HELICOPTER ACCIDENT REPORT AND EXECUTIVE SUMMARY

				Reference:	CA18/2/3/9839		
Helicopter Registration	ZT-RDR	**Date of Accident**		28 November 2019	**Time of Accident**	0852Z	
Type of Helicopter	Bell 505			**Type of Operation**	Private (Part 91)		
Pilot-in-command Licence Type		Private Pilot Licence		**Age**	61	**Licence Valid**	Yes
Pilot-in-command Flying Experience		**Total Flying Hours**		2 260.0		**Hours on Type**	21.7
Last Point of Departure	Kimberley Aerodrome (FAKM), Northern Cape Province						
Next Point of Intended Landing	Kimberley Aerodrome (FAKM), Northern Cape Province						
Damage to Helicopter	Substantial						
Location of the accident site with reference to easily defined geographical points (GPS readings if possible)							
Outside a military base in Kimberley (GPS position: 28°38’59.11” South 024°34’39.56” East) at an elevation of 3 888 feet							
Meteorological Information	Surface wind: 260˚/5kts; temperature: 36˚C; Visibility: CAVOK						
Number of People On-board	1 + 3	**Number of People Injured**	1 + 3	**Number of People Killed**	0	**Other (On Ground)**	0
Synopsis							

On 28 November 2019 at 0826Z, the pilot and three passengers boarded a Bell 505 helicopter with registration ZT-RDR from Kimberley Aerodrome (FAKM) with the intention to land back at the same aerodrome. The private flight was conducted under visual flight rules (VFR) in clear weather conditions. The pilot stated that the purpose of the flight was to fly over the KEM-JV mine for inspection, then route to Kamfers Dam to survey the decreasing water levels and larger than normal population of the flamingos, and then fly to the local council’s water supply pipes to inspect them before returning to FAKM. Once the mission was completed at the dam and the helicopter was en route to the water supply pipelines, during that part of the flight, the pilot and passengers noticed immense water leaks on the main water pipeline to the west of the military base in the Midlands area. The pilot had then made a descent to 300 feet (ft) above ground level (AGL), slowed down the speed and flew west, adjacent the leaking pipeline while one of the passengers photographed the water leaks.

During the turn to the right while inspecting the leaking water pipeline, the helicopter unexpectedly yawed to the right. The pilot tried to regain control by applying left radar pedal and lowering the collective, but he was not successful in bringing the helicopter under control. This was followed by the pilot applying right pedal input, as well as up and down collective movement variations, which were all unsuccessful.

The helicopter impacted the uneven surface near the holes that were dug up for inserting (fitting) pipes. The helicopter sustained substantial damage while the four occupants on-board the helicopter sustained serious injuries.

Probable Cause/s and/or Contributory Factors

During the turn to the right to inspect the leaking water pipeline, the helicopter unexpectedly yawed to the right and lost control, the pilot tried to recover but he was unsuccessful. As a result, the helicopter impacted the uneven surface.

Contributory factors
Loss of tail rotor effectiveness (LTE) as a result of increased main rotor angle of attack during the right turn.
Incorrect technique during right turn.

SRP date	11 May 2021	Publication date	12 May 2021

INTRODUCTION

Reference Number	**:** CA18/2/3/9839
Name of Owner	**:** Diaruk (Pty) Ltd
Name of Operator	**:** Kimfly Charters
Manufacturer	**:** Bell Textron
Model	**:** 505
Nationality	**:** South African
Registration markings	**:** ZT-RDR
Place	**:** Just outside the perimeter fence of a military base near Kimberley
Date	**:** 28 November 2019
Time	**:** 0852Z

Purpose of the Investigation:

*In terms of Regulation 12.03.1 of the Civil Aviation Regulations (CAR) 2011, this report was compiled in the interest of the promotion of aviation safety and the reduction of the risk of aviation accidents or incidents and **not to apportion blame or liability**.*

All times given in this report are Co-ordinated Universal Time (UTC) and will be denoted by (Z). South African Standard Time is UTC plus 2 hours.

Investigation Process:

The accident was notified to the Accident and Incident Investigations Division (AIID) on 28 November 2019. The AIID had appointed an investigator-in-charge. The investigator had dispatched to the accident site on 28 November 2019. Notifications were sent to the State of Manufacture and Design for the helicopter (TSB, Canada) and the State of Manufacture for the engine (BEA, France). Both states had appointed non-travelling accredited representatives. The investigator co-ordinated with all authorities on site by initiating the accident investigation process according to CAR Part 12 and investigation procedures. The AIID is leading the investigation as the Republic of South Africa is the State of Occurrence.

Notes:
1. Whenever the following words are mentioned in this report, they shall mean the following:

- *Accident — this investigated accident*
- *Helicopter — the Bell 505 involved in this accident*
- *Investigation — the investigation into the circumstances of this accident*
- *Pilot — the pilot involved in this accident*
- *Report — this accident report*

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

Disclaimer:

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ABBREVIATION	DESCRIPTION
°	Degrees
AGL	Above Ground Level
AIID	Accident and Incident Investigation Division
AME	Aircraft Maintenance Engineer
AMSL	Above Mean Sea Level
AOC	Air Operating Certificate
ARFF	Aerodrome Rescue and Fire Fighting
ATC	Air Traffic Control
BEA	Bureau d’Enquêtes et d’Ánalyses (France)
C	Celsius
CAR	Civil Aviation Regulations
CG	Centre of Gravity
CRS	Certificate of Release to Service
CVR	Cockpit Voice Recorder
DME	Distance Measuring Equipment
EECU	Electronic Engine Control Unit
ELT	Emergency Locator Transmitter
FADEC	Full Authority Digital Electronic Control
FAKM	Kimberley Aerodrome
FDR	Flight Data Recorder
Ft	Feet
gph	gallons per hour
GPS	Global Positioning System
GTOW	Gross Take Off Weight
hPa	Hectopascal
Hz	Hertz
kt	Knot
LTE	Loss of tail rotor effectiveness
m	Meters
MPI	Mandatory Periodic Inspection
MTP	Minimum Transient Power
N1	Compressor or Gas Producer Speed
N2	Power Turbine Speed
NR	Main Rotor Seed
OGE	Out-of-ground Effect
PIC	Pilot-in-command
QNH	Query Nautical Height
SAWS	South African Weather Service
SD Card	Secure Digital Card
TBO	Time Between Overhaul
TSB	Transport Safety Board (Canada)
TSN	Time Since New
UTC	Co-ordinated Universal Time
VOR	VHF Omnidirectional Range
Xpc	Collective Pitch Position
Z	Zulu (Term for Universal Coordinated Time - Zero hours Greenwich)

1 FACTUAL INFORMATION

1.1 History of Flight

1.1.1 On Thursday morning, 28 November 2019 at 0826Z, the pilot accompanied by three passengers on-board a helicopter with registration ZT-RDR took off on a private flight from Kimberley Aerodrome (FAKM) with the intention to land back at the same aerodrome. The flight was conducted under visual flight rules (VFR). Clear weather conditions prevailed at the time of the accident.

1.1.2 According to the pilot, the purpose of the flight was to conduct an aerial inspection above KEM-JV mine and route to Kamfers Dam to survey the decreasing water levels and the larger than normal flamingo bird population. Once the inspection was completed at the dam, the helicopter routed north-westerly to inspect the local council's water supply pipelines. This is when the pilot and the passengers spotted the leaking main water pipeline. The pilot then made a descent to approximately 300 feet (ft) above ground level (AGL), slowed down the helicopter speed and flew in a northerly direction, which was adjacent to the leaking pipeline while the passengers took pictures of the leaking water pipeline.

1.1.3 The pilot stated that when he turned right, the helicopter suddenly started to yaw in a clockwise direction uncommanded. The pilot tried to correct this by applying full left yaw pedal, but to no effect. The pilot had then lowered the collective pitch lever to reduce torque as well as the yaw rate; this, again, had no effect. He, then applied the right yaw pedal. As the helicopter descended closer to the ground, the pilot pulled the collective pitch lever to cushion the landing.

1.1.4 According to an eyewitness (who was standing 500m south of the accident site), the helicopter was flying from Kamfers Dam and over the railway power lines, but as it was approaching the military base, its nose lowered and the helicopter started to spin. It impacted the ground with the nose first while the main rotor blades severed some shrubs. The helicopter came to rest in an upright position on an uneven surface, close to the trenches that were dug up for the water pipes. Military personnel as well as a military ambulance were the first responders to the accident site.

1.1.5 Following the impact, the emergency locator transmitter (ELT) activated a distress signal (406 MHz) which was detected by the Cospas Sarsat System. The Aeronautical Rescue Coordination Centre (ARCC) was notified of the distress signal and had, in turn, contacted the aircraft owner who was the pilot. The pilot confirmed that they were involved in an accident. Air traffic control (ATC) personnel at FAKM were notified of the accident and had, in turn, activated the crash alarm. The Aerodrome Rescue and Fire-fighting (ARFF) personnel responded to the accident scene. The ARFF personnel stated that they sprayed foam on the leaking fuel to prevent a fire. All four occupants sustained serious injuries during the accident and were transported to the hospital in four ambulances. The helicopter sustained substantial damage. The Emergency Locator Transmitter (ELT) was still audible in the aircraft when the investigation team arrived on-site, and it was de-activated.

