AIRCRAFT ACCIDENT REPORT AND EXECUTIVE SUMMARY

				Reference:		CA18/2/3/10224	
Helicopter Registration	**ZT-RFG**	**Date of Accident**		17 September 2022		**Time of Accident**	0825Z
Type of Helicopter	Aerospatiale AS350B3e Ecureuil (H125)			**Type of Operation**		Private (Part 91)	
Pilot-in-command Licence Type	Private Pilot Licence (PPL)			**Age**	29	**Licence Valid**	Yes
Pilot-in-command Flying Experience		**Total Flying Hours**	129.2			**Hours on Type**	33
Last Point of Departure	De Oudekraal Farm, near Bloemfontein, Free State Province						
Next Point of Intended Landing	Karoo Gateway Aerodrome (FABW), Beaufort West, Western Cape Province						
Damage to Helicopter	Substantial						
Location of the accident site with reference to easily defined geographical points (GPS readings if possible)							
Global Positioning System (GPS) co-ordinates determined to be 32º 18.06.31' South 22º39.54.05' East, near the fuel bay at Beaufort West Airport							
Meteorological Information	Wind direction: 200º; Wind speed: 04kts; Temperature: 20ºC; Dew point: 02ºC; Cloud cover: Nil; Cloud base: Nil; Visibility: 9 999m; QNH: 1015hPa						
Number of People On-board	2+0	**Number of People Injured**	0	**Number of People Killed**	0	**Other (On Ground)**	0

Synopsis

On Saturday morning, 17 September 2022 at approximately 0610Z, two pilots on-board an Airbus Aerospatiale AS350B3e Ecureuil (H125) helicopter with registration ZT-RFG took off on a private flight from De Oudekraal Farm which is located 20 nautical miles (nm) south of Bloemfontein in the Free State province, to Karoo Gateway Aerodrome (FABW) in Beaufort West, Western Cape province. The flight plan was not filed for this flight. The flight was conducted under the provisions of Part 91 of the Civil Aviation Regulations (CAR) 2011 as amended.

The helicopter was fitted with removable controls on the left side (removable controls allow for dual flight and are optional). The pilot flying the helicopter was seated on the left seat and the co-pilot was seated on the right seat. Upon reaching FABW, the crew landed the helicopter to uplift fuel. A video footage from the crew captured the helicopter as it approached FABW in a westerly direction, which was into the wind. The helicopter hover-taxied down Runway 26 centreline in ground effect until it was opposite the Jet A-1 fuel bay before it turned 90º to the right towards the fuel bay. The helicopter touched the ground twice (in the video footage) before it yawed to the left. Thereafter it turned 180º to face the opposite direction from which it had approached, and flipped to the right side. It came to a stop near the fuel bay. The helicopter sustained substantial damage. The occupants on-board the helicopter were not injured during the accident sequence.

Post-accident inspection of the engine and the components did not reveal any signs of malfunction before the accident. The damaged main and tail rotor blades indicated that the engine was producing power at the time of the accident.

Probable Cause/s			
During landing, the helicopter descended vertically and drifted to the right due to a light crosswind component from the left. Whilst the pilot attempted to correct the drift, the helicopter touched the ground twice before it yawed to the left. It spun 180º and flipped to the right side. **Contributory Factor** The pilot flying the helicopter was seated on the left seat.			
SRP Date	14 November 2023	Publication Date	17 November 2023

Occurrence Details

Reference Number	**:** CA18/2/3/10224
Occurrence Category	**:** Accident (Category 1)
Type of Operation	**:** Private (Part 91)
Name of Operator	**:** Private
Helicopter Registration	**:** ZT-RFG
Helicopter Make and Model	**:** Aerospatiale AS350B3e Ecureuil (H125)
Nationality	**:** South African
Place	**:** Karoo Gateway Aerodrome (FABW) near the fuel bay
Date and Time	**:** 17 September 2022, 0825Z
Injuries	**:** None
Damage	**:** Substantial

Purpose of the Investigation

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

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

Investigation Process

The Accident and Incident Investigations Division (AIID) of the South African Civil Aviation Authority (SACAA) was notified of the occurrence on 17 September 2022 at 0900Z. The occurrence was classified as an accident according to the CAR 2011 Part 12 and International Civil Aviation Organisation (ICAO) STD Annex 13 definitions. Notification was sent to the State of Design and Manufacture in accordance with the CAR 2011 Part 12 and ICAO Annex 13 Chapter 4. The State of Design and Manufacture appointed an accredited representative and advisor. The investigator dispatched to the accident site on 18 September 2022.

Notes:

1. *Whenever the following words are mentioned in this report, they shall mean the following:*
   Accident — this investigated accident
   Helicopter — the Aerospatiale AS350B3e Ecureuil (H125) involved in this accident.
   Investigation — the investigation into the circumstances of this accident
   Pilot — the pilot involved in this accident
   Report — this accident report

2. *Photos and figures used in this report were taken from various 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
°C	Degrees Celsius
AIID	Accident and Incident Investigations Division.
AMO	Aircraft Maintenance Organisation
AGL	Above Ground Level
ARFF	Aircraft Rescue and Fire Fighting
ATC	Air Traffic Control
BEA	Bureau of Enquiry Analysis for Civil Aviation Safety
CAR	Civil Aviation Authority
C of A	Certificate of Airworthiness
C of R	Certificate of Registration
CPL	Commercial Pilot Licence
CRS	Certificate of Release to Service
CVR	Cockpit Voice Recorder
EDR	Engine Data Recorder
FAWB	Karoo Gateway Aerodrome
FACT	Cape Town International Airport
FADEC	Full Authority Digital Control
FL	Flight Level
ft	Feet
GPS	Global Positioning System
hPa	Hector Pascal
I.A.W	In Accordance With
ICAO	International Civil Aviation Organisation
IFR	Instrument Flight Rules
m	Metres
METAR	Meteorological Routine Aerodrome Report
MHz	Megahertz
NTSB	National Transport Safety Board
PF	Pilot Flying
QNH	Query Nautical Height
S	South
SACAA	South African Civil Aviation Authority
SAWS	South African Weather Service
S/N	Serial Number
S	South
SD	Secure Digital
RWY	Runway
UTC	Co-ordinated Universal Time
VEMD	Vehicle and Engine Multifunction Display
Z	Zulu (Term for Universal Co-ordinated Time - Zero Hours Greenwich)

1. FACTUAL INFORMATION

1.1. History of Flight

1.1.1. On Saturday morning, 17 September 2022 at approximately 0610Z, two pilots on-board an Airbus Aerospatiale AS350Be Ecureuil (H125) helicopter with registration ZT-RFG took off on a private flight from De Oudekraal Farm which is located 20 nautical miles (nm) south of Bloemfontein in the Free State province, to Karoo Gateway Aerodrome (FABW) in Beaufort West, Western Cape province. The flight plan was not filed for the flight. The flight was conducted under the provisions of Part 91 of the Civil Aviation Regulations (CAR) 2011 as amended. The crew had intended to make a stop at FAWB to uplift fuel before proceeding to Cape Town International Airport (FACT) in the Western Cape province.

