Information

Airframe:

Type	Bell 47G-3B-1	
Serial Number	164	
Manufacturer	Westland Helicopters LTD	
Date of Manufacture	1967	
Total Airframe Hours (At time of Accident)	Unknown	
Last MPI (Date & Hours)	14 July 2018	3743.9
Hours Since Last MPI	Unknown	
Authority to Fly (Issue Date)	03 September 2018	
Authority to Fly (Expiry Date)	30 September 2019	
C of R (Issue Date) (Present owner)	19 December 2018	
Operating Categories	Part 94 & 96	

1.6.1 The Bell 47 is a single-rotor, single-engine light helicopter manufactured by Bell Helicopter. It was based on the third Bell 30 prototype, which was the company's first helicopter designed by Arthur M. Young. The Bell 47 became the first helicopter certified for civilian use on 8 March 1946. The ZS-HGY was manufactured in 1967.

1.6.2 According to the helicopter file, there was an official letter from Westland Helicopter Limited dated 22 August 1977 confirming that the helicopter Bell 47G-3B-1 military number XT 837 was allocated a build number 164 during the demilitarisation of the helicopter in question and, on 18 August 1978, the helicopter was issued a certificate of airworthiness (CoA) by the South African Civil Aviation Authority (SACAA). The helicopter operated until 27 April

2012 before suspending operation for approximately six years. There were no records of storage during the six years the helicopter was not flying.

Note: Civil Aviation Regulations general maintenance rules Part 43, Subpart 2.

Aircraft withdrawn from service for storage

43.02.21 Aircraft withdrawn from service for storage shall meet the preservation instructions of the aircraft's manufacturer as prescribed in the relevant maintenance manuals, service bulletins, service letters or service instructions for the inoperative period. Before such an aircraft is returned to service, any prescribed maintenance shall be carried out prior to release to service.

1.6.3 On 15 February 2018, the helicopter was issued a certificate of release to service (CRS) by an Aircraft Maintenance Organisation (AMO) with an expiry date of 15 February 2019. On 19 February 2018, a request for the renewal of the CoA was submitted to the SACAA and it was then noted that the Bell 47G-3B-1, Serial number 164 was no longer supported by a Type Certificate holder. On 14 July 2018, the helicopter was inspected by the AME for the purpose of de-registering the helicopter from a Type Certified Aircraft (TCA) to a Non-Type Certified Aircraft (NTCA). On 27 July 2018, a performance test flight was carried out after the Mandatory Periodic Inspection (MPI) and the helicopter was found to be in satisfactory condition. The helicopter had accrued a total of 3743.9 hours at that time. The helicopter was issued an Authority to Fly (ATF) certificate on 3 September 2018 with an expiry date of 30 September 2019 or at 3843.9 airframe hours, whichever occurs first.

1.6.4 Since the last MPI, the airframe hours accumulated are unknown as the helicopter flight folio was destroyed by post-impact fire.

Engine:

Type	TVO-435B1A
Serial Number	L-828-52
Hours Since New	±2852.45
Hours Since Overhaul	±741.75

1.6.5 According to the engine logbook, the engine was last overhauled on 6 June 2001. It was then installed on ZS-HGY on 25 May 2011 at 2813.5 total engine hours and 701.8 hours since its last overhaul. Between 25 May 2011 and 14 July 2018, the engine had accumulated a total of approximately 10.90 hours.

Main Rotor Gearbox:

Type	47-620-600-27
Serial Number	WAB 901
Hours Since New	Unknown
Hours Since Overhaul	Unknown

1.6.6 According to available information on the last MPI, the main rotor gearbox had already accumulated a total of 124 hours since its last overhaul. Between 31 July 2018 and 24 March 2019, the helicopter was flown for a further 32.1 hours, bringing the main rotor gearbox total hours to 156.1 since it was last overhauled.