1.1.6 According to one of the passengers who was on the flight as his main interest was the flamingos at Kamfers Dam, the flight was normal until the helicopter started yawing without warning. He further stated that there were no audio or visual warnings in the cockpit that he could recall. The witness stated that the helicopter spun three times in a clockwise direction (when viewed from above) before impacting the ground.

1.1.7 The passenger who was seated behind the pilot took a video during flight. In the video, the helicopter enters a slow right turn and, during the turn, it starts to yaw rapidly in a clockwise direction (viewed from above). An aural warning (low main rotor rpm) is audible in the video. *The 19 seconds video ends when the helicopter impacts the ground.*

1.1.8 The accident occurred during daytime at a GPS position determined to be 28°38'59.11" South 024°34'39.56" East, at an elevation of 3 888 feet (ft).

Figure 1: The accident site location. (Source: Google Earth)

1.2 Injuries to Persons

Injuries	Pilot	Crew	Pass.	Total On-board	Other
Fatal	-	-	-	-	-
Serious	1	-	3	4	-
Minor	-	-	-	-	-
None	-	-	-	-	-
Total	1	-	3	4	-

1.3 Damage to Helicopter

1.3.1 The helicopter sustained substantial damage during the accident sequence.

Figure 2: The helicopter as it came to rest.

1.4 Other Damage

1.4.1 None.

1.5 Personnel Information

1.5.1 Pilot-in-command (PIC)

Nationality	South African	Gender	Male	Age	61
Licence Number	0270292725	Licence Type	Private Pilot Licence		
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Night Rating				
Medical Expiry Date	31 March 2020				
Restrictions	Must wear corrective lenses				
Previous Accidents	None				

Note: Previous accidents refer to past accidents the pilot was involved in, when relevant to this accident.

1.5.2 The pilot had previously acquired a fixed-wing Private Pilot Licence (PPL) and had further pursued acquisition of a helicopter PPL. The helicopter training was completed on 14 February 2005. According to the pilot's logbook, the type conversion to the Bell 505 helicopter was conducted on 9 October 2018 and comprised a dual check of 2.7 hours with a Grade 2 flight instructor. The pilot had a total of 1 047.9 helicopter hours, of which 432.8 hours were on turbine-powered helicopters (Bell 505 and Robinson 66). The pilot was also issued an aviation medical certificate (Class 2) on 28 March 2019 with an expiry date of 31 March 2020. The pilot's competency test was renewed on 31 May 2019 and the licence was issued on 4 June 2019 with an expiry date of 31 May 2020.

1.5.3 It was also noted that a check flight of 0.7 hours was flown by the pilot with the same flight instructor on 8 October 2019 and, later that day, the pilot flew the helicopter from Rand Aerodrome (FAGM) to FAKM. The duration of that flight was 2.3 hours.

Flying Experience:

Total Hours	2 260.0
Total Past 24 Hours	0.5
Total Past 7 Days	0.5
Total Past 90 Days	5.4
Total on Type Past 90 Days	5.4
Total on Type	21.7

Note: According to Garmin G1000H™ 1Hertz (Hz) log file, at the time of the accident the helicopter had been flown for 30 minutes (0.5 hours), and these hours have been added to the pilot's total flying hours in the table above.

The Garmin G1000H™ is an integral flight instrument system typically composed of two flight display units; one serving as a primary flight display, and the other as a multi-function display. Both units have receptacle for Secure Digital card (SD card) that could be used to download flight and engine parameters.

Figure 3: An example of a Garmin G1000H™ display units.

1.6 Aircraft Information

1.6.1 The Bell 505: Source: Bell Flight

The Bell 505 is the latest-generation short light single-engine helicopter. The Bell 505 is powered by the Safran Helicopter Engines (HE) Arrius 2R engine featuring a first-in-class, dual channel Electronic Engine Control Unit (EECU) that delivers exceptional performance along with a maximum cruise speed of over 125 knots (232 km/h). A first-in-class fully integrated Garmin G1000H™ flight deck delivers an unparalleled flying experience by greatly reducing pilot work-load. The Garmin G1000H™ flight deck featuring dual 10.4-inch (26.4 cm) displays provides critical flight information for crew at a glance, enhancing situational awareness and safety. The reliability, speed, performance, and manoeuvrability of the Bell 505 helicopter is integrated with a flat floor, open cabin that is configurable for a wide variety of missions and payloads. The spacious cabin can be configured to carry up to four passengers or configured for internal cargo missions by removing rear cabin seats and/or co-pilot seat. Passenger comfort is enhanced with a quiet and smooth ride along with a large rear cabin that provides ample legroom and headroom. Clamshell doors, located on the co-pilot side, open to a wide 55 inches (140 cm) to allow for easy ingress/egress from the aircraft. Large rear cabin windows and wrap-around windscreens in the cockpit provide excellent visibility for passengers and enhance situational awareness for the crew.

Airframe:

Manufacturer/Model	Bell Textron 505	
Serial Number	65117	
Year of Manufacture	2017	
Total Airframe Hours (at time of accident)	69.9	
Last MPI (hours & date)	62.1	1 October 2019
Hours Since Last MPI	7.8	
C of A (issue date)	27 August 2018	
C of A (expiry date)	31 August 2020	
C of R (issue date) (Present Owner)	1 August 2018	
Type of Fuel Used in the Helicopter	Jet A1	
Previous Accidents	None	

Note: Previous accidents refer to past accidents the helicopter was involved in, when relevant to this accident.

1.6.2 The last maintenance inspection that was carried out on the helicopter prior to the accident flight was certified on 1 October 2019 at 62.1 airframe hours. A Certificate of Release to Service was issued on 1 October 2019 with an expiry date of 1 October 2020, or at 162.1 hours, whichever comes first. The helicopter had flown a further 7.8 hours since its last maintenance inspection.

Engine:

Manufacturer/Model	Arrius 2R Turboshaft
Serial Number	54011
Part Number	R319009000
Hours Since New	69.9
Hours Since Overhaul	TBO not reached

1.6.3 The helicopter was fitted with an electronic engine control unit (EECU) part number 70EMS01020, with serial number 4120. The EECU scan records engine parameters that are downloadable. The EECU scan was removed by a field engineer after the helicopter was recovered and was shipped to the original equipment manufacturer (OEM) Bureau d'Enquêtes et d'Ánalyses (BEA) for downloading at the manufacturer's (Safran HE) facility in Bordes, France, in the presence of a BEA representative.

Software modification Tf91 was implemented through Service Bulletin (SB) 319 73 4091 on 19 September 2019. Due to power turbine vibration, module M02 S/N 8120 was replaced by S/N 8157 on 29 September 2019, followed by a ground run and a vibration check on 1 October 2019. The tests proved software modification to be operating satisfactorily.

Modification Tf90 was implemented through SB 319 72 4090 (bearing replacement) on 29 September 2019 at 62.11 hours, followed by a ground run, a vibration check and a post-maintenance flight on 3 October 2019. The tests proved bearing replacement to be operating satisfactorily.

Main Rotor:

Manufacturer/Model	Bell Textron	
Serial Number/s	BH611060 / BH611381	
Rotor Blades	1	2
Hours Since New	69.9	69.9
Hours Since Overhaul	TBO not reached	TBO not reached
Transmission Type	Main Rotor Gearbox	
Serial Number	BH609204	
Hours Since New	69.9	
Hours Since Overhaul	TBO not reached	

Tail Rotor:

Manufacturer/Model	Bell Textron	
Serial Number/s	CS20942	CS20947
Tail Rotor Blades	206-016-201-135	206-016-201-135
Hours Since New	69.9	69.9
Hours Since Overhaul	TBO not reached	TBO not reached
Transmission Type	Tail Rotor Gearbox	
Serial Number/s	BH609234	
Hours Since New	69.9	
Hours Since Overhaul	TBO not reached	

1.6.4 Weight and balance

The flight was privately conducted with three passengers of varying weights on-board, in addition to the pilot. The flight required approximately 236 lbs of Jet A1 fuel (return flight).

The duration of the flight was 31 minutes, and this was factored into the calculation (below). The fuel consumption for the flight was 118 lbs.

According to the mass and balance report, the maximum take-off mass was 3 680 lbs.

	Longitudinal		
Item Description	Weight (lbs)	Arm (inches)	Moment (lb-in.)
Empty weight	2367	176	416592
Pilot	174	98	17052
Forward passenger	218	98	21364
Passenger aft left	268	135	36180

Passenger aft right	224	135	30240
Gross weight at zero fuel	**3251**	**160**	**521428**
Fuel (321 L) to maximum GTOW	**457**	**166**	**70550**
Gross take-off weight (GTOW)	**3708**	**161**	**608578**
Maximum take-off weight (according to approved weight and balance sheet)	**3680**		
At the time of the accident, the weight was calculated to be 28 lbs more than the MTOW of 3 680 lbs.			