1.1.2. From the video footage obtained from the crew, the pilot flying was seated on the left seat, and the co-pilot was seated on the right seat and was recording the video. According to the co-pilot, no anomalies were found during the pre-flight inspection of the helicopter at De Oudekraal Farm prior to take-off. The helicopter was refuelled with 400 litres of Jet A-1 fuel. Thereafter, they took off at approximately 0610Z and climbed 1000 feet (ft) above ground level (AGL). The helicopter was flown at an average speed of 130 knots (kts), which is 240 kilometres per hour (km/h). It remained at the approximate height of 1000ft AGL for the duration of the flight to FABW. The flight was uneventful. The helicopter was fitted with the removable controls on the left side (the removable controls which allow for dual flight are optional), as well as on-board recording devices which included the camera, full authority digital engine control (Fadec), engine data recorder (EDR) and Vehicle and Engine Multifunction Display (VEMD).

1.1.3. The co-pilot reported that the approach for Runway 26 at FABW was stable and normal. The helicopter flew down the centreline at a height of 500 ft AGL and at a speed of 20 kts. Approximately 300m down the centreline, it turned 90º to the right and hover-taxied in ground effect towards the fuel bay. It then hovered over the selected landing spot and landed normally. The co-pilot indicated that immediately after landing and before the engine shutdown, the helicopter entered a severe ground resonance. The co-pilot took corrective action and lifted off. The helicopter yawed to the left uncontrollably due to lack of tail rotor authority. During the yaw, the co-pilot attempted to fly the helicopter away from the fuel bay but the helicopter yawed to the left and spun 180º. During the spin, the tail boom impacted the equipment near the fuel bay, this resulted in the tail cone separating from the tail boom. The helicopter flipped to the right and the main rotor blades contacted the ground whilst rotating. The helicopter came to rest on its right side.

1.1.4. After the accident, the co-pilot reported that he immediately switched off the master switch and shutdown the engine. Thereafter, together with the pilot, they unbuckled their seatbelts and disembarked from the helicopter unassisted using the left-side door; they were uninjured. The Aircraft Rescue and Fire Fighting (ARFF) personnel arrived at the scene within minutes of the occurrence. They took precautionary measures by spraying Alcohol Resistant Aqueous Film-Forming Foam (AR-AFFF) on the helicopter to prevent a fire. The South African Police Service (SAPS) personnel and the ambulance team also dispatched to the accident scene. The helicopter was substantially damaged.

1.1.5 The co-pilot forwarded the 1 minute and 30 seconds cellular phone video file to the investigation team. The video recording was taken from the right side on-board the helicopter. Upon review of the video footage, it could be seen that the approach and landing sequence on RWY 26 was stable. The helicopter hover-taxied past the windsock, which indicated a light crosswind from the left (Figure 1). After passing the windsock, the helicopter turned 90º to the right and proceeded at low height (in ground effect) towards the fuel bay. On the video, the engine sounded normal throughout the hover taxi. As the helicopter proceeded towards the intended spot, the pilot's right hand was off the flight controls (Figure 3). *Figures 4 and 5 show that the right flight controls were unattended*. When the helicopter approached the fuel bay, it descended vertically and drifted to the right before it touched down on the ground twice (*this was confirmed during downloads*). At this moment, the co-pilot reached for the controls using their right hand (Figures 6 and 7); when the pilot reached for the controls, the instruments on the right shook abruptly, followed by a loud thud. The engine continued to run and was shut down by overspeed protection (*this was also confirmed during the downloads*). This was the end of the recording.

AS350Be Flight Manual (17):
Minimum crew, states the following: "*One pilot in right seat."*

Section 7.7 Flight Controls states the following:
"*The basic helicopter is fitted with controls on the right side."*

Figure 1. The helicopter hover-taxiing on the runway. (Source: Cellular phone video)

Figure 2: Pilot points at windsock. (Source: Cellular phone video)

Figure 3: Controls are unattended. (Source: cellular phone video)

Figures 4 and 5: Still pictures show unattended right flight controls from different angles. (Source: Cellular phone video)

Figures 6 and 7: The pilot reaches for the right flight controls. (Source: cellular phone video)

1.1.6 The accident occurred during daytime at Global Positioning System (GPS) co-ordinates determined to be 32º 18.06.31' South 22°39.54.05' East, at an elevation of approximately 2 932 feet (ft).

Figure 8: The approximate flight path. (Source: Google Earth)

1.2. Injuries to Persons

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

Note: Other means people on the ground.

1.3. Damage to Helicopter

1.3.1. The helicopter was substantially damaged during the accident sequence.

Figure 9: The helicopter's final resting position at the accident site. (Source: Operator)

1.4. Other Damage

1.4.1. None.

1.5. Personnel Information

Pilot Flying (pilot-in-command)

Nationality	South African	Gender	Female	Age	29
Licence Type	Private Pilot Licence (PPL) Helicopter				
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Night Flight and Instrument				
Medical Class & Expiry Date	Class 2; 22 August 2023				
Restrictions	Wear corrective lenses				
Previous Accidents	None				

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

Flying Experience:

Total Hours	129.2
Total Past 24 Hours	7.0
Total Past 7 Days	10.0
Total Past 90 Days	34.8
Total on Type Past 90 Days	33.0
Total on Type	33

1.5.1 The pilot flying was initially issued a Private Pilot Licence (PPL) on 11 July 2017. Her last licence validation was on 20 July 2022 with an expiry date of 31 July 2024. The helicopter type was endorsed on the pilot flying's licence. The pilot flying was issued a Class 2 aviation medical certificate on 23 August 2018 with an expiry date of 22 August 2023.