Main Rotor Blades:

Type	47-110-250-1023
Serial Numbers	M922 & M1857
Hours Since New	Unknown
Hours Since Overhaul	Unknown

Tail Rotor Gearbox:

Type	47-640-075-1
Serial Number	ADB-10044
Hours Since New	Unknown
Hours Since Overhaul	Unknown

1.6.7 According to the helicopter file and logbook, it was noted that the helicopter had flown a total of only 10.90 hours between March 2012 and July 2018. According to the helicopter file, on 18 June 2012, the tail rotor gearbox S/N ADB-10044 was overhauled and hours since new were unknown. It was then installed on the (Bell) helicopter at 3733.9 airframe hours since new. According to the last inspection completed by an approved aircraft maintenance engineer (AME) on 14 August 2018, the tail rotor system was inspected and there were no defects recorded (see inspection instructions below). There was no evidence found regarding oil uplift in the tail gearbox. According to available information, on the last MPI, the tail rotor gearbox had accumulated a total of 4.1 hours since its last overhaul. Between 31 July 2018 and 24 March 2019, the helicopter was flown for a further 32.1 hours, bringing the main rotor gearbox total hours to 36.2 since it was last overhauled. The tail rotor gearbox hours at the time of the accident are unknown.

1.6.8 TAIL ROTOR SYSTEM

(Source: Model 47G-3B & 47G-3B-1 maintenance & overhaul instructions section 1, page 1-47 to 1-48)

1. *Inspect female coupling at transmission for end play. If end play exists, remove boot and forward shaft and inspect teeth and splines for wear.*
2. *Deleted*
3. *Inspect tail rotor pitch change mechanism for integrity.*
4. *Inspect bearings in pitch link for condition.*
5. *Inspect tail rotor blade bearing for condition.*
6. *Drain and refill gearbox. Lockwire all plugs.*
   a. Metal particles in oil are cause for immediate disassembly of gearbox for complete inspection.
7. *Inspect cable quadrant and connecting push pull tubes for security and freedom of operation. Check security of quadrant stops and cable attachments and guards. Check cable tension.*

Tail Rotor Blades:

Type	47-642-117-105
Serial Numbers	A-313 & A-3138
Hours Since New	Unknown
Hours Since Overhaul	Unknown

1.7. Meteorological Information

1.7.1 The weather information on the table (below) was provided by the South African Weather Service (SAWS) from the station in Venetia Mine Airfield, 15 nautical miles (NM) south of the accident site at 0900Z on 30 July 2019 (the day of the accident).

Wind direction	330˚	Wind speed	4 kts	Visibility	9999m
Temperature	22˚C	Cloud cover	None	Cloud base	N/A
Dew point	N/A	QNH	940hPA		

1.8. Aids to Navigation

1.8.1 The helicopter was equipped with standard navigational equipment as approved by the Regulator (SACAA) for the helicopter type. There was no record found which indicated that the communication system was unserviceable prior to the accident as the flight folio was destroyed by post-impact fire.

1.9. Communication

1.9.1 The helicopter was equipped with standard communication equipment as per the minimum equipment list approved by the Regulator. There was no record found which indicated that the communication system was unserviceable prior to the accident as the flight folio was destroyed by post-impact fire.

1.10. Aerodrome Information

1.10.1 The accident did not occur at or near an aerodrome. The accident occurred 15 NM south of Venetia Airfield at GPS co-ordinates determined to be 22˚41´52˝S, 029˚22´44˝E and at an elevation of 2516ft.

1.11. Flight Recorders

1.11.1 The helicopter was not equipped with a flight data recorder (FDR) or a cockpit voice recorder (CVR). Neither recorder was required by the relevant aviation regulations.

1.12. Wreckage and Impact Information

1.12.1 The passenger stated that approximately 15 minutes into the flight, the tail section of the helicopter started vibrating and, a few seconds later, the helicopter span clockwise about six times and the pilot lost control of the helicopter. The main wreckage was found intact with major components still attached. The two fuel tanks were found on the left and right side of the helicopter's wreckage. The left tank had shattered on impact, resulting in fuel-fed fire, and the right tank was distorted as a result of the impact.