1.7 Meteorological Information

1.7.1 The weather information below was obtained from the Meteorological Aeronautical Report (METAR) that was issued by the South African Weather Service (SAWS) for FAKM, located 10 nautical miles (nm) from the accident site. (METAR FAKM 280900Z 26005KT CAVOK 36/01 Q1018=)

Wind Direction	260º	Wind Speed	5kts	Visibility	+10 km
Temperature	36ºC	Cloud Cover	Nil	Cloud Base	Nil
Dew Point	1ºC	QNH	1018 hPa		

1.8 Aids to Navigation

1.8.1 The helicopter was equipped with a navigational system approved by the Regulator (SACAA) for the helicopter type. There were no reported defects prior to the accident flight.

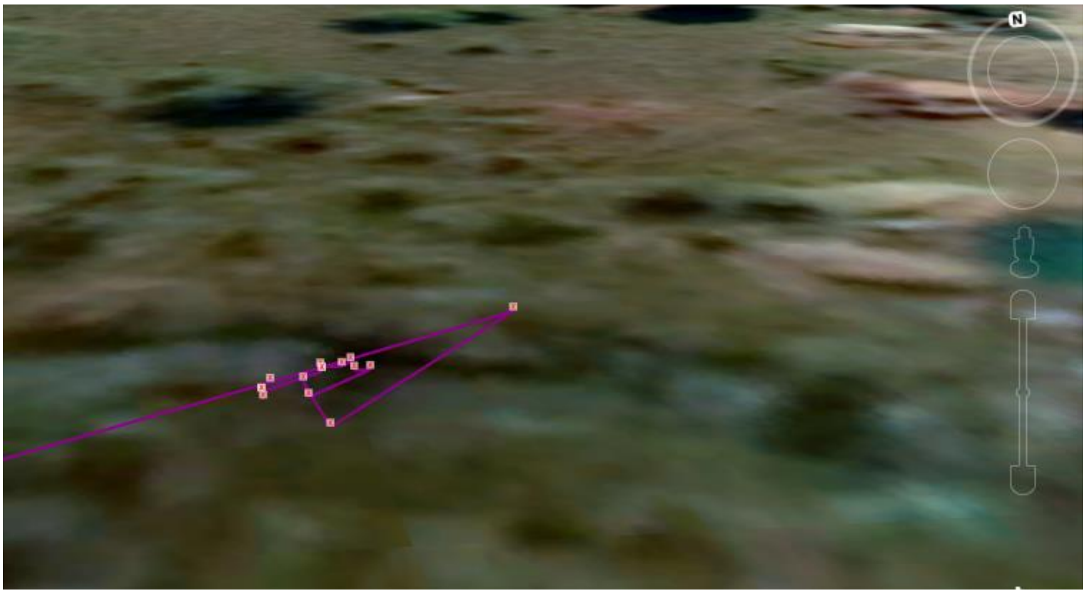


Figure 4: The helicopter's flight part just before impact
(arrow depicting direction of flight). (Source: Garmin G1000H™ 1Hertz (Hz) log file)

Figure 5: GPS plotting of the accident flight path. (Source: Garmin G1000H™ 1Hertz (Hz) log file)

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 were no recorded defects prior to or during the accident flight.

1.10 Aerodrome Information

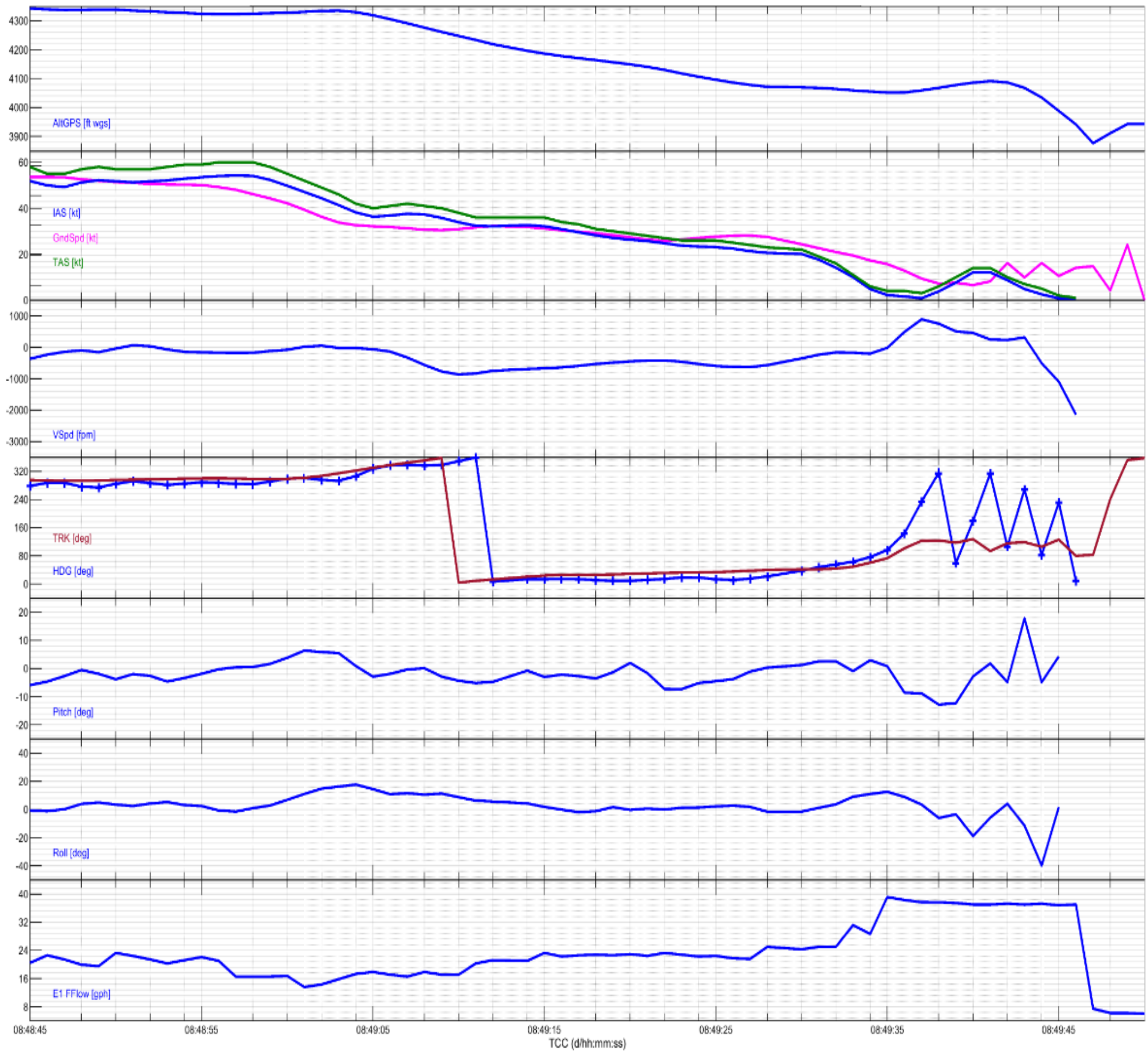
1.10.1 The accident did not happen within the boundary of an aerodrome.

1.11 Flight Recorders

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

1.11.2 The helicopter was fitted with two Garmin G1000H™ electronic flight instrument system (EFIS). The EFIS had a built-in system called 1Hz log which records flight and engine parameters as well as GPS information that could be loaded to an SD card. The SD card was retrieved and sent to the manufacturer and BEA for decoding and analysis.

1.11.3 The data was retrieved successfully from the G1000H™ 1Hz file and has been plotted on the graph (Graph 1) depicting the last minute of the accident flight. Among the recorded parameters were Alt (altitude), IAS (indicated airspeed), Vspd (vertical speed), HDG (heading), pitch, roll and fuel flow. It could be established on the graph that during approach to the water mains, the helicopter was seen descending from 4 340 feet to 4 050 feet. The elevation at the accident site was 3 888 feet, which placed the helicopter at a height of approximately 162 feet AGL during a turn to the right while travelling at near zero forward speed. The vertical speed increased exponentially at approximately 1 000 feet per minute (fpm) and a rapid change in heading, indicating a full rotational spinning action of about 3½ turns while a decrease in speed from 20 to 0 kts was recorded. A pitching down attitude was observed with a slight positive roll along the lateral axis. An increase in fuel flow from 24 gallons per hour (gph) to 40gph was observed and was maintained for approximately 10 seconds until the end of the flight.



Graph 1: Garmin G1000H™ 1Hz log graph.

1.12 Wreckage and Impact Information

1.12.1 The helicopter was found in an upright position (on its belly) with the nose facing north north-east.

Figure 6: The helicopter post-accident.

1.12.2 Main wreckage

Both skids of the helicopter were found bent outwards, indicative of high vertical energy impact (Figure 6). The right skid gear broke off in the middle as a result of overload, but it was found still attached to the helicopter. The initial impact of the skids was observed on the uneven ground surface. Ground scar marks showed that the helicopter bounced and made an anti-clockwise (left) turn before it came to rest. The marks and soil (dirt) on the front right-side of the nose cone indicated that the fuselage had a slight right bank in a nose-down attitude before it came into contact with the ground (Figure 9).