1.5.2 According to available information, the pilot flying flew diverse types of helicopters as pilot-in-command and as co-pilot, including the AS350B2, Eurocopter EC20/130, Robinson 22/44 Jet Ranger and multi engines fixed wing aircraft. The pilot flying stated that she underwent a type conversion to AS350B2 on 26 July 2022; and on 27 July 2022, she completed her conversion within 5 hours of flying.

Personnel Information

Pilot (co-pilot)

Nationality	South African	Gender	Male	Age	61
Licence Type	Airline Transport Pilot Licence (ATPL)				
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Night Flight and Instrument				
Medical Class & Expiry Date	Class 1; 31 October 2022				
Restrictions	Wear corrective lenses				
Previous Accidents	None				

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

Flying Experience:

Total Hours	3720.2
Total Past 24 Hours	7.0
Total Past 7 Days	10.0
Total Past 90 Days	48.1
Total on Type Past 90 Days	36.6
Total on Type	450.1

1.5.3 The co-pilot was initially issued an Airline Transport Pilot Licence (ATPL) on 13 April 2021. His last licence validation was on 8 February 2022 with an expiry date of 28 February 2023. The helicopter type was endorsed on his licence. The co-pilot was issued a Class 1 aviation medical certificate on 20 April 2022 with an expiry date of 30 October 2022.

1.6. Helicopter Information

1.6.1. The Eurocopter AS350B3e is a light helicopter which seats six (four on the back seats and two in the front). The helicopter is certified with the pilot flying seated on the right side. The helicopter has fixed right-side controls (removable dual controls are optional). The Aerospatiale Eurocopter AS350B3e is powered with a new Safran Arriel 2D engine including a new generation dual digital engine control system (FADEC), backed with one independent control system for automatic start-up sequences and care-free engine handling. This modern engine is fitted with an Engine Data Recorder (EDR).

Airframe:

Manufacturer/Model	Airbus Aerospatiale AS350B3e (H125)	
Serial Number	8896	
Year of Manufacture	23 September 2020	
Total Airframe Hours (At Time of Accident)	133.37	
Last Inspection (Date & Hours)	26 July 2022	94.5
Airframe Hours Since Last Inspection	38.87	
CRS Issue Date	26 July 2022	
C of A (Issue Date & Expiry Date)	24 December 2020	31 December 2022
C of R (Issue Date) (Present Owner)	28 July 2021	
Operating Category	Part 91	
Type of Fuel Used	JET A1	
Previous Accidents	None	

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

Engine:

Manufacturer/Model	Arriel 2D
Serial Number	53558
Part Number	0292020030
Hours Since New	133.37
Hours Since Overhaul	Not yet reached

Main Rotor Gearbox:

Part Number	350A32031002
Serial Number	M6458
Hours Since New	133.37
Hours Since Overhaul	Not yet reached

Main Rotor Blades:

Number of blades	1	2	3
Part Number	355A110030 .04	355A110030 .04	355A110030 .04
Serial Number/s	48677	48671	48593
Hours Since New	133.37	133.37	133.37
Hours Since Overhaul	Not yet reached	Not yet reached	Not yet reached

Tail Rotor Gearbox:

Part Number	350A33021000
Serial Number	MA 121433
Hours Since New	133.37
Hours Since Overhaul	Not yet reached

Tail Rotor Blade:

Number of blades	1
Part Number	355A12006004
Serial Number/s	24527
Hours Since New	133,37
Hours Since Overhaul	Not yet reached

1.6.2. According to available information, the helicopter was first registered to the present owner on 28 July 2021. The Certificate of Release to Service (CRS) was re-issued on 26 July 2022 with an expiry date of 28 July 2023 or at 194.5 airframe cycles, whichever occurs first.

1.6.3. The helicopter had a valid Certificate of Airworthiness (C of A) that was initially issued by the Regulator (SACAA) on 24 December 2020 with an expiry date of 31 December 2022.

1.6.4. The maintenance logbooks showed that all scheduled maintenance were conducted as required. The helicopter had no recorded defects at the time of the accident. The helicopter had accrued a total of approximately 133.37 airframe hours. The last annual inspection on the helicopter was certified on 26 July 2022 at 94.5 airframe hours. The blades balancing as per the Aircraft Maintenance Manual (AMM) is only required when the hub is replaced or after the replacement of one of its components. The AMM states

that the main and tail rotor balancing should be conducted at every 600 airframe hours or every two years.

1.6.5 Weight and balance

The helicopter was fuelled to about 89% capacity (380 litres) at the start of the flight. The helicopter was flown for approximately 2 hours and 22 minutes. The pilot flying estimated that the helicopter had about 20% (85 litres) fuel remaining at the time of the accident. This equated to a weight of about 68 kilograms (kg) of fuel. The helicopter's empty weight is 1 220kg. The maximum certified take-off weight is 2 250 kg when the load is carried internally. At 2.250 kg, the allowable centre of gravity (CG) range is between 3.110 metres (m) and 3.425m aft of datum. According to the helicopter's weighing data, the CG was 3.495 millimetres (mm) (see Figure 10). The weight of the co-pilot was 115 kg, the pilot flying's weight was 90 kg, whilst the baggage was 80 kg. Therefore, the weight of the helicopter was within limits (see the table below).

Empty Weight	1220 kg (2690 lbs)
Pilot	115 kg (254 lbs)
Pilot flying	90 kg (198 lbs)
Fuel	68 kg (150 lbs)
Baggage	80 kg (176 lbs)
Total	1573 kg (3468 lbs)
MTOW	2250 kg (992 lbs)

Note: The weights above were taken from the pilot questionnaire.

