AIRCRAFT ACCIDENT REPORT AND EXECUTIVE SUMMARY

			Reference:	CA18/2/3/10419	
Helicopter Registration	ZS-RLS	**Date of Accident**	15 February 2024	**Time of Accident**	1820Z
Type of Helicopter	Bell 407		**Type of Operation**	Training (Part 141)	
Pilot-in-command Licence Type	Commercial Pilot Licence	**Age**	39	**Licence Valid**	Yes
Pilot-in-command Flying Experience	**Total Flying Hours**	2 609.4	**Hours on Type**	157.2	
Last Point of Departure	Ultimate Heliport, Midrand, Gauteng Province				
Next Point of Intended Landing	Ultimate Heliport, Midrand, Gauteng Province				
Damage to Helicopter	Substantial				

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

On Runway 35 at Grand Central Aerodrome (GPS co-ordinates: 25°59´19.96" South 028°08´40.20" East) at an elevation of 5 337 feet (ft)

Meteorological Information	Surface wind: 300°/10 kt; temperature: 24°C; dew point: 17°C						
Number of People On-board	2 + 0	**Number of People Injured**	0	**Number of People Killed**	0	**Other (On Ground)**	0

Synopsis

On Thursday evening, 15 February 2024, a flight instructor (FI) and a pilot on-board a Bell 407 helicopter registered ZS-RLS took off on a type conversion training flight from Ultimate Heliport to Grand Central Aerodrome (FAGC), both located in Gauteng province. The intention of the flight was to conduct simulated engine failure exercises at FAGC before returning to the departure heliport. The FI stated that after lift-off from Ultimate Heliport, he demonstrated two engine failure exercises and autorotation overhead the heliport; thereafter, they routed north towards FAGC. Upon arrival at FAGC, the FI demonstrated the engine failure exercises again whilst the pilot observed. After the demonstration, the pilot was briefed and, thereafter, allowed to perform the demonstrated exercises. He (pilot) took control of the helicopter and climbed to 1 000 feet (ft) above ground level (AGL) and flew a circuit. During final approach for Runway (RWY) 35, he lowered the collective pitch control lever whilst the FI smoothly rolled the throttle (twist grip) to idle position to enter an autorotation flight. Immediately after, an audio warning alerted the crew that the engine had flamed out (stopped). The FI took control of the helicopter and opened the throttle well below the ground idle with the intent to auto re-light (restart) the engine, but without success. He then decided to execute a forced landing during which the helicopter impacted the ground hard with the landing gear skids. As a result, the main rotor blades severed the tail boom. The helicopter sustained substantial damage; the FI and the pilot vacated the helicopter unharmed.

Probable Cause/s and/or Contributory Factors

The FI executed an unsuccessful autorotation which resulted in a hard landing after rolling down the throttle to idle position during which the engine flamed out. The cause of the engine flame-out was undetermined.

Contributing Factors:
1. Lack of visual reference due to darkness.
2. The FI was likely fixated on restarting the engine during autorotation.
3. Lack of situational awareness.

SRP Date	13 May 2025	Publication Date	14 May 2025

Occurrence Details

Reference Number	**:** CA18/2/3/10419
Occurrence Category	**:** Accident (Category 1)
Type of Operation	**:** Training (Part 141)
Name of Operator	**:** National Airways Corporation (NAC)
Helicopter Registration	**:** ZS-RLS
Aircraft Make and Model	**:** Bell 407
Nationality	**:** South African
Place	**:** Runway 35 at Grand Central Aerodrome (FAGC)
Date and Time	**:** 15 February 2024 at 1820Z
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) was notified of the occurrence that involved a Bell 407 helicopter at FAGC in Gauteng province, on Thursday, 15 February 2024 at 1820Z. The occurrence was classified as an accident according to the CAR 2011 Part 12 and the International Civil Aviation Organisation (ICAO) STD Annex 13 definitions.

The AIID appointed an investigator-in-charge (IIC) who was dispatched to the site to commence with the full investigation. Notifications were sent to the State of Registry, Operator, Design and Manufacturer in accordance with the CAR 2011 Part 12 and the ICAO Annex 13 Chapter 4. The States of Manufacturer and Engine Design appointed two accredited representatives (airframe and engine). The AIID will lead the investigation and issue the final report of this accident in accordance with the CAR 2011 Part 12 and the ICAO Annex 13.

The AIID reports are made available to the public at:
https://www.caa.co.za/industry-information/accidents-and-incidents/

Notes:

1. *Whenever the following words are mentioned in this report, they shall mean the following:*
   Accident — this investigated accident
   Aircraft — the Bell 407 helicopter 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 different sources and may have been adjusted from the original for the sole purpose of improving the 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
ACCID	Accident
AIID	Accident and Incident Investigations Division
AMO	Aircraft Maintenance Organisation
AMROC	Authorised Maintenance Repair and Overhaul Centre
ARCC	Aeronautical and Rescue Coordination Centre
ARFFS	Aerodrome Rescue and Firefighting Services
ATO	Approved Training Organisation
CAR	Civil Aviation Regulations
CAVOK	Cloud and Visibility OK
C of A	Certificate of Airworthiness
C of R	Certificate of Registration
CPL	Commercial Pilot Licence
CRS	Certificate of Release to Service
ECU	Electronic Control Unit
FADEC	Full Authority Digital Engine Control
FAGC	Grand Central Aerodrome
FM	Flight Manual
Ft	Feet
FI	Flight Instructor
GPS	Global Positioning System
GW	Gross Weight
HMU	Hydromechanical Unit
hPa	Hectopascal
IIC	Investigator-in-Charge
KIAS	Indicated Airspeed in Knots
Kt	Knots
M	Metres
METAR	Meteorological Aerodrome Report
MGT	Measured Gas Temperature
N1	Low-pressure Spool
N2	Turbine Spool
NG	Gas Producer RPM
NP	Power Turbine RPM
NR	Main Rotor RPM
PAPI	Precision Approach Path Indicator
PIC	Pilot-in-Command
PLA	Power Lever Angle
POH	Pilot’s Operating Handbook
QNH	Barometric Pressure Adjusted to Sea Level
RPM	Revolutions per Minute
SACAA	South African Civil Aviation Authority
SN	Serial Number
UTC	Co-ordinated Universal Time
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions
Z	Zulu (Term for Universal Co-ordinated Time - Zero Hours Greenwich)