1.12.3 The impact damage observed indicated that the helicopter was yawing on impact. The passengers' seats had collapsed, except for the pilot's seat which collapsed only on one side (right-hand side) (Figure 7). The pilot was seated on the right-side seat.

Figures 7 and 8: The collapsed seats (left image), and the left and right skid gear (right image).

Figure 9: Bent pitot tube, dirt and marks on right-side of the nose section.

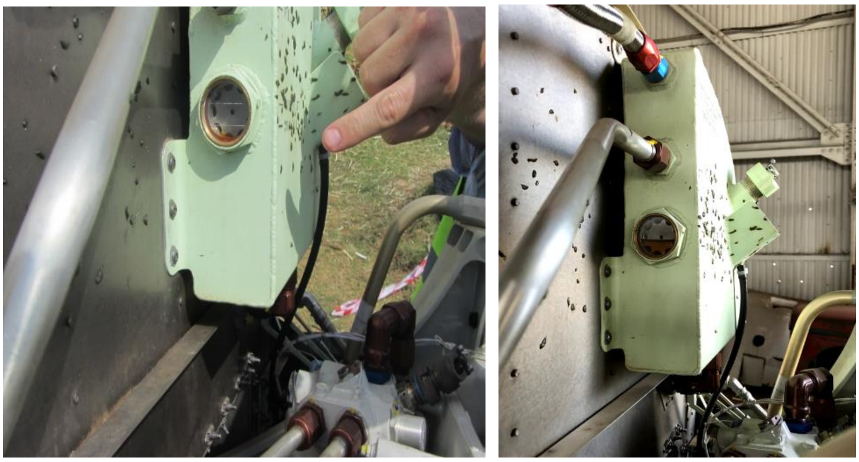
1.12.4 Tail boom assembly

The tail boom was observed to have tilted slightly to the right due to overload; but it did not detach completely. The skin where the tail boom attaches had sheared off from its rivets due to overload and, as a result, the middle tail drive shaft disconnected from the front shaft. The tail rotor vertical fin was found buckled at the bottom, indicative of contact with the ground; it was also twisted slightly to the left, indicating a lateral motion on impact. The tail rotor guard and the horizontal stabiliser were still attached and intact and appeared undamaged.

Figure 10: An opening between the fuselage and tail boom shows a detached tail boom.

1.12.5 Engine (Arrius 2R SN: 54011)

The engine was still attached on its mountings. The oil level indication was showing zero. The engine was cranked by the aircraft maintenance engineer (AME) in the cockpit at the accident site and there was freedom of movement and no abnormal noise was heard. The oil level indicated full after cranking. The engine driveshaft was rotating freely when rotated by hand and the sprag clutch freewheel was engaging and disengaging, showing signs of no abnormality.



Figures11 and 12: Oil level before the engine crank (left) and oil level after the engine crank (right).

1.12.6 The main transmission was still intact although the left attaching mounting (SN: 000009) was observed to have failed/collapsed as a result of impact. The mast and the swashplate were intact. The left control tube was severed near the point where it attaches to the non-rotating star. There was no visible sign of hydraulic leaks that were observed in the transmission deck, servo actuators or pipes. The three actuators were still attached to their mounting points. The level of the fluid indicated ¾ full (Figure 14).

Figure 13: Damaged transmission mounting.

Figure 14: Hydraulic fluid level in the resevoir.

Figure15: Hydraulic switch position as found on the instrument panel.

1.12.7 The tail gearbox outside condition exhibited signs of impact damage. The site glass had burst and trickling oil was visible around the casing. The magnetic pickup was inspected and no visible chips were present. The gears inside were observed to be intact and accounted for. The drive between the drive shaft and the tail gearbox was simulated and connection was positive.

1.12.8 Flight controls continuity checks were perfomed on the anti-torque pedals, cyclic stick and collective stick by moving the controls. The anti-torque left and right pedal movement was transmitted to the pitch change of the tail rotor blades through steel cable, which were still intact. Cyclic and collective movement was transmitted through control tubes and linkages, although movement was limited as a result of hydraulic jam/lock on the servo actuators and a disturbed pitch change control tube that was severed by the transmission cowling, as well as a jam on the bellcranks. The piece of the severed pitch control tube was found lying on the ground (right-side) next to the helicopter. The throttle position switch on the collective stick was found in flying mode position and with the pilot collective fully raised or applied. The helicopter was fitted with dual controls except for the collective for the co-pilot, which had been blanked off. The co-pilot cyclic was found lying on the floor between the anti-torque pedals. According to available information, the co-pilot cyclic was removed post-accident to facilitate medical help and recovery for the occupant who was seated on the left front seat.

Figure 16: Damaged clevis bolt of bottom pitch control tube.

1.12.9 Both main rotor blades were still attached to the main rotor head. The main rotor blades did not exhibit any significant damage. However, it was noted that there was a shrub that was severed by one of the main rotor blades. Both main rotors exhibited identical signs of compression load stress at the same place near the blade root lower skin. One of the blades had a fracture as a result of the compression stress.

Figure 17: The main rotor blades after they had been recovered.

1.12.10 Tail rotor

The tail rotor blades were still attached to the tail gearbox and both had 90˚ bends as a result of impact. The tail rotor pitch change links were found in good condition and still attached to the tail rotor (Figure 18). The oil sight glass had cracked, indicative that it was shuttered by the balance weight during impact. The electrical magnetic plug was removed and inspected for metal fillings/flakes, and none were found.

Figure 18: Damage sustained by the tail rotor blades.

1.12.11 The shrub-tops that were severed by the main rotor blades indicated that the blades were turning at speed on impact.

Figure 19: A shrub that was severed by the main rotor blades.

1.13 Medical and Pathological Information

1.13.1 None.

1.14 Fire

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

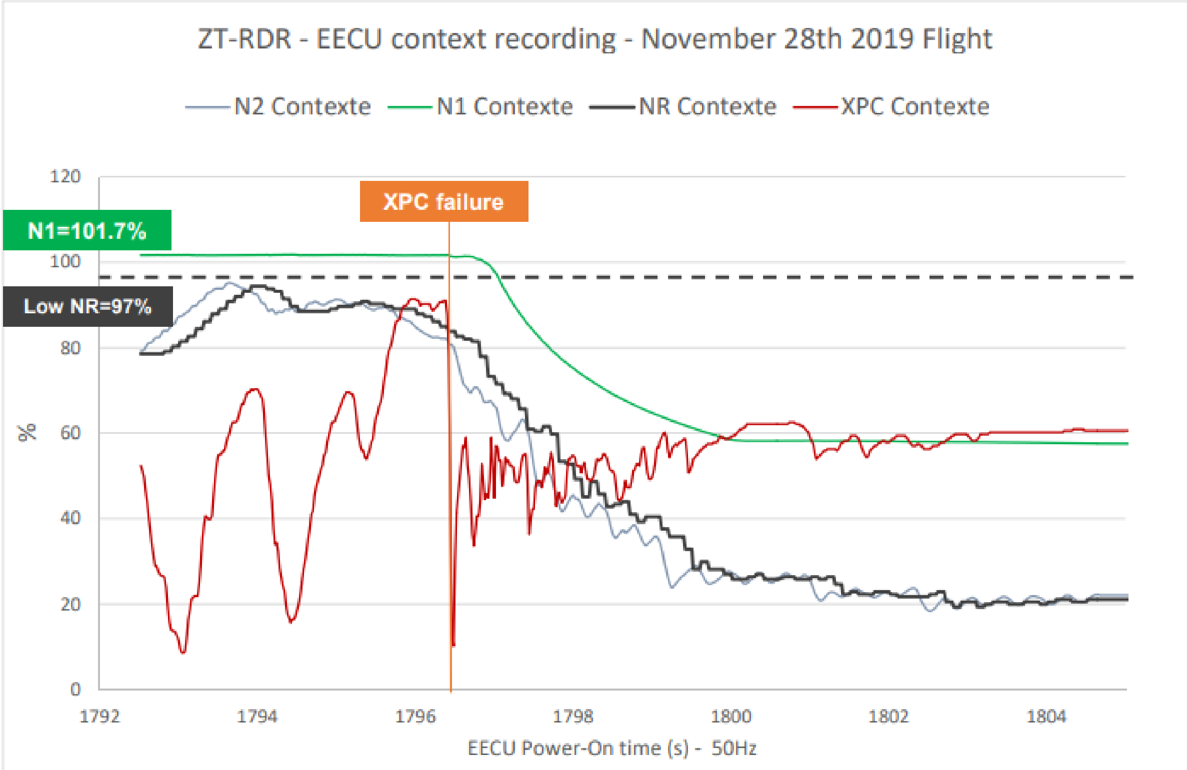
1.15 Survival Aspects

1.15.1 The accident was considered survivable even though the impact was hard. The airframe and the cabin structure remained intact and the safety harnesses in the helicopter for the pilot and passengers were used and did not fail. The helicopter crashed on an open field next to a military base and the medical doctors from the military base were the first responders to the accident scene. The crash worthiness seats assisted in minimising the vertical impact forces by collapsing and absorbing shock.