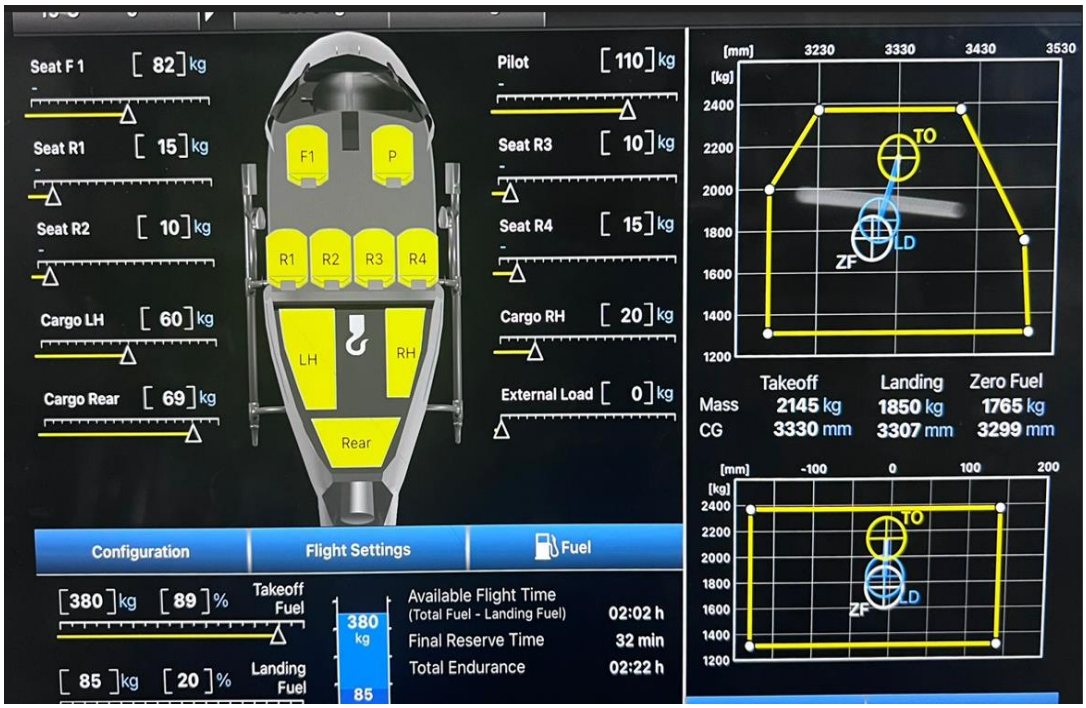


Figure 10: The top right graph in the picture shows longitudinal CG location in blue circle and the bottom right shows latitudinal CG location in blue circle, and they are all well inside the envelop. During take-off, the CG was 3330mm and landing was at 3307mm.

1.7 Meteorological Information

1.7.1 The weather information entered in the table below was sourced from the Meteorological Aerodrome Report (METAR) that was issued by the South African Weather Service (SAWS) for FABW on 17 September 2022 at 0825Z.

Wind Direction	200°	Wind Speed	04kt	Visibility	9999m
Temperature	20°C	Cloud Cover	Nil	Cloud Base	Nil
Dew Point	02°C	QNH	1015hPa		

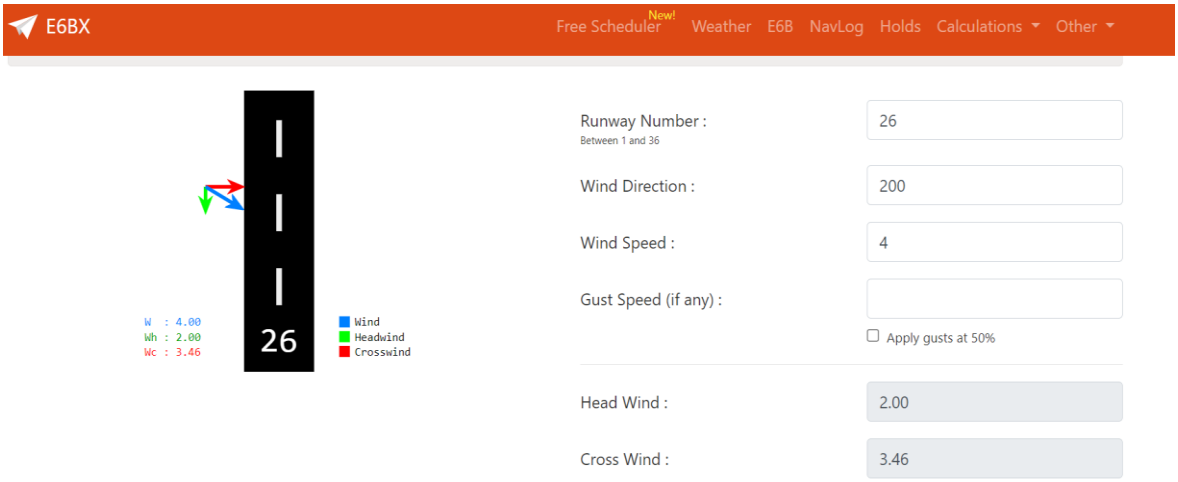


Figure 11: Cross wind component. Source: https://e6bx.com/wind-components)

1.8 Aids to Navigation

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

1.9 Communication

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

1.10 Aerodrome Information

1.10.1 The accident occurred at the FABW, next to the fuel bowser.

Aerodrome Location	Fort Beaufort West
Aerodrome Status	Licensed
Aerodrome Co-ordinates	32º16'55"South, 22º36'53" East
Aerodrome Altitude	2929 feet
Runway Headings	085º/ 265º
Runway Dimensions	4872 x 98 feet/ 1485 x 30 metres
Heading of Runway Used	265º
Runway Surface	Asphalt
Approach Facilities	Runway lights
Radio Frequency	125.6 MHz

1.11 Flight Recorders

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

1.11.2 The helicopter was equipped with the following on-board recording devices:

- Vehicle and Engine Multifunction Display (VEMD)
- Camera: the manufacturer reported that the secure digital (SD) card was not inserted in the camera, therefore, it was not serviceable. The pilot reported that the SD card was removed several months before the accident flight to review a flight that was undertaken by another pilot. The SD card was not downloadable at the time; therefore, it was not replaced. The pilot further reported that he was not concerned with the camera not having an SD card because the camera records the most recent two hours of flight time. The aircraft maintenance organisation (AMO) reported that the camera was serviceable prior to the accident flight. The AMO further reported that a functional test of the camera is conducted every 12 months. The manufacturer could not perform downloads from the camera.
- Full Authority Digital Engine Control (FADEC)
- Engine Data Recorder (EDR)

1.12 Wreckage and Impact Information

1.12.1 The helicopter was hover-taxiing at a height of 500 ft AGL and at a speed of 20 kts, (definition of hover-taxi in ground effect is presented in 1.12.3) towards the fuel bay. During the landing phase, the helicopter touched down on the ground twice with the skids, bounced, yawed to the left and spun 180º before it flipped and came to rest on its right side. The tail boom and the horizontal stabiliser were severed from the main body by the equipment at the fuel bowser (see Figure 12). The three main rotor blades struck

the ground and sheared from the rotor head (see Figure 13). The helicopter was found resting on its right side with the nose pointing south-east (SE), which was the direction of flight. The integrity of the cockpit was not compromised.