1. FACTUAL INFORMATION

1.1. History of Flight

1.1.1. On Thursday evening, 15 February 2024, a flight instructor (FI) and a pilot on-board a Bell 407 helicopter registered ZS-RLS took off on a type conversion training flight from Ultimate Heliport in Midrand to Grand Central Aerodrome (FAGC), both located in Gauteng province. The purpose of the flight was to conduct simulated engine failure exercises before returning to the departure heliport. The flight was conducted under visual meteorological conditions (VMC) and under the provisions of Part 141 of the Civil Aviation Regulations (CAR) 2011 as amended.

1.1.2. The FI reported that after lift-off from the Ultimate Heliport, he demonstrated two simulated engine failure exercises overhead the heliport before routing to FAGC. The control tower at FAGC was unmanned at the time. Upon arrival at FAGC, the FI demonstrated the simulated engine failure exercises again and, thereafter, handed over the controls to the pilot. The helicopter climbed to 1 000 feet (ft) above ground level (AGL) and flew a circuit. During the final approach for Runway 35 and before the pilot could perform the first simulated engine failure exercise, the FI enquired if he (pilot) was comfortable performing the exercise. The pilot confirmed that he was comfortable and ready. Thereafter, the pilot lowered the collective pitch control lever and entered an autorotative flight during which the FI rolled the throttle (twist grip) to the idle position to split the needles between the engine revolutions per minute (RPM) and the main rotor RPM on the dual gauge (the rotor RPM pointed to the green [100%] arch on the dual gauge). The crew heard an engine out aural warning (beeping sound) which meant that the engine had failed (stopped). The FI opened the throttle to auto-relight (restart) the engine, but without success. He then took control of the helicopter and performed a forced landing. The FI further stated that due to a lack of reference as it was dark, he initiated the flare at approximately 80ft AGL, which was higher than normal. Consequently, the helicopter descended and impacted the ground hard with the landing gear skids. As a result, the main rotor blades flapped down and severed the tail boom. The helicopter skidded for a few metres on the runway before it stopped on the centreline facing north.

1.1.3. The FI notified the approved training organisation (ATO) personnel about the accident. Both occupants disembarked from the helicopter unharmed. The FI disconnected the battery as a safety precaution prior to disembarking the helicopter. The Aerodrome Rescue and Firefighting (ARFF) personnel were dispatched to the accident scene.

1.1.4. During the interview, the pilot who is of Indian descent and a foreigner to South Africa, stated that he arrived at the Ultimate Heliport facility at approximately 0600Z with two other pilots from his country (India). They were all briefed by the FI who later flew with them, individually,

on a training flight for about 1 hour and 20 minutes in the general training area (GFA). After landing with the last of the three pilots, they (pilots) returned to their hotel. Later that afternoon, they returned to the Ultimate Heliport facility in preparation for the evening training. He stated that the evening flight training was conducted by a different FI (from the one they had earlier that day). Before the training flight, the FI briefed the pilots about the exercises he had planned to perform, which involved simulated engine failures. After the first pilot had completed his training and disembarked from the helicopter, he boarded the helicopter. *The accident occurred whilst the FI was flying with the second pilot*.

1.1.5. The accident occurred at nighttime on Runway 35 at FAGC at Global Positioning System (GPS) co-ordinates determined to be 25°59´19.96" South 028°08´40.20" East, at an elevation of 5 337 feet (ft).

Figure 1: The overlay of the accident site. (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 sustained substantial damage.

Figure 2: The helicopter after the accident.

1.4. Other Damage

1.4.1. None.

1.5. Personnel Information

Flight Instructor (FI)

Nationality	South African	Gender	Male	Age	39
Licence Type	Commercial Pilot Licence (CPL)				
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Grade II Flight Instructor rating; Night rating				
Medical Class & Expiry Date	31 August 2024				
Restrictions	Special Restriction as Specified (SSL)				
Previous Accidents	None				

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

Flying Experience:

Total Hours	2 609.4
Total Past 24 Hours	2.3
Total Past 7 Days	4.6
Total Past 90 Days	49.4
Total on Type Past 90 Days	20.9
Total on Type	157.2

1.5.1. The pilot had a Commercial Pilot Licence (CPL) that was issued on 2 August 2023 with an expiry date of 31 August 2024 under Part 61 of the South African Civil Aviation Regulations (CAR) 2011 as amended. The pilot had a Grade II Flight Instructor rating that was issued on 2 August 2023 with an expiry date of 31 August 2024. The pilot was also issued a Night rating.

1.5.2. The pilot had a valid Class 1 aviation medical certificate that was issued on 14 August 2023 with an expiry date of 31 August 2024 with medical restrictions (Special Restrictions as Specified [SSL]).

Pilot (FP)

Nationality	Indian	Gender	Male	Age	38
Licence Type	Military Licence (Foreign)				
Licence Valid	Yes	Type Endorsed	No		
Ratings	None				
Medical Class & Expiry Date	28 February 2029				
Restrictions	None				
Previous Accidents	None				

Flying Experience:

Total Hours	1 901.4
Total Past 24 Hours	0.4
Total Past 7 Days	2.4
Total Past 90 Days	5.0
Total on Type Past 90 Days	5.0
Total on Type	5.0

1.5.3. The pilot had a Military Pilot Licence that was issued by the Indian Defence Force on 8 May 2009. The Military Pilot Licence was validated by the Directorate General of Civil Aviation (DGCA) of India on 8 February 2024.