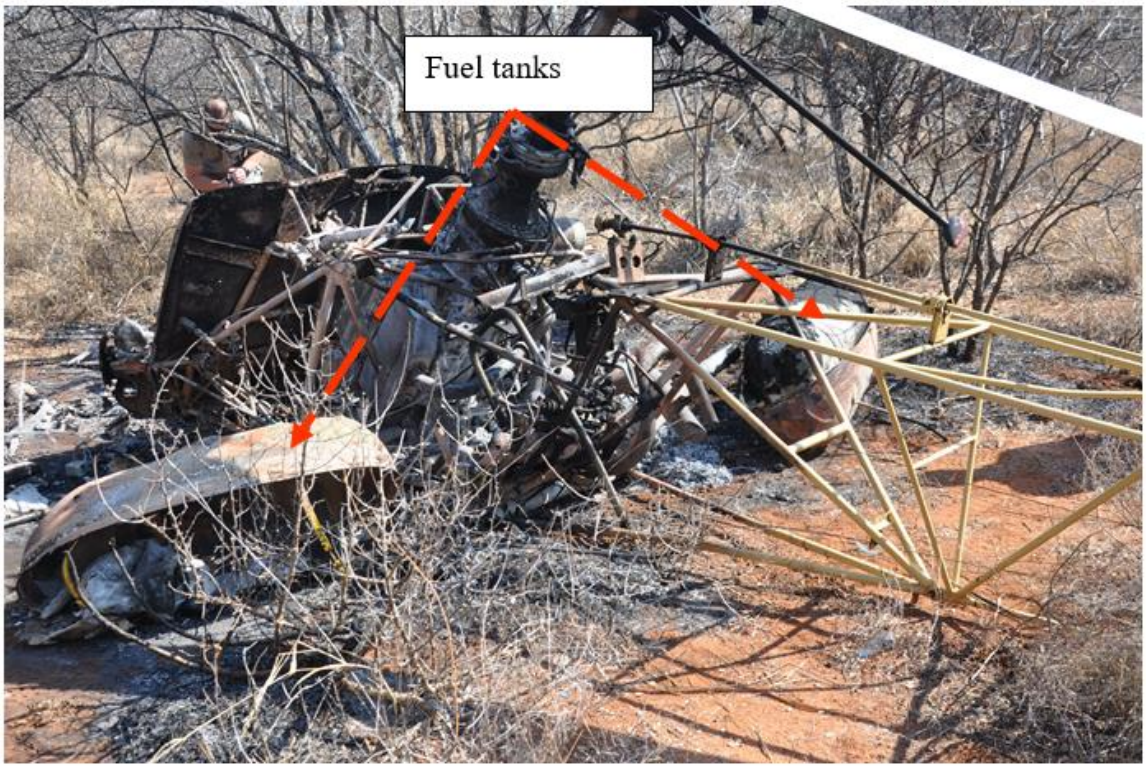

Figure 4: Fuel tanks at the accident site.

1.12.2 During the on-site investigation, it was evident that the engine still had power when the accident occurred. The main rotor blades struck and severed shrubs before the helicopter came to rest.

Figure 5: Right view of the severed shrub.

1.12.3 The helicopter cabin area and the instrument panel were destroyed by post-impact fire.

Figure 6: The cabin area after the accident.

1.12.4 The engine and all its wiring were also destroyed by post-impact fire.

Figure 7: Burnt engine post-accident.

Figure 8: Engine wiring destroyed by post-impact fire.

1.12.5 The tail rotor shaft was disconnected on impact from the engine and the tail rotor gearbox section.

Figure 9: The front tail rotor drive shaft.

1.12.6 The tail rotor blades could be turned by hand post-accident. When the tail rotor shaft was turned, the tail rotor blades could not be turned, indicating a discontinuity between the tail drive shaft and the gearbox.

Figure 10: The rear tail rotor drive shaft.

1.12.7 General inspection of the gearbox at the accident site showed no visual oil leaks in the vicinity of the housing. The oil cap was still attached and showed no visible signs of failure or of being loose.

Figure 11: The tail rotor gearbox as it was found on-site.

1.13. Medical and Pathological Information

1.13.1 The pilot was seriously injured and unconscious, and later succumbed to his injuries. The passenger sustained serious injuries during the accident sequence. The post-mortem report was still outstanding at the time of completing this report. Should any of the results

have a bearing on the circumstances leading to this accident, they will be treated as new evidence that will necessitate the reopening of this investigation.

1.14. Fire

1.14.1 Post-impact fire ensued after impact, destroying the helicopter.

1.15. Survival Aspects

1.15.1 The survivability of occupants was highly unlikely due to the impact damage sustained by the helicopter in the cabin and cockpit structure, which resulted in fatal injuries to the pilot and serious injuries to the passenger. Both occupants were wearing their safety harnesses; and none of the safety harnesses had failed during the accident.

1.16. Tests and Research

1.16.1The tail rotor gearbox was stripped and inspected on 17 June 2020 by investigators.