1.12.2 The continuity and operation of the main rotor cyclic and collective controls were confirmed from the pilot's controls to the mechanical deck. The correct tail rotor control functionality was confirmed from the tail rotor pedals to the tail boom (where it separated from the fuselage) and from the tail boom to the tail rotor.

1.12.3 Damage on the main rotor blades indicated that the main rotor was operating at high speed when it struck the ground. The three arms of the Starflex main rotor head displayed rotational damage. The circuit breaker (CB) and the fuse were intact (see Figure 14).

1.12.4 Post-accident examination of the helicopter did not reveal any anomalies with the airframe or engine that would have precluded normal operation. The engine was delivering power to the rotors when the accident occurred. It was also verified that the key parts of the flight controls were intact prior to ground impact, and the helicopter was controllable.

Figure 12: The separated tail rotor. (Source: Operator)

Figure 13: The sheared main rotor blades.

Figure 14: The circuit breakers.

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 as no damage was caused to the cockpit and cabin structure of the helicopter. The seats and the restraints were intact. There was no fire. The evacuation from the helicopter was prompt.

Figure 15: The intact cabin.

1.16 Tests and Research

1.16.1 Technical investigation

The helicopter's engine data recorder (EDR) has memory functions which can later show whether some failures have occurred during the flight, or if certain limitations have been exceeded. The unit was sent to specialists for examination at the French Accident Investigation Authority Bureau of Enquiry and Analysis for Civil Aviation Safety (BEA), as well as to the manufacturer.

C2 - Confidential

SAFRAN

ARRIEL 2D SN 53558 EDR dump analysis – AS350B3e ZT-RFG
September 17th 2022 – Beaufort West Aerodrome, South Africa

List of abreviation

- EECU	Engine Electronic Control Unit
- EDR	Engine Data Recorder
- EPC	Engine power Check
- N1,NG,XNH	Gas generator rotational speed
- N2,NTL,XNPT	Power turbine rotational speed
- NR	Aircraft main rotor rotation speed
- P0	Ambient temp
- P3	Centrifugal compressor outlet pressure
- PON	Power ON
- T4	Engine high pressure turbine outlet temperature
- TQ	Engine Torque
- XPC	Collective pitch potentiometer signal
- XPA	Yaw pedal potentiometer signal

1.16.2 The following information was recorded in the memory dump of the Arriel 2D SN 53558 EDR (engine Data Recorder)

- *The engine was installed on the AS350B3 helicopter registered ZT-RFG.*
- ***Function:*** *The engine Data recorder (EDR) stores and records specific parameters relating to its engine.*

- ***Position:*** *The EDR is mounted on a plate, which is attached to the engine harness and located under the engine platform, near the EECU.*

- ***Mains characteristics*** *The EDR and the engine are matched components. The EDR exchanges data with the EECU during operation The EDR can exchange data with a maintenance laptop for maintenance purpose.*

Function description: *The parameters stored and recorded in the EDR include:*

- Counters (cycles, creep damage etc.)

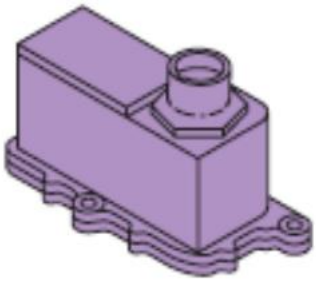
- Conformation values (TQ and T4)

- Failure and maintenance flags

- Engine power check

- Engine configuration (P/N and S/N)

- Continuous recording (last 50 operating hours)



Engine Data Recorder

EDR (available data) presentation 5

*- **Continuous records analysis***

- It records engine parameters during the last 50 hours of operation with a data frequency acquisition rate of 1 second.

- The Continuous records contain separate data for Channel A and Channel B recordings.

- Contexts analysis

- It records engine parameters 4 seconds before and 4 seconds after the occurrence of

discrepancies or over-limits whilst the EDR is powered with a data frequency acquisition rate of 0.02 second.

- The Contexts are broken down into "Engine Running" and "Engine not running" records depending on the situation with the engine at the time of occurrence of the discrepancy.

- Both are also broken down into two separate records for Channel A and Channel B.

- Flags analysis

- It records the occurrence of discrepancies.

The "Flags analysis" recordings provide the list of discrepancies that were recorded by the EDR whilst powered.

The discrepancies appear as code words within data blocks.

When discrepancies occur simultaneously one or more code words may be recorded within a block.

- Discrepancies are grouped in "Engine Running" or "Engine not running" blocks depending on the situation with the engine at the time of occurrence of the discrepancy. Recordings are also separated for Channel A and Channel B.

- EDR and EECU

- The EECU ensures the acquisition and recording of input-output data and engine parameters.

The EECU then sends the data in batches to the EDR which saves it. This implies a transmission delay between the two components. In case of an accident, the latest data from the EECU may not be transmitted to the EDR. On the other hand, failures or contexts are sent from the EECU to the EDR as soon as they appear.

Data recorded in the EDR 6

*- **Mains findings:***

- Arriel 2D S/N 53558 was operating normally till the moment of the impact of the aircraft with the ground.

- No engine flag message recorded before the impact.

- Flight number - Flight number 127 and 128 is the accident flight.

- It also corresponds to EDR Power-ON (PON) 845

*- **Limit exceedances***

- There are limits exceeded and reported in the EDR memories corresponding to the accident flight or PON.

- N2: 34,39 % for 2,5 seconds

- TQ: 104,57 daNm - NR: 43,36% for 4 seconds

- EPC - Last EPC record was done 59 hours (Engine operating hours) before the accident. The result is conformed.

- The last flights recorded are the Flight N°127 and 128 with a total duration of 2hours 21 minutes. The duration of these records is equivalent with the flight duration of the accident. - We can confirm that these records correspond to the accident flight.

- This corresponds also to EDR PON N°845.