1.16 Tests and Research

1.16.1 Following the accident, the EECU and SD cards (1Hz and GPS nav) were retrieved from the helicopter and forwarded to BEA, Safran HE and Bell Flight manufacturers, respectively. The SD card log contained the accident flight and an initial download was conducted at the helicopter agent's facility in South Africa. The engine manufacturer successfully downloaded the EECU data and a technical report was issued. The following details were uncovered:

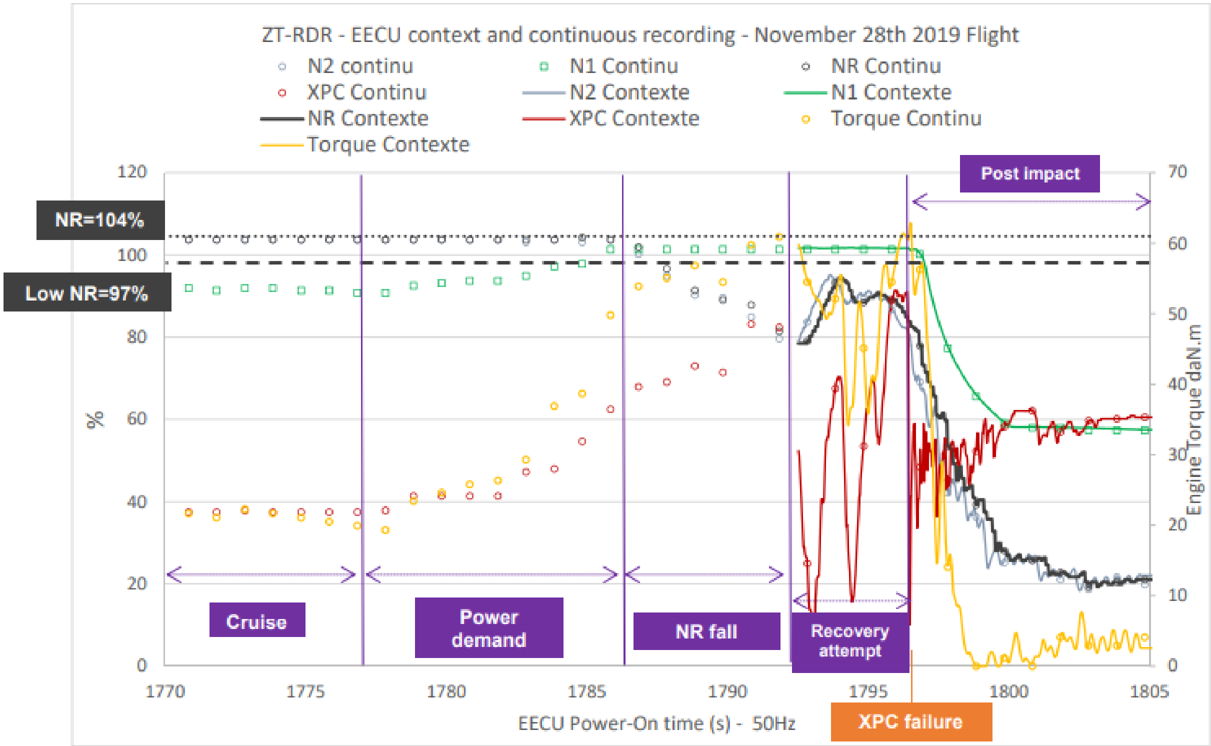
1.16.2 EECU context recording:



Graph 2: Engine parameters 50Hz – EECU context recording (Xpc failure context record, zoomed).

Before the XPC failure raised at 08:49:46, it could be noticed that:

- *The N1 rating was stable at 101.7%, which corresponds to an Arrius 2R "N1 MTP stop" at 55036 rpm (MTP=Maximum Transient Power, Arrius 2R 100% N1 = 54 117 rpm). The N1 rating stabilised at MTP stop, which meant that the gas generator was delivering its maximum power in the day's condition.*
- *N2 and NR are correlated. Max NR and Max N2 measured from the context recording were respectively 94.33% and 95.19%.*
- *A great and quick variation to the collective pitch (XPC) was ordered (from 10%Xpc up to 70% and back to 18% within a second). This pattern was repeated several times just before the Xpc failure raised.*



Graph 3: The engine parameters 1Hz & 50Hz EECU context and continuous recording of last 26 seconds.

- ***Cruise flight:*** *stable Xpc, N2, NR, engine torque and N1.*
- ***Responsive power demand:*** *Xpc increase, the N2 and NR were maintained at the expected 104% along with N1 and torque that increased without reaching any limit.*
- ***NR fall:*** *power demand continued to increase during this phase, but N2 and NR are failing along with a maximum gas generator rating at a stabilised MTP stop (101.7%), and an engine torque also close to a stop (60.93daN measured for a 63daN maximum torque). Therefore, the engine and its fuel flow were still under the EECU control, but the engine acceleration is limited by engine limits. As the gas generator was delivering its maximum available power, the load applied to the power turbine (by the A/C) was in excess. From that time, the more the Xpc is increasing, the more the NR and N2 were failing in a divergent way.*
- ***Recovery attempt phase:*** *a quick decrease followed by great variations of the Xpc were applied without sustainable effect on N2 and NR, which were maintained under the low NR warning (97%) while the N1 stayed stabilised at maximum rating (101.7%).*
- ***Post-impact phase:*** *the engine was shut down normally at 1886s POT.*

1.16.3 Analysis by Safran HE

The ZT-RDR Arrius 2R EECU S/N 4120 investigation provided continuous recordings, context recordings and EECU flags log (including the limits maintenance log) that were all analysed. The engine parameters gathered in a series of charts showed that the engine was functioning as expected, with a gas generator at 101,7%N1, which was the maximum N1 rating in the day's condition, during the last 26 seconds before impact. The N1 maximum *rating is aimed at protecting the engine's mechanical integrity. This N1 threshold is coded in the engine's regulation software (Max. EECU embedded value also called "MTP STOP"). Approximately 11 seconds before impact, the NR and N2 fell below 104%. It was the consequence of an exceeding torque demand than what the engine was designed to deliver in the day's condition. Indeed, once at N1 maximum rating, the engine could not deliver more power to the power turbine. As Xpc continued to increase, the main rotor blades angle of attack also increased, and so the torque demand. This torque demand was usually compensated by an increase of the gas generator rating. With N1 at maximum rating, the gas generator was not able to compensate and to regulate N2 at 104% anymore. Hence, the torque demand increase made the N2 decreased, along with the rotor speed. From 11s to 5s before impact, continuing in an additional torque demand (Xpc increase) while the gas generator rating was at a maximum stop, contributed to accelerate the N2 and NR decrease down to below 80%. Torque is continuously increasing during this phase, up to 60.93 daN (max torque limit is 63daN). Approximately 5 seconds before the impact, at the moment when the torque demand is reduced (Xpc decrease), with the same N1 rating at MTP Stop threshold, the power turbine accelerated again along with NR. However, the torque demand was increased again shortly after that, and was followed with quick Xpc variations, which prevented N2 and NR to reach the 104% (nominal NR/N2 rating) before the impact of the helicopter with the ground. No engine running "failure" flag was recorded during the flight before impact. The only block of engine running "failure" flags that was raised is most probably related to the impact of the aircraft with the ground (Xpc failure). At impact, electrical connections are often lost, some values may be erratic, inconsistent, or behave with very high gradients that are detected as failures by the EECU. A merge of EECU continuous recording and EECU context recording was displayed, and their consistency and continuity were established.*

1.16.4 Conclusion about EECU data by BEA

The analysis performed by Safran Helicopter Engines during the investigation of the EECU P/N 70EMS01010 S/N 4120 from Arrius 2R S/N 54011 did not reveal any engine discrepancy before the accident. When used within its limits, the engine was functioning as expected during the accident flight. When asked to go beyond its power range, the engine was not able to cope with the demanded torque. However, the gas generator rating N1 reached the MTP Stop, which meant that the gas generator was delivering its maximum power in the day's condition. The free turbine rating N2 and rotor speed NR then dropped below a flight-sustainable value and were never recovered before the impact of the helicopter with the ground.

1.16.5 Following the accident, a thorough examination of the engine was conducted by the technical representative from the engine manufacturer in the presence of the AIID investigators. A borescope inspection was conducted on the hot and cold section of the engine. The inspection of the centrifugal compressor blades, gas generator turbine blades and power turbine blades did not reveal any signs of damage.

Figure 20: The centrifugal compressor blades.

Figure 21: The gas generator turbine.

Figure 22: The power turbine blades.

Figure 23: The flame tube.

1.17 Organisational and Management Information

1.17.1 The helicopter was operated privately.

1.17.2 The aircraft maintenance organisation (AMO) 0027 that carried out the last maintenance inspection on this helicopter prior to the accident flight was in possession of an AMO approval certificate that was issued by the Regulator on 27 November 2018 with an expiry date of 30 November 2019.