1.5.4. The pilot had a Class 2 medical certificate that was issued on 12 February 2024 with an expiry date of 28 February 2029 with no restrictions. The pilot also had a medical certificate that issued in India on 8 August 2023 with an expiry date of 7 August 2024.

1.5.5. The pilot had a foreign training file kept at the ATO as required by the Regulator (SACAA). On 12 February 2024, the FI, who was on the accident flight, conducted comprehensive ground school lessons which included all aspects of the helicopter such as the systems, components, operation and emergency techniques. On the following day, 13 February 2024, the pilot was quizzed on the technical aspects of the helicopter. The quiz was conducted by the same FI who presented the session.

1.5.6. At the time of the accident flight, the pilot was undergoing a conversion training onto a Bell 407 helicopter after the DGCA of India had issued a foreign approval for the type rating training to be conducted by the SACAA-approved ATO.

1.5.7 The pilot had a Level 6 language proficiency rating in accordance with the ICAO Aviation English standards. However, the pilot did not have a radio licence and, therefore, was not authorised to operate the radio within the South African airspace.

1.5.8 This approval was granted by the DGCA of India under foreign jurisdiction; no licensing action was completed by the SACAA.

1.6. Helicopter Information (Source: Aircraft Flight Manual)

1.6.1. *The Bell 407 is a single-engine, seven-place light helicopter. The standard configuration provides for one pilot and six passengers. The fuselage consists of three main sections: the forward section, the intermediate section, and the tail boom section. The forward section utilises an aluminium honeycomb and carbon graphite structure and provides the major load-carrying elements of the forward cabin. The intermediate section is a semi monocoque structure that uses bulkheads, longerons, and carbon fibre composite side skins. The tail boom is an aluminium monocoque construction that transmits all stresses through its external skins. The helicopter is powered by a Rolls-Royce, Model 250-C47B engine. The main rotor is a four-bladed, soft-in-plane design with a composite hub and individually interchangeable blades. The tail rotor is a two-bladed teetering rotor that provides directional control. The basic helicopter landing gear is the low skid type. Optional pop-out emergency flotation gear or high skid gear is also available. The full authority digital engine control (FADEC) uses a single-channel control with one microprocessor and one electronic lane. There is also a manual mode hydro-mechanical backup. The FADEC system has two main components: the*

airframe-mounted Electronic Control Unit (ECU) and the engine-mounted Hydro Mechanical Unit (HMU). The ENGINE OUT light and (pulsing) warning horn circuit will activate when the FADEC detects an engine flameout (by sensing Ng deceleration) or when the gas producer (Ng) speed is 55 ±1% or less.

Airframe:

Manufacturer/Model	Bell Helicopter Textron Inc / 407	
Serial Number	53009	
Year of Manufacture	1996	
Total Airframe Hours (At Time of Accident)	3 949.2	
Last Inspection (Hours & Date)	3 882.4	09 June 2023
Airframe Hours Since Last Inspection	66.8	
CRS Issue Date	09 June 2023	
C of A (Issue Date & Expiry Date)	06 June 1999	30 June 2024
C of R (Issue Date) (Present Owner)	09 June 2023	
Operating Category	Part 141	
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	Rolls-Royce / 250-C47B
Serial Number	CAE-847010
Part Number	250-C47B
Hours Since New	Modular Assembly
Hours Since Overhaul	Modular Assembly

1.6.2. According to the airframe logbook, the last mandatory periodic inspection (MPI) of the helicopter was certified on 9 June 2023 at 3 882.4 airframe hours.

1.6.3. The Certificate of Release to Service (CRS) was issued on 9 June 2023 at 3 882.4 hours with an expiry date of 8 June 2024 or at 3 982.4 hours, whichever comes first.

1.6.4. Based on the last maintenance inspection work pack, there were no previous faults detected during the Electronic Control Unit (ECU) download.

1.6.5. The weight and balance calculations were within the maximum allowable take-off weight for the helicopter, according to the Aircraft Flight Manual (AFM).

1.7. Meteorological Information

1.7.1. The weather information in the table below was obtained from the flight instructor via the pilot questionnaire.

Wind Direction	300°	Wind Speed	10kt	Visibility	9999m
Temperature	24°C	Cloud Cover	FEW	Cloud Base	N/A
Dew Point	17°C	QNH	N/A		

1.8. Aids to Navigation

1.8.1. The helicopter was equipped with standard navigational equipment as approved by the Regulator. There were no records indicating that the navigational equipment was unserviceable before 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 before the flight.

1.10. Aerodrome Information

1.10.1. The accident occurred on Runway 35 at FAGC.

Aerodrome Location	Midrand, Gauteng province
Aerodrome Status	Licensed
Aerodrome Co-ordinates	25°59’21.75” South, 028°08’22.99” East
Aerodrome Elevation	5 337ft
Runway Headings	17/35
Runway Dimensions	1 828m x 23m
Heading of Runway Used	35
Runway Surface	Asphalt
Approach Facilities	Runway lights, PAPI
Radio Frequency	122.80 MHz

1.11. Flight Recorders

1.11.1. The helicopter was neither 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.

1.12. Wreckage and Impact Information

1.12.1. The helicopter came to rest facing north, approximately 475 metres (m) from the threshold of Runway 35. The cabin and the cockpit structure had remained intact. The skid landing gear showed signs of deformation, but it was still attached to the fuselage. The tail boom separated from the airframe; it was severed at two points, which meant that there were three structural pieces of the tail boom on site, namely: the tail cone, horizontal stabiliser and the front section of the tail boom. The severed structural pieces of the tail boom were located at the edge of the runway and on the right side of the wreckage. There were scrape marks on the runway that spanned 45m from the point of impact.