- During this flight, the engine parameters (NG, T4 and torque) change in accordance with the XPC request. Normal engine operation. Refer page 8 & 9

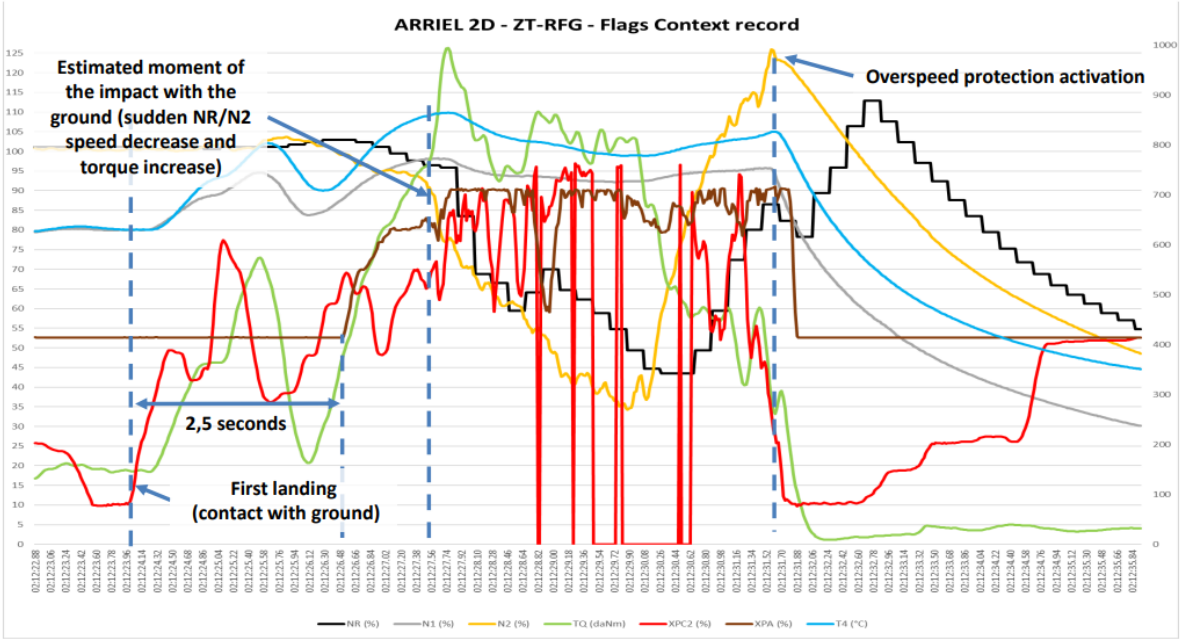
- At 2hours 20min 31seconds it can be noticed the activation of the N2 overspeed protection when the engine N2 reached 120 %.

- It is more difficult to determine with accuracy the exact moment of the aircraft roll over and impact of the main rotor with the ground. We can assume that the NR decreased when the main rotor blades touched the ground.

SAFRAN

ARRIEL 2D SN 53558 EDR dump analysis – AS350B3e ZT-RFG
September 17th 2022 – Beaufort West Aerodrome, South Africa

4 Data recorded in the EDR



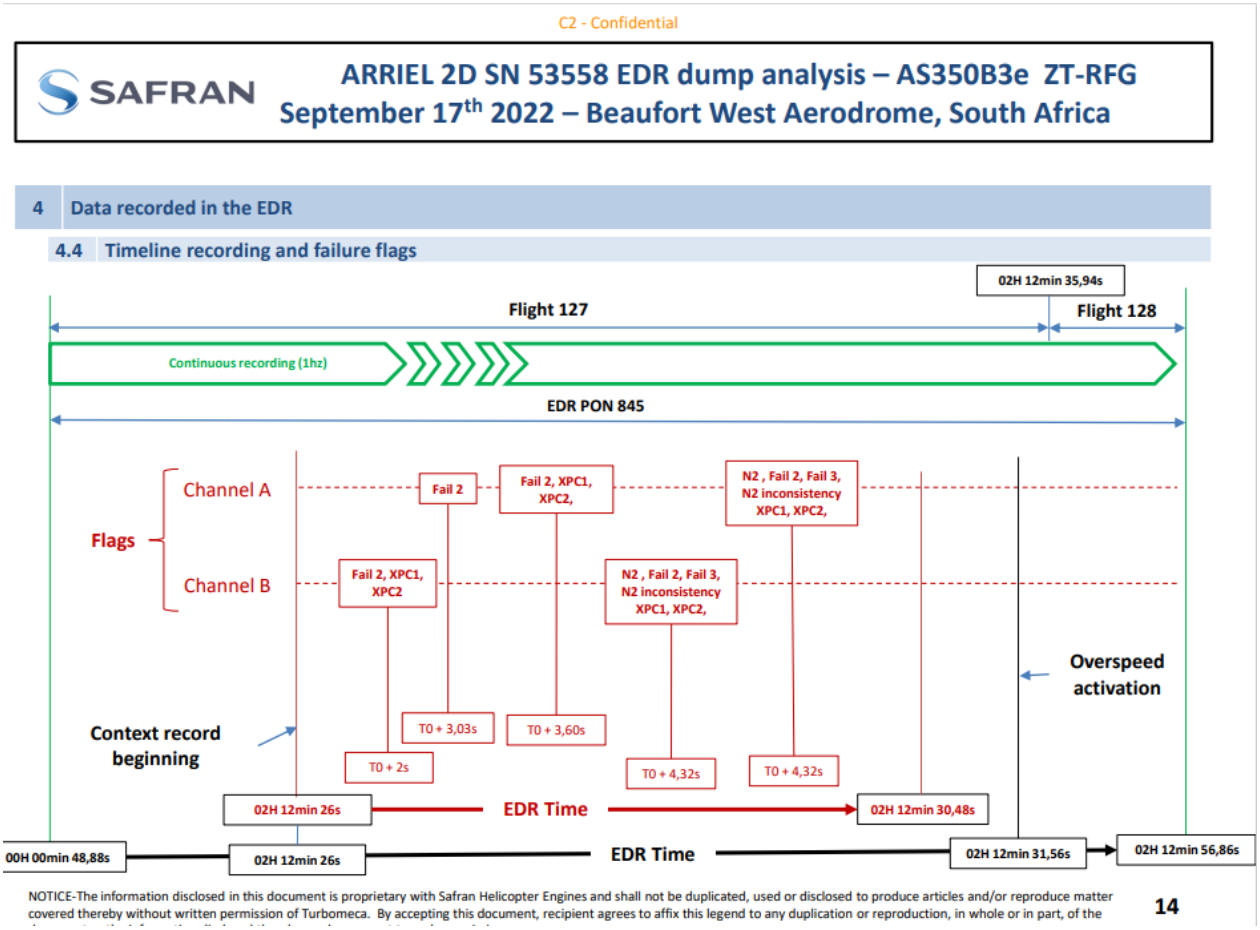
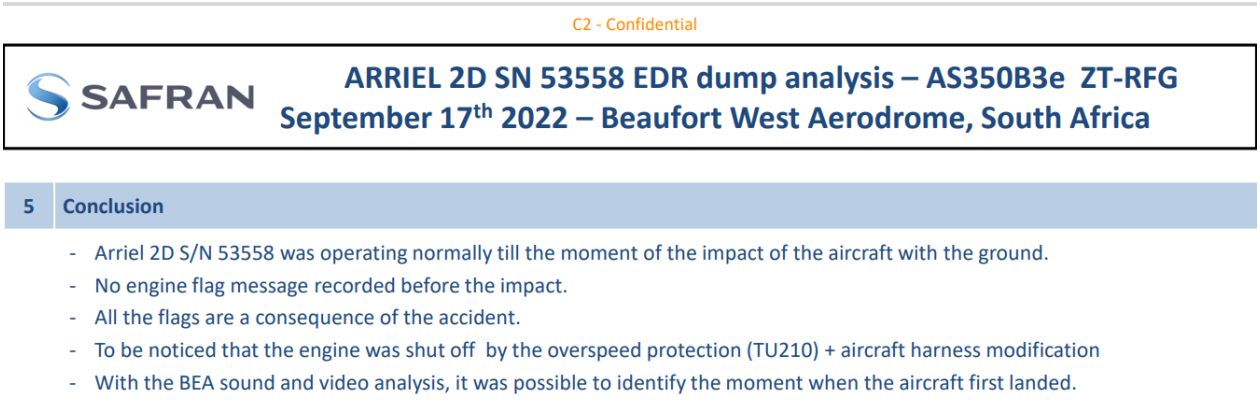