1.18 Additional Information

1.18.1 Loss of Tail Rotor Effectiveness (LTE) (Source: NTSB safety alert article) See attached NTSB article for a detailed report:

In helicopters, loss of tail rotor effectiveness (LTE), or unanticipated yaw, is an uncommanded *rapid yaw that does not subside of its own accord. The LTE can occur in all single-engine, tail rotor-equipped helicopters at airspeeds lower than 30 knots and, if uncorrected, can cause the pilot to lose helicopter control, potentially resulting in serious injuries or death. Various factors can contribute to LTE, including varying airflow from the main rotor blades (particularly at high power settings) or from the environment, which can affect the airflow entering the tail rotor; operating at airspeeds below translational lift; operating at high altitudes and high gross weights; operating near large buildings or ridgelines, which can cause turbulence; and the relative wind direction (see figures 1 and 2 below).*

On US-manufactured single-rotor helicopters, the main rotor rotates counter-clockwise as viewed from above. The torque produced by the main rotor causes the fuselage of the helicopter to rotate in the opposite direction (nose right). On some European- and Russian-manufactured helicopters, the main rotor rotates clockwise as viewed from above. In those helicopters, the torque produced by the main rotor causes the fuselage to rotate nose left. Operating with the relative wind direction within ±15° of the 10 o'clock position (for counter clockwise main rotor helicopters) or the 2 o'clock position (for clockwise main rotor helicopters) generates vortices that directly blow into the tail rotor. Also, tailwinds from 120° to 240° can cause high workloads. Finally, crosswinds can create roughness due to tail rotor vortex ring state (wind from 210° to 330° on counter clockwise main rotor helicopters or from 30° to 150° on clockwise main rotor helicopters).

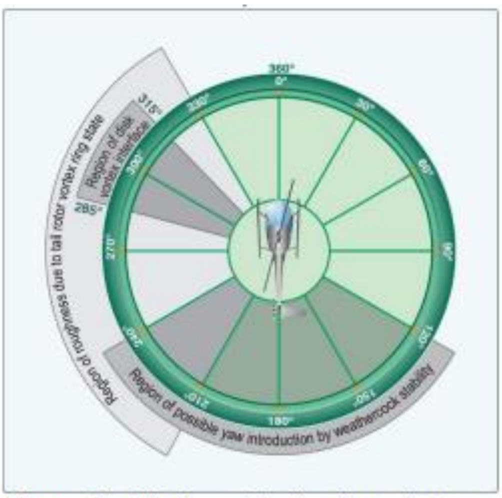


Figure 1. Relative wind directions that can contribute to LTE for counterclockwise main rotor helicopters.

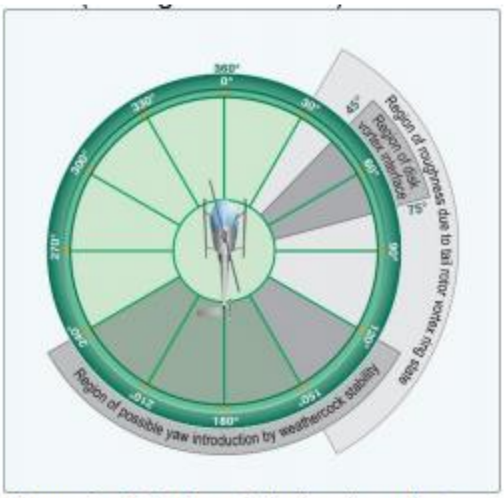


Figure 2. Relative wind directions that can contribute to LTE for clockwise main rotor helicopters.

1.18.2 Pressure and density altitude calculations:

Pressure altitude = (standard pressure – current pressure setting) * 1 000 + field elevation
(29.92 – 30.07) * 1 000 + 3888
4 038 feet

Density altitude = pressure altitude + (120*(OAT – ISA Temp))
4038 + (120*(36-7))
7 518 feet

1.18.3 Hover ceiling out of ground effect (OGE) (Source: Bell 505 FM)

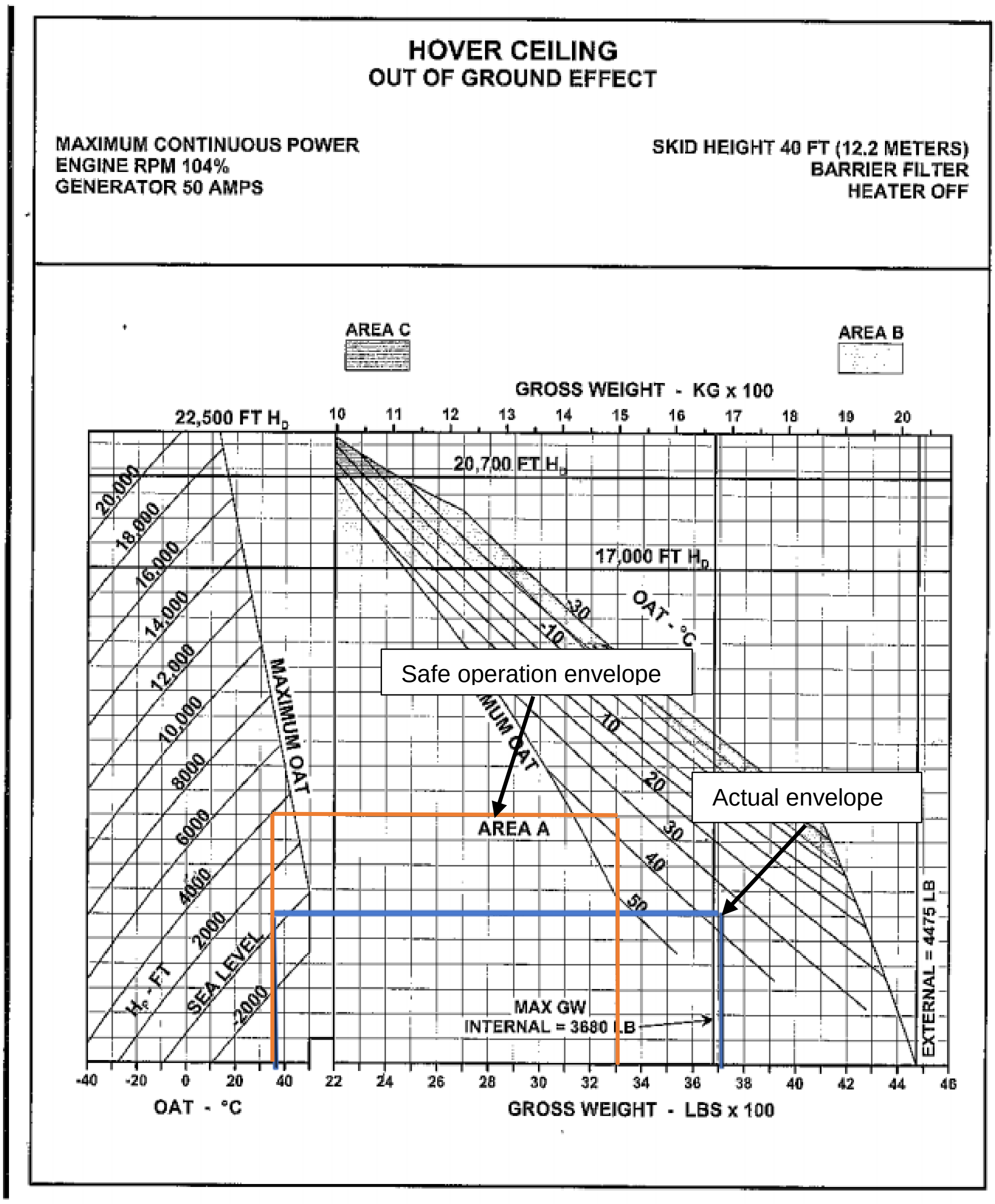


Figure 4-7. Hover ceiling OGE (Sheet 3 of 4)

Graph 4: Hover ceiling OGE. (Source: BHT 505 FM)

1.18.3 The maximum take-off weight (MTOW) for the helicopter at the time of the accident was calculated to have been 3 708 lbs which was 28 lbs more than the certified MTOW of 3 680 lbs. According to the hover ceiling OGE chart, the maximum allowable weight to operate safely at 4 000ft was measured to be at 3 300 lbs, which indicates that the helicopter's weight to operate at 4000ft was over by 408 lbs. The pressure altitude was 4 038ft, therefore, the difference was 538ft. The ambient temperature on the day of the accident was 36˚C. The density altitude at the time of the accident was calculated to be 7 518ft.