There was no fuel or oil leakage on the upper deck of the helicopter or on the ground. The instrument panel was found intact. The helicopter had dual flight controls installed. It was confirmed that the collective pitch lever control was fully down, and the twist grip/throttle lever was at the maximum open position. The position of the throttle lever on the Hydro Mechanical Unit (HMU), which is located on the right side of the engine, confirmed the position of the throttle lever at the maximum open position. The fuel valve and the master switch were turned off whilst the booster pumps were turned on. The cockpit had two doors; the right door Perspex sheet had a crack. The battery terminal was disconnected.

Figure 3: The helicopter post-accident.

1.12.2. Main Rotor Blades

All four main rotor blades exhibited signs of impact damage on the mid-section and on the tips. The main rotor head had fractured. The attachment points of the white pitch change link had fractured and separated; the white pitch change link was located approximately 3m forward of the nose section. Three of the pitch change control tubes were still attached to the main rotor head; one of the pitch change control tubes near the clevis attachment had failed. The rotating and non-rotating swashplates were still secured.

Figure 4: Damage to the main rotor head.

Figure 5: The damaged pitch change link attachment.

Figure 6: The damage sustained to one of the main rotor blades.

1.12.3. Main and Tail Rotor Gearbox

The main rotor gearbox was in good condition and with no signs of damage. The oil level in the side glass was a quarter-full, and no signs of oil leaks were observed. The oil level was confirmed after the cone was placed upright. The attachment points did not show any signs of being damaged. The main drive shaft was still secured, and there were no signs of deformation or misalignment. The tail rotor drive shaft was severed at different places after the main rotor blades severed the tail boom. The tail rotor blades leading edges and surface were intact with no damage. The tail rotor gearbox was found intact.

1.12.4. Flight Controls

The helicopter was equipped with dual flight controls. The control tubes were checked for continuity, which was confirmed. The collective and cyclic movements were transmitted to the control tubes via the servo actuators. The anti-torque pedal check was found in an unsatisfactory condition due to damage on the tail boom. The servo actuators were found intact, and no hydraulic leaks were detected. The bell cranks were secured with no signs of failure.

1.12.5. Tail Boom

The main rotor blades severed the tail boom at the point it attaches to the fuselage. The horizontal stabiliser and tail cone exhibited signs of damage after they contacted the main rotor blades. The tail cone skin had an imprint that matched the profile of the main rotor blade leading edge paint. Scrape marks were found on the underside of the tail rotor guard, but the

tail rotor guard was not bent. The vertical stabiliser exhibited signs of contact with the tail rotor blades on the inner surface.

Figure 7: The tail cone at the accident site.

Figure 8: The severed horizontal stabiliser.

Figure 9: A section of the tail rotor drive shaft at the accident site.

1.12.6. Engine

The engine was found intact and in good condition. The outside surface of the compressor blades was in good condition. The compressor was turned by hand, and it rotated smoothly. The turbine blades were not damaged. There were no signs of fuel or oil pipe rupture or dislocation. The forward and lower chip detectors were removed and checked for metal chips; they were found clean. Fuel sample from the forward and rear tanks was collected; the fuel was of the correct grade (Jet A1) and had no sediments or impurities.

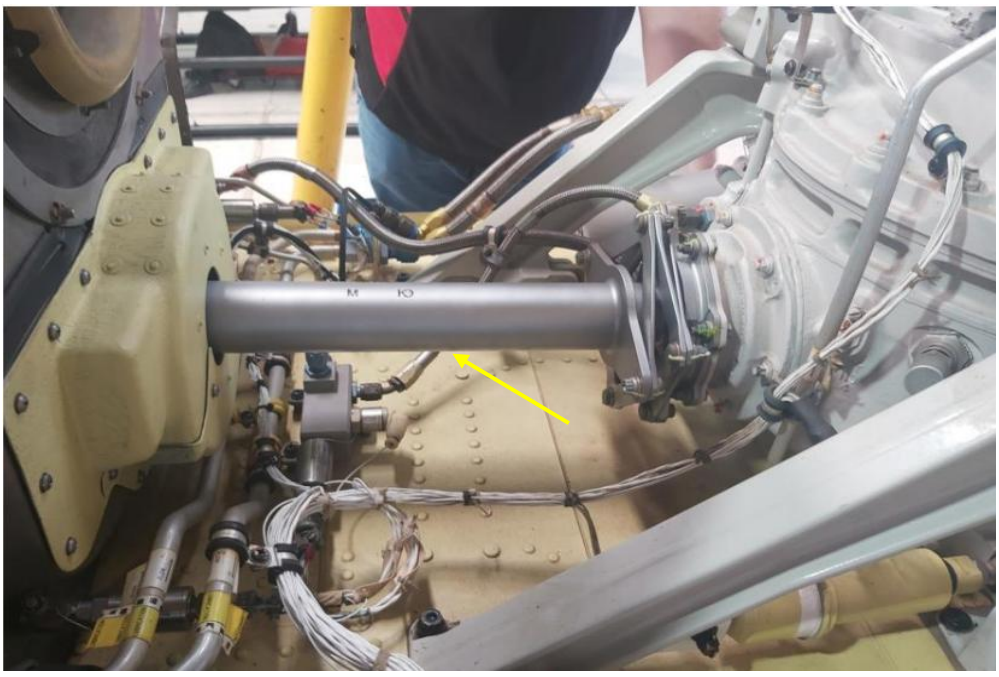


Figure 10: The engine drive shaft.

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 the cockpit/cabin structure remained intact. The occupants had made use of the helicopter equipped safety harnesses.