Figure 16: The chronology of the flags with regards to accident timing. (Source: Manufacturer)



1.17 Organisational and Management Information

1.17.1 The flight was conducted under visual flight rules (VFR) and under Part 91 of the Civil Aviation Regulations (CAR) 2011 as amended.

1.17.2 The AMO that conducted the last maintenance inspection on the helicopter was issued an AMO certificate on 10 August 2022 with an expiry date of 31 August 2023.

1.18 Additional Information

1.18.1 The Airbus AS350B3e (H125) Flight Manual Section 4.1, number 9.1 states the following:

APPROACH AND LANDING

9.2 Landing

CAUTION:

From hover, reduce collective pitch very gradually until initial touch-down is made, then cancel collective pitch completely.

1.18.2 The Helicopter Flying Handbook Federal Aviation *Administration (FAA-H-8083-21B, page 11-11),* state the following.

Ground Resonance

Helicopters with articulating rotors (usually designs with three or more main rotor blades) are subject to ground resonance, a destructive vibration phenomenon that occurs at certain rotor speeds when the helicopter is on the ground. Ground resonance is a mechanical design issue that results from the helicopter's airframe having a natural frequency that can be intensified by an out-of-balance rotor. The unbalanced rotor disk vibrates at the same frequency (or multiple thereof) of the airframe's resonant frequency, and the harmonic oscillation increases because the engine is adding power to the system, increasing the magnitude (amplitude) of the vibrations until the structure or structures fail. This condition can cause a helicopter to self-destruct in a matter of seconds.

Hard contact with the ground on one corner (and usually with wheel-type landing gear) can send a shockwave to the main rotor head, resulting in the blades of a three-blade rotor disk moving from their normal 120º relationship to each other. This movement occurs along the drag hinge and could result in something like 122º, 122º, and 116º between blades. [Figure 11-4] When another part of the landing gear strikes the surface, the unbalanced condition could be further aggravated. If the rpm is low, the only corrective action to stop ground resonance is to close the throttle immediately and fully lower the collective to place the blades in low pitch. If the rpm is in the normal operating range, fly the helicopter off the ground, and allow the blades to rephase themselves automatically. Then, make a normal touchdown. If a pilot lifts off and allows the helicopter to firmly re-contact the surface before the blades are realigned, a second shock could move the blades again and aggravate the already unbalanced condition. This could lead to a violent, uncontrollable oscillation. This situation does not occur in rigid or semi-rigid rotor disks because there is no drag hinge. In addition, skid-type landing gear is not as prone to ground resonance as wheel type landing gear, since the

rubber tyres' resonant frequency typically can match that of the spinning rotor, unlike the condition of a rigid landing gear.

Figure 11-4. *Ground resonance.*

1.18.3 In Ground Effect (IGE) (Source: FAA-H-8082-21B, Chapter 2, page 2-12)

Ground effect is the increased efficiency of the rotor disk caused by interference of the airflow when near the ground. The air pressure or density is increased, which acts to decrease the downward velocity of air. Ground effect permits relative wind to be more horizontal, lift vector to be more vertical, and induced drag to be reduced. These conditions allow the rotor disk to be more efficient. Maximum ground effect is achieved when hovering over smooth hard surfaces. When hovering over surfaces as tall grass, trees, bushes, rough terrain, and water, maximum ground effect is reduced. Rotor efficiency is increased by ground effect to a height of about one rotor diameter (measured from the ground to the rotor disk) for most helicopters. Since the induced flow velocities are decreased, the AOA is increased, which requires a reduced blade pitch angle and a reduction in induced drag. This reduces the power required to hover IGE. [Figure 2-22].