1.18.4 Height velocity diagram:

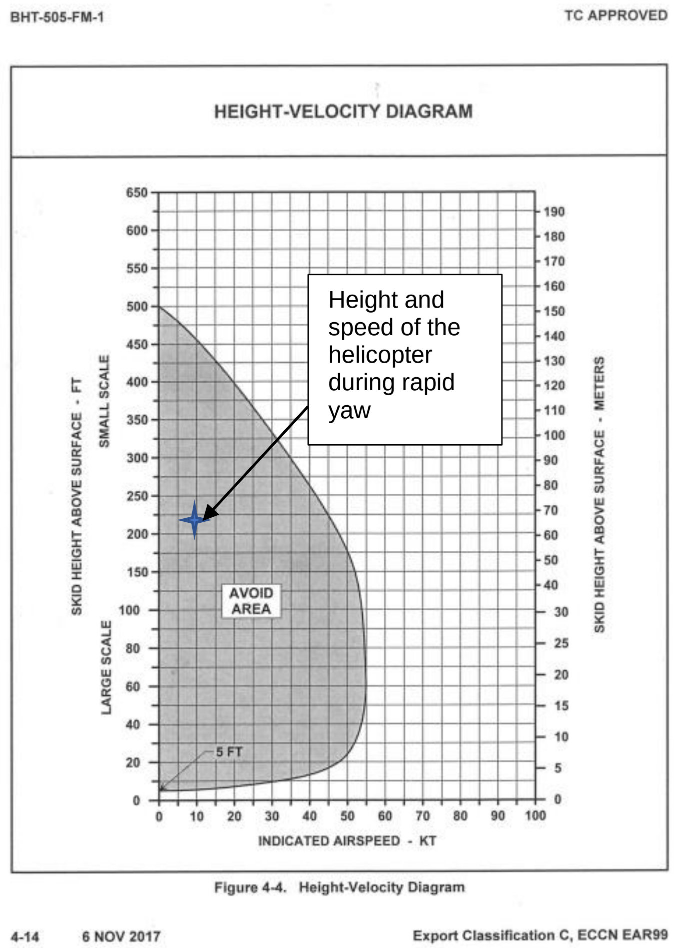


Diagram 1: Height velocity (Bell 505 AFM).

1.18.5 Pilot's Operating Handbook (POH) extract (Complete loss of tail rotor in-flight).

Indications

- *Uncontrollable yawing to the right (left-side slip).*
- *Nose-down tucking.*
- *Possible roll of fuselage.*

Procedure

To reach a suitable landing site, the vertical fin may permit controlled level flight at low power setting and sufficient airspeed creating weather cock effect.

1. *If unable to maintain level flight*
   a. *Enter autorotation*
   b. *Maintain a minimum airspeed of 40 KIAS*
   c. *Throttle – idle*
   d. *Do the engine failure in-flight procedure, as per (paragraph 3-3-A-2)*

2. *If able to maintain level flight and reach suitable landing site:*

a. Do approach while maintaining left yaw

b. On final approach, maintain helicopter in mild flare.

c. Land with forward airspeed and minimal sideslip.

Engine failure in-flight procedure, as per (paragraph 3-3-A-2)

Indications:

Left yaw

Engine out warning illuminated

Note

Audio activated when Ng drops below 50%

Engine instruments indicate power loss

MFD switches to ENGINE page

NR decreasing with RPM warning light

And audio on when NR drops below 95%

Procedure

1. *Maintain heading and altitude control while lowering the collective.*
2. *Collective – Adjust as required to maintain 90 to 111% NR*

Note

Maintaining NR at high-end of operating range will provide maximum rotor energy to accomplish landing but will increase rate of descent.

3. *Cyclic – Adjust to obtained desired autorotative airspeed*

Note

Maximum airspeed for steady state autorotation is 100 KIAS. Minimum rate of descent airspeed is 50 KIAS (glide ratio of approximately 0.5 NM per 1000 feet AGL). Maximum glide distance airspeed is 70 KIAS (glide ratio of approximately 0.6 NM per 1000 feet AGL). Recommended autorotation speed is 60 KIAS to increase the flare efficiency.

Note

If desired and sufficient altitude remains, perform the ENGINE RESTART IN FLIGHT (paragraph 3-3-B)

4. *ENGINE OFF*

5 *Flare to lose airspeed*

6. *Apply collective as flare effect decreases*

7. *Cushion the landing*
8. *Maintain cyclic in centred position*
9. *Lower collective smoothly*
10. *Complete helicopter shutdown.*

1.19 Useful or Effective Investigation Techniques

1.19.1 None.

2 ANALYSIS

2.1. General

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

2.2 Analysis

2.2.1 Man

The pilot was issued a Private Pilot Licence (PPL) on 4 June 2019 with an expiry date of 31 May 2020. He was also issued a Class 2 medical certificate on 28 March 2019 with an expiry date of 31 March 2020. The pilot conducted a conversion on the Bell 505 on 9 October 2018 which comprised a dual check of 2.7 hours with an instructor. The pilot had a total of 1 047.9 helicopter hours, of which 432.8 hours were on turbine-powered helicopters. The pilot had accumulated a total of 21.7 flying hours on the helicopter type. Based on this information, the pilot was properly qualified to conduct the flight.

During low NR situation, an attempt to recover from the upset was initiated, followed by collective input variations which were noticeable on the EECU graph but had no effect in stabilising the NR at 104%. When the rapid uncommanded yaw around the vertical axis occurred, the input of the left pedal was ineffective due to loss of thrust produced by the tail rotor blades and a delay in application. As stated in the non-normal emergency procedure on the POH, it is required that the pilot enter autorotation, maintain a minimum of 40 KIAS and advance throttle to idle; all this was not done. It is also required that the engine failure in-flight procedure be conducted to minimise torque effect; and this was not done. The height of 162ft AGL and speed (< 10 KIAS) at which the helicopter was being operated was below the minimum height required to successfully conduct autorotation. The height velocity diagram (Diagram 1) requires that the aircraft be at a height of 500ft and above to conduct autorotation safely.

2.2.2 Machine

The last annual inspection was carried out by the AMO on 1 October 2019 with an expiry date of 1 October 2020, and a Certificate of Release to Service was issued on 1 October 2019 at 62.1 hours, with an expiry date of 1 October 2020 or at 162.1, whichever comes first. The helicopter was issued a Certificate of Airworthiness on 27 August 2018 with an expiry date of 31 August 2020.

The helicopter weight and balance at the time of the accident that was computed was found to be 3 708 lbs, which was 28 lbs more than the maximum all up weight (MAUW) of 3 680 lbs. The pressure altitude and density altitude at the time of the accident were calculated to be 4 038ft and 7 518ft, respectively. Based on the calculated values of pressure altitude and density altitude, the power available was not sufficient to sustain flight due to given conditions, making it difficult for the pilot to recover the helicopter.

The borescope inspection that was carried out by technical representation revealed no anomalies with the engine's internal components.

The downloaded data from EECU and Garmin G1000H™ 1Hz file did not reveal any mechanical malfunction prior to the accident flight. The recorded data revealed that the engine was supplying the required rated power prior to impact.

2.2.3 Mission

The purpose was to conduct a private flight over the KEM-JV mine for an aerial inspection, then route to Kamfers Dam to examine the decreasing water levels and the larger than normal Flamingo population, then fly to the local council's water pipelines to inspect them before returning to FAKM. The pilot and the passengers spotted water leaking from the main pipeline and they flew closer to inspect and take pictures.

2.2.4 Investigation reveal

During the turn to the right to inspect leaking water pipeline, the helicopter yawed unexpectedly to the right, the pilot tried to recover but was unsuccessful and lost control. As a result, the helicopter impacted the uneven surface.

3 CONCLUSION

3.1 General

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

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

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

3.2 Findings

3.2.1 The pilot was issued a PPL on 4 June 2019 with an expiry date of 31 May 2020. He was also issued a Class 2 medical certificate on 28 March 2019 with an expiry date of 31 March 2020.

3.2.2 The pilot conducted a conversion on the Bell 505 on 9 October 2018 which comprised a dual check of 2.7 hours with an instructor. The pilot had a total of 1 047.9 helicopter hours, of which 432.8 hours were on turbine-powered helicopters. The pilot then ferried the helicopter from FAGM to FAKM and flew a further 2.3 hours. Since the conversion, the pilot had accumulated 21.7 flying hours on the helicopter type.

3.2.3 The last annual inspection was carried out by the AMO on 1 October 2019 with an expiry date of 1 October 2020, and a Certificate of Release to Service was issued on 1 October 2019 at 62.1 hours with an expiry date of 1 October 2020 or at 162.1 hours, whichever comes first.

3.2.4 The helicopter was issued a Certificate of Airworthiness on 27 August 2018 with an expiry date of 31 August 2020.

3.2.5 The Certificate of Registration of the present owner was issued on 1 August 2018.

3.2.6 The maximum take-off weight (MTOW) for the helicopter at the time of the accident was calculated to have been 3 708 lbs which was 28 lbs more than the certified MTOW of 3 680 lbs.

3.2.7 The weather conditions at the time of the accident had no factor.

3.2.8 The downloaded data from EECU system and Garmin G1000H™ 1Hz log file did not reveal any mechanical malfunction prior to the accident flight.

3.2.9 During the turn to the right to inspect the leaking water pipeline, the helicopter unexpectedly yawed to the right and lost control, the pilot tried to recover and was unsuccessful; as a result, the helicopter impacted the uneven surface.