1.16. Tests and Research

1.16.1. The following observations were made after the examination of the ECU with serial number (SN) JG5ALK0892 at the SACAA-approved facility in Germiston, Johannesburg:

I. Examination of the ECU indicated that it operated normally before the accident.

II. The recorded data revealed that the throttle power lever angle (PLA) rolled well below the ground idle, as well as below the point at which the hydromechanical unit (HMU) would cut off fuel.

a) Throttle roll-back to this extent resulted in an engine flameout and a gas produced RPM (Ng) under speed.

b) The auto re-light sequence was not possible because the throttle had been rolled to a cut-off position and the engine responded by shutting down. This was the cause of the flame out.

c) Additionally, the remaining altitude was insufficient for the crew to attempt a manual restart.

III. The continuity control was established from the collective twist grip to the HMU.

IV. The throttle linkage rigging to the HMU was misaligned by 5° to the lower side. Damage sustained during the accident was not sufficient to alter the throttle to the HMU rigging.

Throttle Position	PLA Limit – Bell Manual	PLA – Roll to Open	PLA – Roll to Closed
Closed	-2.5° to +2.5°	~ 2.0°	~ 2.0°
Idle	34° to 36°	~ 26.5°	~ 30.0°
Fly	69.5° to 70.5°	~ 59.5°	~ 63.0°
Full Open	97.5° to 102.5°	~ 90.0°	~ 90.0°

Figure 11: Comparison between the throttle rigging values and the limits from Bell Helicopters.

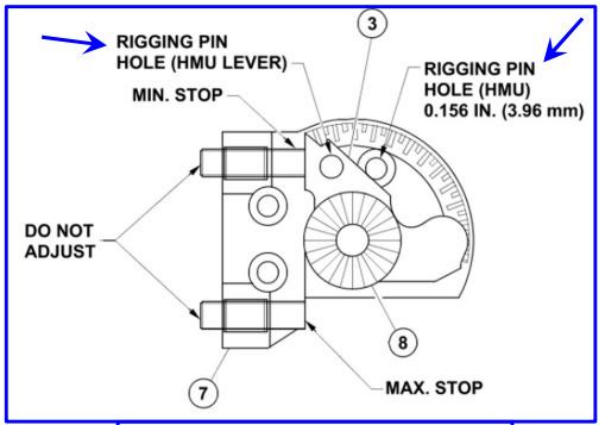


Figure 12: Bell illustration HMU rigging.

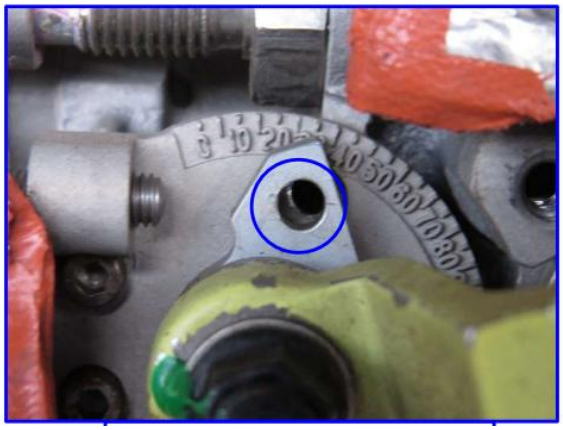


Figure 13: HMU rigging misalignment.

1.16.2. The engine (Model M250 Rolls-Royce) was transported to a SACAA-approved Authorised Maintenance, Repair and Overhaul Centre (AMROC) located at the Rand Airport in Johannesburg. Upon completion of standard test bench preparedness tasks by the technicians, the engine was considered acceptable to run on the test bench.

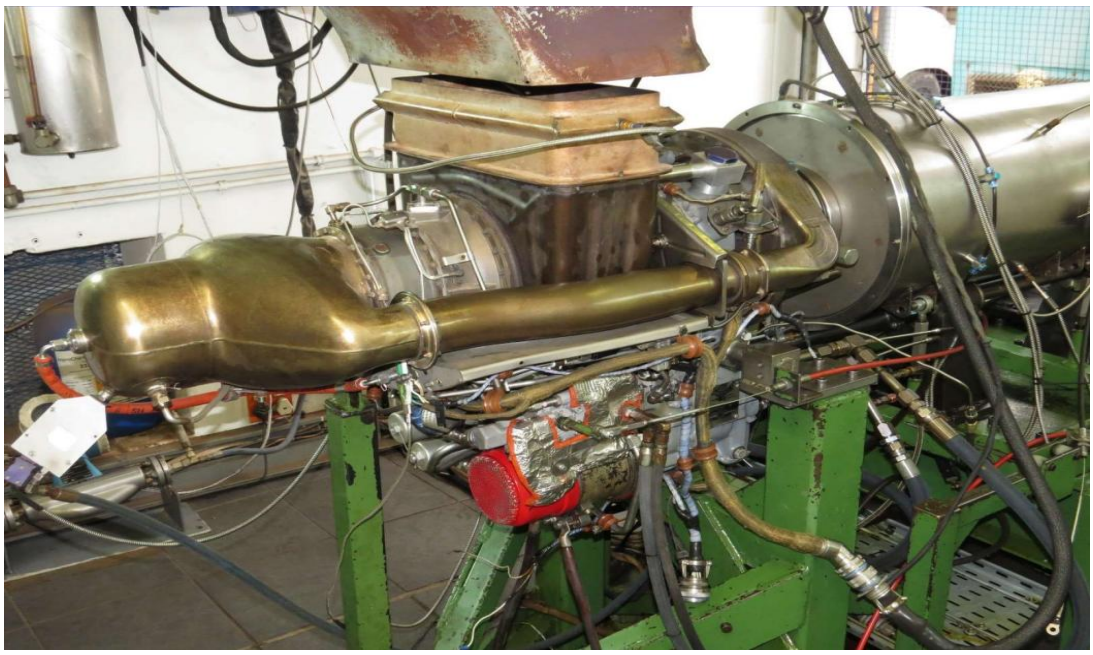


Figure 14: The engine on the test bench.