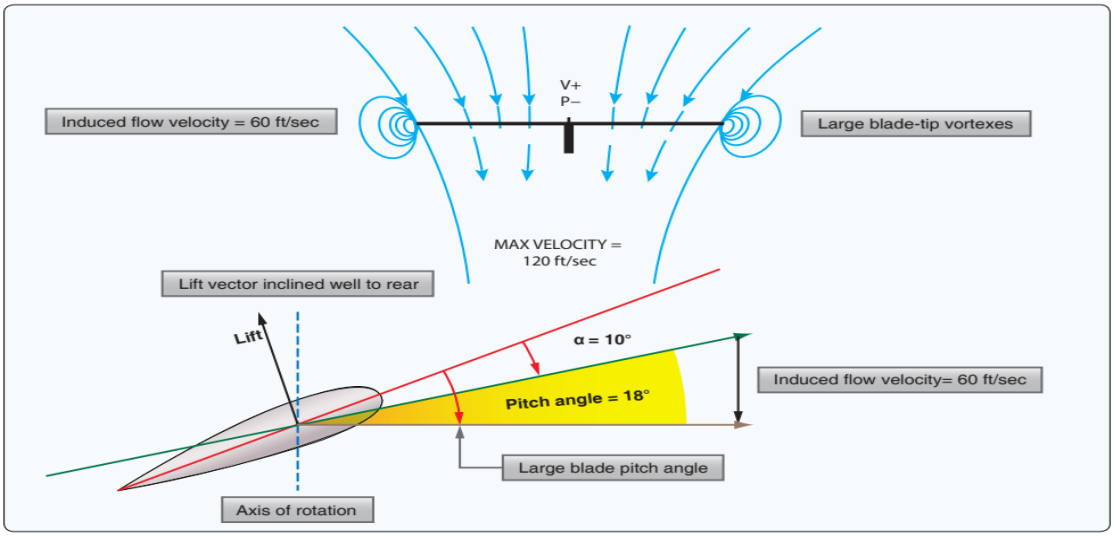


Figure 2-22. *In ground effect (IGE).*

1.19 Useful or Effective Investigation Techniques

1.19.1 None.

2 ANALYSIS

2.1 General

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

2.2 Analysis

2.2.1 The pilot flying was properly licenced and qualified to undertake the flight; she met all the requirements in terms of the CAR 2011. No evidence indicated any pre-existing medical or behavioural conditions that might have adversely affected her performance. The pilot flying flew diverse types of helicopters as PIC and as co-pilot. The pilot flying was seated on the left-side seat and not the right seat as prescribed in the flight manual. This, possibly, made it difficult for her to control the helicopter during landing in ground effect as the helicopter drifted to the right. The pilot had landed at this aerodrome in the past.

2.2.2 The helicopter was properly certified, equipped and maintained in accordance with the CAR 2011. The mass and the CG of the helicopter were within the prescribed limits.

2.2.3 The wreckage examinations found no anomalies with the flight controls, and there were no inconsistent impact damage characteristics found. In addition, downloads from the

Engine Data Recorder showed no instrument readings or system status lights (from the master caution warning panel) that would indicate problems with the helicopter's engine prior to the accident flight.

2.2.4 The investigation established that the engine was delivering power to the rotors when the accident occurred, and the flight controls were intact prior to the impact. All damage was a result of the helicopter impacting the ground.

2.2.5 The weather report was as follows: Wind direction: 200º; Wind speed: 04 kts; Temperature: 20ºC; Dew Point: 02ºC; Cloud Cover: Nil; Cloud Base: Nil; Visibility: 9 999m; QNH: 1015hPa. There was a crosswind component of 3.6 kts which caused the helicopter to drift to the right once the pilot turned 90º from Runway 26.

2.2.6 The main rotor blades and Starflex main rotor head damage were consistent with the blades rotating at high speed when they struck the ground. They were also consistent with the main rotor being driven by the engine when it struck the ground. There were no pre-existing faults found, and the damage sustained by the engine was consistent with the impact sequence.

2.2.7 The helicopter flight manual states: "*From hover, reduce collective pitch very gradually until initial touch-down is made, then cancel collective pitch completely."*

2.2.8 During landing, the helicopter descended vertically and drifted to the right due to the crosswind component from the left before it touched down twice; it then yawed to the left and spun 180º to face the opposite direction from which it had approached. It flipped and came to a stop on its right side.

2.2.9 Although the co-pilot stated that he shut down the engine, evidence showed that the overspeed protection was responsible for shutting down the engine after impact.

2.2.10 Although the co-pilot stated that he took over control and attempted to move the helicopter away from the fuel bay, evidence suggested that it would have been unlikely for him to control the helicopter after the initial yaw.

2.2.11 Although the co-pilot had indicated that the helicopter entered ground resonance after a safe landing, evidence suggest that there was no ground resonance, and the helicopter was hover-taxiing in ground effect before the pilot lost control.

3. CONCLUSION

3.1. General

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

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

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

3.2. Findings

3.2.1 The pilot flying was certified and qualified for the flight and had met all the requirements in terms of the CAR 2011. The pilot flying had a Private Pilot Licence (Helicopter) and a valid Class 2 aviation medical certificate. The pilot flying flew diverse types of helicopters as PIC and co-pilot.

3.2.2 The co-pilot was certified and qualified for the flight, and had met all the requirements in terms of the CAR 2011. The co-pilot had an Airline Transport Pilot Licence (Helicopter) and a valid Class 1 aviation medical certificate. The co-pilot flew diverse types of helicopters as PIC.

3.2.3 The helicopter was fitted with dual flight controls and was flown from the left side at the time of the accident instead of the right as per the flight manual.

3.2.4 The helicopter was registered in accordance with the regulations and had a valid airworthiness review certificate.

3.2.5 The rotor blades balancing is conducted every 600 airframe hours or every two years. At the time of the accident, the helicopter had accumulated 133.37 airframe hours. The rotor blades balancing was due at 466.63 airframe hours.

3.2.6 Evidence showed that the overspeed protection was responsible for shutting down the engine after impact.

3.2.7 The helicopter was structurally intact prior to impact, it was damaged by impact forces.

3.2.8 Extensive damage to the main rotors and tail rotor did not prevent meaningful examinations; it was established that the engine was delivering power when the accident occurred.

3.2.9 There were no indications of any defects or malfunctions on the helicopter, or irregularities with its maintenance that could have contributed to the accident.

3.2.10 Although the co-pilot had indicated that the helicopter entered ground resonance after a safe landing, evidence suggested that there was no ground resonance, and the helicopter was hover-taxiing in ground effect.

3.2.11 Weather conditions were a factor as there was a crosswind component of 3.66 kts which caused the helicopter to drift to the right side.

3.2.12 Although the co-pilot stated that he took over the control and attempted to direct the helicopter away from the fuel bay, evidence suggested that it would have been unlikely for him to control the helicopter after the initial loss of control. During landing, the helicopter descended vertically and drifted to the right due to a light crosswind component from the left. Whilst the co-pilot attempted to control the drift, the helicopter touched down on the ground twice before it yawed to the left. It spun 180º to face the opposite direction. It flipped and came to a stop on its right side. There was no evidence of ground resonance.

3.3. Probable Cause/s

3.3.1 During landing, the helicopter descended vertically and drifted to the right due to a light crosswind component from the left. Whilst the co-pilot attempted to correct the drift, the helicopter touched down on the ground twice before it yawed to the left. It spun 180º degrees and flipped before it came to a stop on its right side.

3.4. Contributory Factor/s

3.4.1 The pilot was flying from the left seat.

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. None.

5. APPENDICES

5.1. None.

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