1.16.2 The following were observed during the stripping:

Tail rotor system inspection checks were done on the tail rotor blades, pitch change mechanism, tail drive shaft and the tail gearbox. The following observations were made:

- The pitch change mechanism operated normally in both directions.
- During rotation of the drive shaft, it was observed that the tail gearbox output shaft rotation did not fit the rotation of the drive shaft properly. It was loose (during rotation) and appeared to be ragged.
- The long section of the tail drive shaft system had separated from the gearbox and the following was observed — the bearings that support the drive shaft were still intact and exhibited normal operation.
- The bearing of the output shaft was uneven during rotation, which is attributed to impact.

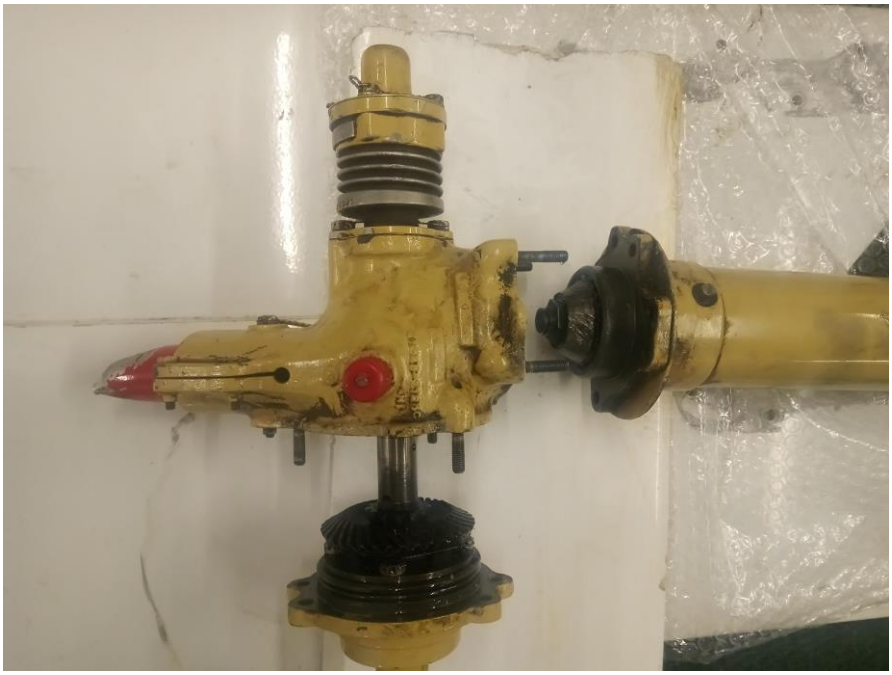

Figure 12: A completely worn pinion gear teeth and worn bevel gear teeth.

- The pinion gear teeth and bevel gear teeth were worn out of limits.

Figure 13 & 14: A closer look at the worn pinion gear teeth and worn bevel gear teeth.

1.16.3 The tail gearbox was inspected, and the following was observed:

- The exterior condition of the casing was good with no cracks or rupture
- There was no visible oil inside the housing, an indication that there was insufficient oil prior to the accident
- There was a presence of metal pieces around the inside of the housing

Figure 15: The tail rotor gearbox housing.

- The housing cavity exhibited some metal shavings mixed with sludge-like substance.

Figure 16: The gear side of the gearbox housing.

1.17 Organisational and Management Information

1.17.1 This was a private game culling flight operated under Part 137 of the Civil Aviation Regulations (CAR) 2011 as amended.

1.18 Additional Information

(Source: ROTORCRAFT FLYING HANDBOOK, FAA-helicopter handbook 8083-21, page 11-4 to 11-5)

1.18.1 Height /Velocity diagram.

Operating at the altitudes and airspeeds shown within the crosshatched or shaded areas of the height/velocity (H/V) diagram below may not allow enough time for the critical transition from powered flight to autorotation. According to the witness, the helicopter was flying at indicated airspeed of 20-30kts and was approximately 200ft AGL.