3.3 Probable Cause/s

3.3.1. During the turn to the right to inspect the leaking water pipeline, the helicopter unexpectedly yawed to the right and lost control, the pilot tried to recover but he was unsuccessful. As a result, the helicopter impacted the uneven surface.

3.4 Contributory Factors

3.4.1 Loss of tail rotor effectiveness (LTE) as a result of increased main rotor angle of attack during the right turn.

3.4.2 Incorrect technique during right turn.

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 in the interest of safety that all pilots operating helicopters (Bell 505) at low altitude should make themselves well versed with emergency procedures and sharpen their skills to condition their reflexes and muscle memory to perform better during emergency situations.

4.2.2 **Safety message:** It is recommended that pilots operating helicopters carry out weight and balance calculation as part of their pre-flight planning before any flight, especially when the flight includes passengers.

5 APPENDICES

5.1 National Transportation Safety Board (NTSB) safety alert. (Loss of tail rotor effectiveness)

This report is issued by:
Accident and Incident Investigations Division
South African Civil Aviation Authority
Republic of South Africa

NTSB

SAFETY ALERT

National Transportation Safety Board

★ Loss of Tail Rotor Effectiveness in Helicopters ★

Be alert for uncommanded yaw so you don't get caught off guard!

The problem

- In helicopters, loss of tail rotor effectiveness (LTE), or unanticipated yaw, is an uncommanded rapid yaw that does not subside of its own accord. LTE can occur in all single-engine, tail rotor-equipped helicopters at airspeeds lower than 30 knots and, if uncorrected, can cause the pilot to lose helicopter control, potentially resulting in serious injuries or death.
- Various factors can contribute to LTE, including varying airflow from the main rotor blades (particularly at high power settings) or from the environment, which can affect the airflow entering the tail rotor; operating at airspeeds below translational lift; operating at high altitudes and high gross weights; operating near large buildings or ridgelines, which can cause turbulence; and the relative wind direction (see figures 1 and 2).[1]

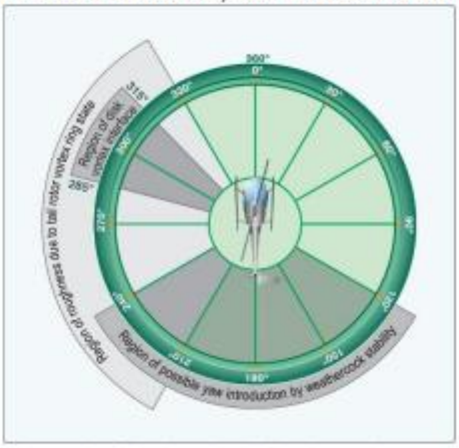


Figure 1. Relative wind directions that can contribute to LTE for counterclockwise main rotor helicopters.

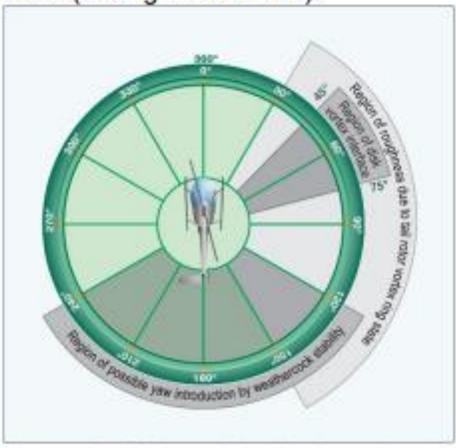


Figure 2. Relative wind directions that can contribute to LTE for clockwise main rotor helicopters.

[1] On US-manufactured single-rotor helicopters, the main rotor rotates counterclockwise as viewed from above. The torque produced by the main rotor causes the fuselage of the helicopter to rotate in the opposite direction (nose right). On some European- and Russian-manufactured helicopters, the main rotor rotates clockwise as viewed from above. In those helicopters, the torque produced by the main rotor causes the fuselage to rotate nose left. Operating with the relative wind direction within ±15° of the 10-o'clock position (for counterclockwise main rotor helicopters) or the 2-o'clock position (for clockwise main rotor helicopters) generates vortices that directly blow into the tail rotor. Also, tailwinds from 120° to 240° can cause high workloads. Finally, crosswinds can create roughness due to tail rotor vortex ring state (wind from 210° to 330° on counterclockwise main rotor helicopters or from 30° to 150° on clockwise main rotor helicopters).

- Due to safety concerns, training for LTE is rarely done in an actual helicopter. Simulators allow pilots to practice recovery; however, the element of surprise—and the rapid yaw that pilots may experience when the helicopter encounters LTE in flight—is difficult to realistically achieve in some simulators.

Related accidents

During the 10-year period from 2004 to 2014, the National Transportation Safety Board (NTSB) investigated 55 accidents involving LTE. In the following cases, the pilots were unable to recover when the helicopters encountered unanticipated yaw. All three cases involved helicopters with counterclockwise rotating main rotor blades.

- The pilot was making an approach to a hospital helipad into light wind at night when he chose to go around. The pilot lowered the helicopter's nose, added power, and raised the collective; the helicopter then entered a rapid "violent" right spin. The pilot applied left antitorque pedal and cyclic but was unable to recover. The helicopter spun several times before impacting power lines and terrain. Just before the pilot added power to go around, the helicopter was traveling about 5 knots groundspeed. At such a low groundspeed, the tail rotor is required to produce nearly 100% of the directional control. The pilot likely did not adequately account for the helicopter's low airspeed when he applied power to go around, which resulted in a sudden, uncommanded right yaw due to LTE. (CEN15FA003)

- The pilot and two passengers were surveying deer, with the helicopter about 50 to 100 ft above ground level with a 5- to 10-knot left crosswind and an indicated groundspeed of 30 to 35 knots. As terrain began to rise, the pilot added power to clear a ridge. The pilot reported that, when the helicopter was about 100 ft from the top of the ridge, the helicopter began to yaw to the right. He added power to clear the ridgeline, which greatly increased the right yawing motion. The helicopter began spinning, crossed over the ridgeline backward, and continued spinning before it contacted the ground and rolled over onto its left side. A passenger reported that, although the wind was about 10 knots when they started the survey, the wind speed increased when the helicopter reached the top of the ridge, and the pilot had to correct for it twice before the helicopter began spinning to the right. The helicopter was operating with wind coming from the left and at a high power setting; the unanticipated right yaw and subsequent spinning of the helicopter are consistent with LTE. (CEN13TA165)

- The pilot had planned a Part 91 sightseeing flight around New York City with two passengers; however, four passengers arrived for the flight. The pilot did not complete performance calculations before the accident flight, and the helicopter was in excess of its maximum allowable gross weight at takeoff. Shortly after departure, while the helicopter was climbing to 60 ft above the water, the pilot failed to anticipate and correct for conditions (high gross weight, low indicated airspeed, and a right downwind turn) conducive to LTE, which resulted in LTE and an uncontrolled spin. (ERA12MA005)

SA-062 March 2017

What can you do?

- Include wind speed and direction in your preflight planning because it can greatly affect your helicopter's susceptibility to LTE.
- Know your helicopter's performance limitations, as outlined per the manufacturer, and adhere to them.
- Be aware of your helicopter's flight control characteristics, particularly tail rotor pedal forces, so that you can quickly recognize and resolve the onset of unanticipated yaw.
- Review the Federal Aviation Administration's (FAA) *Helicopter Flying Handbook* for specific tips on avoiding LTE. Here are a few tips to get you started:
    - Conduct a thorough preflight planning assessment with particular attention to the helicopter's maximum allowable gross weight.
    - Maintain awareness of the wind direction and speed in flight, especially in high workload areas, when flying along ridgelines and around buildings, and when hovering in wind of about 8 to 12 knots when a loss of translational lift can occur.
    - Avoid tailwinds or crosswinds (the direction depends on the type of helicopter you are flying) when operating below an airspeed of 30 knots.
    - Avoid out-of-ground-effect operations and high-power-demand situations below 30 knots.
    - Monitor the amount of antitorque pedal being used. If insufficient pedal is available, you may not be able to counteract an unanticipated right yaw.
- Train for and know how to recover immediately from LTE so that you are prepared. Remember that LTE can be sudden, and pilots have described the onset of yaw as "violent."

Interested in more information?

The following FAA resources are available on the FAA's website (www.faa.gov):

- The *Helicopter Flying Handbook* (FAA-H-8083-21A), chapter 11, "Helicopter Emergencies and Hazards," provides an in-depth explanation of LTE.
- Advisory Circular 90-95, "Unanticipated Right Yaw in Helicopters," explains unanticipated yaw in helicopters, why it occurs, how to prevent it, and how pilots can respond to it.

The NTSB has produced a video regarding LTE, which includes one investigator's experience with LTE and tips on what you can do to be prepared.

The NTSB's Aviation Information Resources web page (www.ntsb.gov/air) provides convenient access to NTSB aviation safety products. The reports for the accidents referenced in this safety alert are accessible by NTSB accident number from the Aviation Accident Database link, and each accident's public docket is accessible from the Accident Dockets link for the Docket Management System. This safety alert and others can be accessed from the Aviation Safety Alerts link.

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