The following was observed after engine-run test:

a) There was no visible, external evidence of pre-impact fire, damage or malfunction of the engine.

b) Continuity was established for both the rotational speed of the low-pressure spool (N1) and the rotational speed of the high-pressure compressor and turbine spool (N2). Both rotors could be rotated by hand, and they moved smoothly with no noise.

c) The engine was placed on a test bench with the intent of running a 6-point performance test in accordance with Rolls-Royce M250-C40 Series Overhaul Manual procedures. The engine performed satisfactorily at all measured test points.

d) All available evidence supports that the engine could produce sufficient power and respond to throttle inputs.

1.16.3. Appendices A and B provide more information about the components that were tested.

1.17. Organisational and Management Information

1.17.1. The training flight was conducted under the provisions of Part 141 of the CAR 2011 as amended.

1.17.2. The approved training organisation (ATO) was issued the ATO Certificate on 28 August 2023 with an expiry date of 30 September 2028.

1.17.3. The ATO had an approved training programme to provide the helicopter type conversion and this was deemed acceptable by the DGCA of India for the pilots to complete their training.

1.17.4. The AMO that conducted the last MPI had an AMO Certificate that was issued on 27 March 2023 with an expiry date of 30 March 2024.

1.18. Additional Information

1.18.1. The following information is an extract from the BELL 407 Flight Manual.

3-3-A-2. ENGINE FAILURE — IN-FLIGHT

• INDICATIONS:

1. Left yaw.
2. ENGINE OUT and RPM warning lights illuminated.
3. Engine instruments indicate power loss.
4. Engine out audio activated when NG drops below 55%.
5. NR decreasing with RPM warning light and audio on when NR drops below 95%.

PROCEDURE:

1. Maintain heading and attitude control.
2. Collective — Adjust as required to maintain 85 to 107% NR.
3. Cyclic — Adjust to obtain desired autorotative AIRSPEED.
4. Attempt engine restart if ample altitude remains. (Refer to ENGINE RESTART, paragraph 3-3-B.)
5. FUEL VALVE switch — OFF.
6. At low altitude:
   a. Throttle — OFF.
   b. Flare to lose airspeed.
7. Apply collective as flare effect decreases to further reduce forward speed and cushion landing. Upon ground contact, collective shall be reduced smoothly while maintaining cyclic in neutral or centered position.
8. Complete helicopter shutdown.

NOTE

Maintaining NR at high end of operating range will provide maximum rotor energy to accomplish landing, but will cause an increased rate of descent.

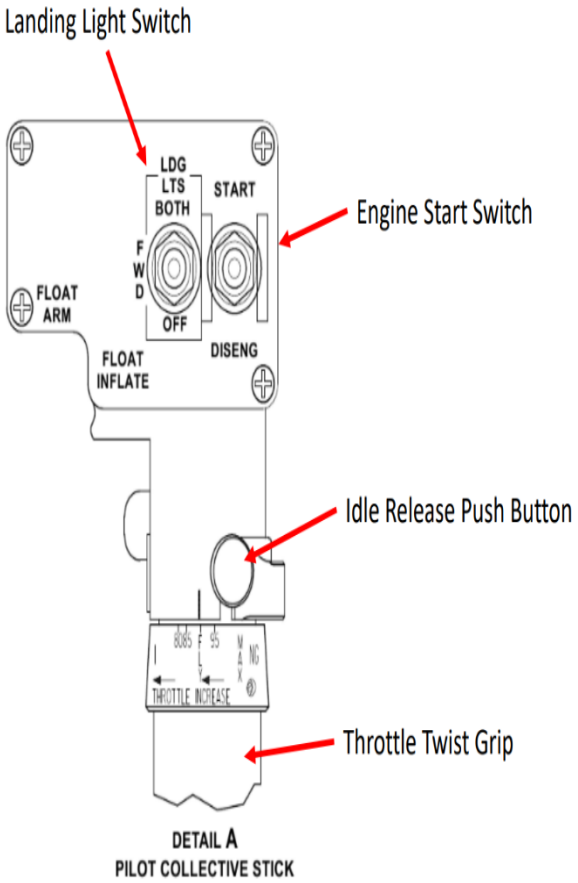
NOTE

Maximum AIRSPEED for steady state autorotation is 100 KIAS. Minimum rate of descent airspeed is 55 KIAS. Maximum glide distance airspeed is 80 KIAS.

1-30-B-2. COLLECTIVE

The collective control stick (Figure 1-22) is mounted between the pilot and copilot crew seats. The collective control stick controls the collective hydraulic servo actuator through push-pull tubes. This operates the collective lever mounted on the top of the transmission. The collective lever raises and lowers the swashplate ball-sleeve assembly and the cyclic levers to induce collective pitch to the main rotor blades without affecting the cyclic path. A spring is installed under the copilot's crew seat to balance the required force to raise and lower the collective with the hydraulic boost system operating.

A collective friction knob is located near the base of the collective stick between the pilot and copilot seats. A throttle twist grip for the engine is mounted on the collective stick. A mechanical idle release push button is located in front of the twist grip throttle. A switchbox located on the forward end of the collective stick provides a base for the engine start switch and landing light switch.