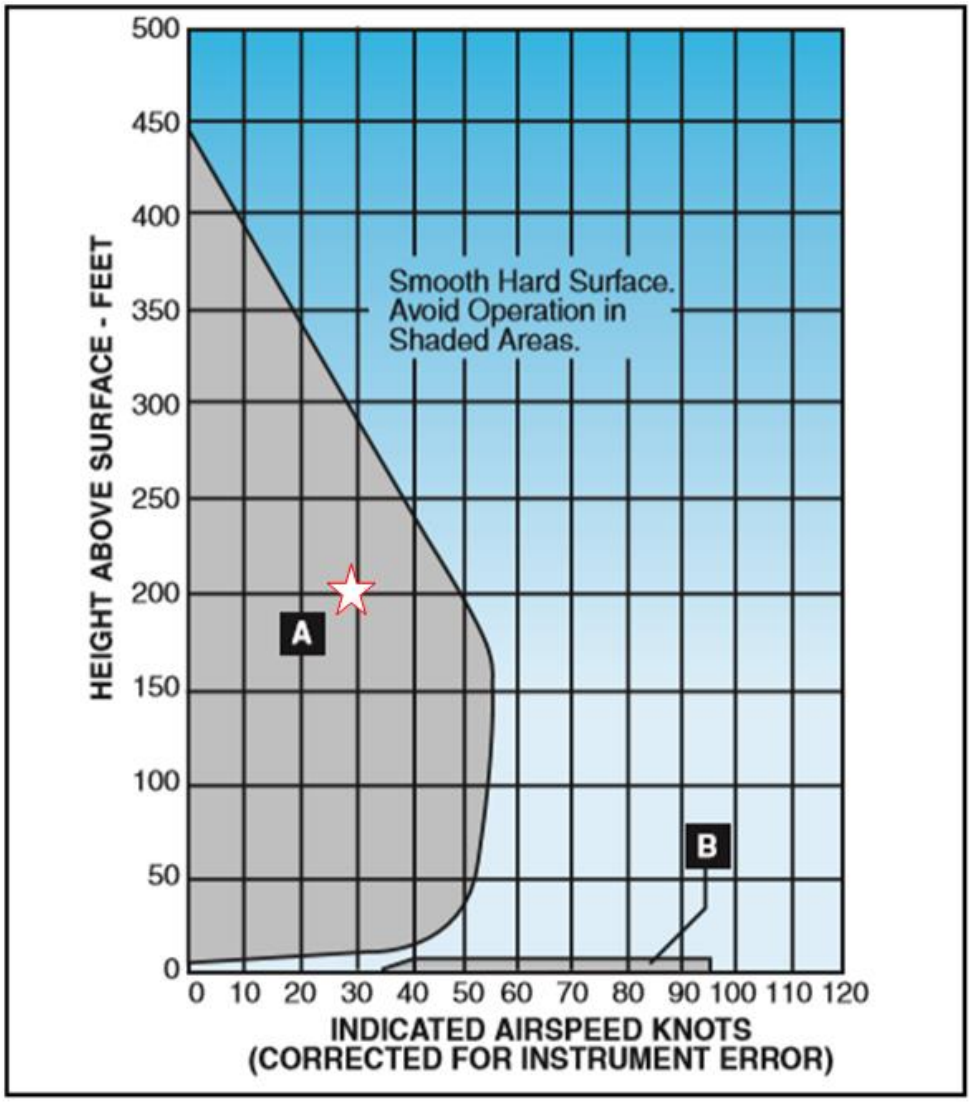

Figure 17: By carefully studying the height/velocity diagram, one would be able to avoid the combination of altitude and airspeed that may not allow one sufficient time or altitude to enter a stabilised autorotative descent.

(Source: ROTORCRAFT FLYING HANDBOOK, FAA-helicopter handbook 8083-21, Pages 11-11 to 11-15)

ANTITORQUE SYSTEM FAILURE

Antitorque failures usually fall into two categories. One focuses on failure of the power drive portion of the tail rotor system resulting in a complete loss of antitorque. The other category covers mechanical control failures where the pilot is unable to change or control tail rotor thrust even though the tail rotor may still be providing antitorque thrust. Tail rotor drive system failures include driveshaft failures, tail rotor gearbox failures, or a complete loss of the tail rotor itself. In any of these cases, the loss of antitorque normally results in an immediate yawing of the helicopter's nose. The helicopter yaws to the right in a counter-clockwise rotor system and to the left in a clockwise system. This discussion assumes a helicopter with a counter-clockwise rotor system. The severity of the yaw is proportionate to the amount of power being used and the airspeed. An antitorque failure with a high-power setting at a low airspeed results in a severe yawing to the right. At low power settings and