Pilot Collective Control stick

Throttle twist grip on co-pilot collective control stick

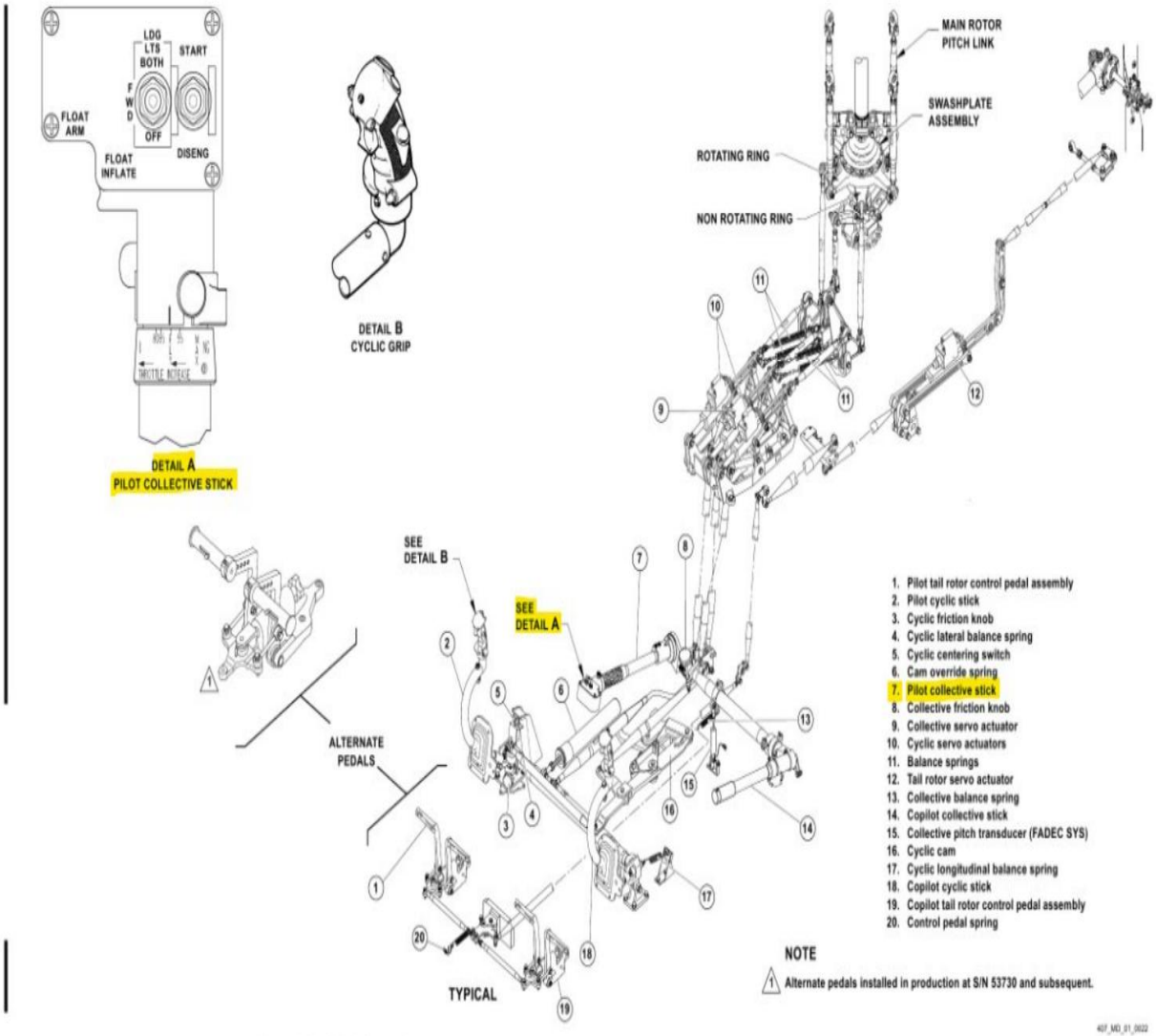


Figure 1-22. Flight Controls

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

Instructor

2.2.1. The FI had a Commercial Pilot Licence (CPL) that was issued on 25 November 2010. The licence was renewed on 2 August 2023 with an expiry date of 31 August 2024. The FI had flown a total of 2 303.8 hours of which 157.2 hours were on the helicopter type. The FI also had a Night rating for the helicopter type. The helicopter was endorsed on his licence and logbook. Therefore, the FI was qualified to undertake this flight.

2.2.2. The FI was issued a Class 1 aviation medical certificate on 14 August 2023 with an expiry date of 31 August 2024. The FI was properly licensed to conduct the flight and was medically fit in accordance with Part 67 of the CAR 2011.

2.2.3. Post-accident investigation showed that the autorotation conducted during the simulated engine failure exercises was unsuccessful. After the pilot had simulated an engine failure exercise, the FI rolled the throttle to idle with the intent to simulate an engine-out scenario. During this time, the engine flamed out (stopped). The FI took over the control of the helicopter and tried to restart the engine but was unsuccessful. The helicopter descended and impacted the ground hard with the landing gear skids.

2.2.4. During the interview, the FI stated that he had briefed the pilots about their flight plan prior to the flight. He further stated that he had reviewed the terminology he would be using during the emergency procedures and clarified the differences between handling a daylight and nighttime emergency. The pilots confirmed their understanding and were satisfied with the planned training. During the flight, the FI reiterated the terminology, and the pilot's demonstrated comprehension. The pilot successfully executed the first autorotation after the FI used the specified terminology. This is an indication that there was no language barrier or communication challenges related to the flight plan and simulated engine failure exercises.

Pilot

2.2.5. The pilot was issued a foreign approval by the Indian Directorate General of Civil Aviation on 8 February 2024. Based on this approval, he was exempted from the SACAA licensing requirements. The pilot had flown a total of 1 901.4 hours of which 5 hours were on the helicopter type. The pilot was qualified to undertake the flight.

2.2.6. The pilot was issued a Class 2 aviation medical certificate on 12 February 2024 with an expiry date of 28 February 2029. The pilot was properly licensed to conduct the flight and was medically fit in accordance with Part 67 of the CAR 2011.