high airspeeds, the yaw is less severe. High airspeeds tend to streamline the helicopter and keep it from spinning. If a tail rotor failure occurs, power has to be reduced in order to reduce main rotor torque. The techniques differ depending on whether the helicopter is in flight or in a hover but will ultimately require an autorotation. If a complete tail rotor failure occurs while hovering, enter a hovering autorotation by rolling off the throttle. If the failure occurs in forward flight, enter a normal autorotation by lowering the collective and rolling off the throttle. If the helicopter has enough forward airspeed (close to cruising speed) when the failure occurs, and depending on the helicopter design, the vertical stabilizer may provide enough directional control to allow you to manoeuvre the helicopter to a more desirable landing sight. Some of the yaw may be compensated for by applying slight cyclic control opposite the direction of yaw. This helps in directional control, but also increases drag. Care must be taken not to lose too much forward airspeed because the streamlining effect diminishes as airspeed is reduced. Also, more altitude is required to accelerate to the correct airspeed if an autorotation is entered into at a low airspeed. A mechanical control failure limits or prevents control of tail rotor thrust and is usually caused by a stuck or broken control rod or cable. While the tail rotor is still producing antitorque thrust, it cannot be controlled by the pilot. The amount of antitorque depends on the position where the controls jam or fail. Once again, the techniques differ depending on the amount of tail rotor thrust, but an autorotation is generally not required.

ABNORMAL VIBRATIONS

With the many rotating parts found in helicopters, some vibration is inherent. You need to understand the cause and effect of helicopter vibrations because abnormal vibrations cause premature component wear and may even result in structural failure. With experience, you learn what vibrations are normal versus those that are abnormal and can then decide whether continued flight is safe or not. Helicopter vibrations are categorized into low, medium, or high frequency. 11-15

MEDIUM AND HIGH FREQUENCY VIBRATIONS

Medium frequency vibrations (1,000 - 2,000 cycles per minute) and high frequency vibrations (2,000 cycles per minute or higher) are normally associated with out of-balance components that rotate at a high r.p.m., such as the tail rotor, engine, cooling fans, and components of the drive train, including transmissions, drive shafts, bearings, pulleys, and belts. Most tail rotor vibrations can be felt through the tail rotor pedals as long as there are no hydraulic actuators, which usually dampen out the vibration. Any imbalance in the tail rotor system is very harmful, as it can cause cracks to develop and rivets to work loose. Piston engines usually produce a normal amount of high frequency vibration, which is aggravated by engine malfunctions such as spark plug fouling, incorrect magneto timing, carburettor icing and/or incorrect fuel/air mixture. Vibrations in turbine engines are often difficult to detect as these engines operate at a very high r.p.m.

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. These shall not be read as apportioning blame or liability to any particular organisation or individual.

2.1.1 The pilot was issued a Private Pilot Licence with culling rating endorsed on it. He had flown a total of approximately 12685.7 hours, and approximately 316.9 hours were on the helicopter type. He was also issued a Class 2 aviation medical certificate with a restriction to wear corrective lenses.

2.1.2 Approximately 15 minutes into the flight, the tail section of the helicopter started to vibrate. The pilot disengaged the fuel pump and then engaged it again, but the helicopter continued to vibrate. The helicopter started spinning clockwise with the engine still running for about 5 seconds. The passenger stated that the helicopter continued to spin approximately 6 times and the pilot lost control. Then, the helicopter started a descent, impacted the ground and came to rest facing west. During the investigation, two possible scenarios and the likelihood of the cause of the helicopter spinning to the right were explored. The first scenario was the loss of thrust of the tail rotor, and the other was an anti-torque system failure. The moment the pilot felt the vibration, he switched off the fuel pump. The emergency procedure requires an immediate engine shutdown and landing as soon as practicable. At this time, the pilot was supposed to have switched off the engine and not the fuel pump to minimise torque.

2.1.3 The last two helicopter inspections indicated that the tail rotor gearbox was properly inspected. However, the condition of the gearbox housing and the wear on the gears indicated that the gearbox had “old” and insufficient oil that might have caused the damage on the gear teeth, resulting in the failure of the tail rotor assembly.

2.1.4 The Rotorcraft Flying Handbook stipulates that the pilot should reduce collective pitch to aid in arresting the yaw rate and roll throttle off. However, this will cause the helicopter’s descent to be rapid. It also states that if the rotation cannot be stopped and ground contact is imminent, an autorotation may be the best course of action. The helicopter came to rest in an upright position, indicating that the pilot tried to recover from the spin but there was not enough height to recover; or that the pilot might have not closed the throttle quick

enough to conserve power for the flare at the end of autorotation.

2.1.5 The witness stated that the helicopter was flying at an indicated airspeed of 20-30kts and that it was approximately 200ft AGL. This configuration made the helicopter susceptible to high vertical impact forces as it was operating inside the grey shaded area A (see Figure 17) without any room to fully recover in case of an emergency.

2.1.6 The investigation revealed that during the flight, the pilot lost control of the helicopter as a result of the damaged tail rotor driveshaft pinion which did not provide a direct drive to the output shaft of the tail rotor gearbox. This resulted in the tail rotor failure which caused the helicopter to spin uncontrollably before impacting the ground. During the investigation of the tail rotor gearbox, some metal shavings mixed with sludge were found in the housing cavity, indicating neglect in oil replacement. Sludge is a “tell-tale” sign of a neglected gearbox. The helicopter had been flown approximately 10.90 hours in six years following the gearbox overhaul. It is likely that this had caused some components and liquids to deteriorate, resulting in excessive heat exposure to the gears.

3 CONCLUSION

3.1 General

3.2 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 particular organisation or individual.

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

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

3.3 Findings

3.3.1 The pilot was initially issued a Private Pilot Licence (PPL) on 7 July 1989. He completed his last renewal skills test on 24 March 2019 and was reissued a licence with an expiry date of 31 March 2020.

3.3.2 The pilot undertook his medical examination on 25 February 2019 and was reissued an aviation medical certificate with an expiry date of 25 February 2020.

3.3.3 On 19 February 2018, a request for the renewal of the CoA was submitted, and the helicopter had flown a total of 3743.9 hours. It was then noted that the Bell 47G-3B-1, Serial number 164 was no longer supported by a Type Certificate holder.

3.3.4 The AME was initially issued a licence on 26 October 1981. He did his revalidation and was reissued an AME licence on 29 January 2018 with an expiry date of 16 May 2020.

3.3.5 Between March 2012 and July 2018, the helicopter had flown a total of 10.90 hours as operation was suspended for approximately six years. On 27 July 2018, a performance test flight was carried out on the helicopter and was found to be satisfactory.

3.3.6 On 3 September 2018, the helicopter was issued an Authority to Fly certificate with an expiry date of 30 September 2019.

3.3.7 The helicopter's flight folio was destroyed by post-impact fire, therefore, the helicopter hours at the time of the accident are unknown.

3.3.8 Inspection of the tail gearbox did not reveal any signs of oil in the interior of the housing, an indication that there was insufficient oil prior to the accident.

3.3.9 The tail gearbox was retrieved and subjected to a teardown inspection. The teardown inspection revealed that the pinion gear teeth and bevel gear teeth were worn, resulting in poor contact (operation) during rotation.

3.3.10 The investigation revealed that during the flight, the pilot lost control of the helicopter as a result of the damaged tail rotor driveshaft pinion which did not provide a direct drive to the output shaft of the tail rotor gearbox. This resulted in the tail rotor failure, which caused the helicopter to spin uncontrollably before impacting the ground.

3.3.11 The accident helicopter had not been actively operating for many years and it had also not been complying with the manufacturer's requirements nor the SACAA preservation storage instructions for aircraft that had not been in service for a lengthy period.

3.4 Probable Cause/s

3.4.1 During the flight, the pilot lost control of the helicopter as a result of the damaged tail rotor driveshaft pinion which did not provide a direct drive to the output shaft of the tail rotor gearbox. This resulted in the tail rotor failure, which caused the helicopter to spin uncontrollably before impacting the ground.

3.4.2 **Contributory Factors:**

3.4.2.1 The gearbox was insufficiently lubricated, resulting in the gears overheating and rubbing against each other.

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 Recommendation/s

4.2.1 It is recommended to the Director of Civil Aviation to enhance oversight of NTCA aircraft especially at the time of Authority to Fly renewals. This presents the opportunity to review the aircraft maintenance records to determine if the aircraft had been in compliance with the manufacturers' instructions and the SACAA's requirements.

5 APPENDICES

5.1 None.

This Report is issued by:

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