2.2.7. The pilot started the B407 training syllabus on 12 February 2024 which covered various topics, including engine failure in all phases of flight and engine restart procedures in-flight. The exercises in the training syllabus were completed in accordance with the aircraft flight manual and the South African Civil Aviation Technical Standards (SACATS) and CARs. After 12 hours of ground school, the pilot attained a 91% pass on the 13 February 2024. This training provided the necessary knowledge and skills to prepare the pilot for autorotation exercises.

2.2.8. The pilot had logged 113.05 hours as pilot-in-command, 56.5 hours as second-in-command, and 66.5 hours of dual instruction during night flights in the military; however, he did not have a Civilian Night rating.

Aircraft

2.2.9. The last helicopter MPI was conducted and certified on 9 June 2023 at 3 882.4 airframe hours. The helicopter had accrued 66.8 hours since the last MPI. The maintenance was conducted in accordance with the Bell 407 Maintenance Manual as well as procedures stipulated by the Regulator. Therefore, there were no maintenance issues prior to the flight.

2.2.10. The helicopter had a valid Certificate of Airworthiness (C of A) that was initially issued on 6 June 1999. The C of A had an expiry date of 30 June 2024.

2.2.11. The Certificate of Release to Service (CRS) was issued on 9 June 2023 with an expiry date of 8 August 2024 or at 3 983.4 hours, whichever comes first. Therefore, the helicopter was deemed airworthy to undertake the flight.

2.2.12. The Certificate of Registration (C of R) was issued to the present owner on 10 November 2023.

2.2.13. During engine examination by the accredited representative and the IIC, it was noted that the HMU engine rigging was misaligned. However, this did not contribute to the engine flame-out as this was still within the allowable limitations for normal engine operation.

2.2.14. The engine was placed on a test bench with the intent of running a 6-point performance test in accordance with Rolls-Royce M250-C40 Series Overhaul Manual procedure. The engine met all the measured parameters during the test run.

Environment

2.2.15. Favourable weather conditions prevailed at the time of the flight; therefore, the weather did not contribute to this accident.

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

Personnel

3.2.1. The FI had a Commercial Pilot Licence (CPL) that was issued on 2 August 2023 with an expiry date of 31 August 2024. The FI was issued a Class 1 aviation medical certificate on 14 August 2023 with an expiry date of 31 August 2024 with medical restrictions (SSL). The FI was issued a Grade II Instructor rating on 2 August 2023 with an expiry date of 31 August 2024.

3.2.2. The pilot under training was issued a Military Pilot Licence on 8 May 2009. He was issued a Class 2 medical certificate on 12 February 2024 with an expiry date of 28 February 2029 with no medical restrictions. The pilot also had a medical certificate that was issued in India on 8 August 2023 with an expiry date of 7 August 2024.

3.2.3. The Military Pilot Licence was validated by the Directorate General of Civil Aviation of India on 8 February 2024.

Helicopter

3.2.4. The aircraft maintenance engineer (AME) who conducted the last MPI was initially issued the AME Licence on 14 May 2015. The licence was renewed on 24 April 2023. The helicopter type was endorsed on his licence. The AME was authorised to conduct maintenance and sign off the release of the helicopter.

3.2.5. The last MPI of the helicopter was conducted on 9 June 2023 at 3 882.4 airframe hours. The Certificate of Release to Service (CRS) was issued on 9 June 2023 at 3 882.4 hours with an expiry date of 8 June 2024 or at 3 982.4 hours, whichever comes first.

3.2.6. The AMO which certified and released the helicopter was issued an AMO Certificate on 27 March 2023 with an expiry date of 31 March 2024.

3.2.7. The aircraft was initially issued a Certificate of Airworthiness (C of A) on 11 July 1999; the reissued C of A had an expiry date of 30 June 2024.

3.2.8. The helicopter's Certificate of Registration (C of R) was issued to the current owner on 30 July 2019.

3.2.9. There were no sediments found in the fuel samples collected after the accident; the fuel was of the correct grade.

3.2.10. During the engine tests and examinations post-accident, it was concluded that the engine met all the parameters associated with normal engine operation.

ATO

3.2.11. The ATO was issued an ATO Certificate on 17 June 2020 with an expiry date of 30 June 2025.

3.2.12. The ATO had an approved training programme.

3.2.13. The ATO conducted the training to the pilot based on a foreign training approval.

3.3. Probable Cause/s

3.3.1 The FI executed an unsuccessful autorotation which resulted in a hard landing after rolling down the throttle to idle position during which the engine flamed out. The cause of the engine flame-out was undetermined.

3.4. Contributory Factor/s

3.4.1. Lack of visual reference due to darkness.

3.4.2. The FI was likely fixated on restarting the engine during autorotation.

3.4.3. Lack of situational awareness.

4. SAFETY RECOMMENDATIONS

4.1. General

The safety recommendations listed in this report are proposed according to paragraph 6.8 of Annex 13 to the Convention on International Civil Aviation and are based on the conclusions listed in heading 3 of this report. The AIID expects that all safety issues identified by the investigation are addressed by the receiving States and organisations.

4.2. Safety Recommendation/s

4.2.1 It is recommended to the Director of Civil Aviation Authority that training schools should ensure that flight instructors conduct a detailed pre-flight risk assessment before night training exercises. This includes discussing the specific risks associated with engine failure training at night, ensuring that both instructor and foreign pilots are comfortable with the exercise, and confirming that the aircraft and equipment are in optimal condition for night operations.

5. APPENDICES

5.1. Appendix A - Extract from the ECU test report

5.2. Appendix B - Extract from the engine test report

5.3. Appendix C – Foreign approval by the Indian Directorate General of Civil Aviation

This report is issued by:

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

5.1. Appendix A

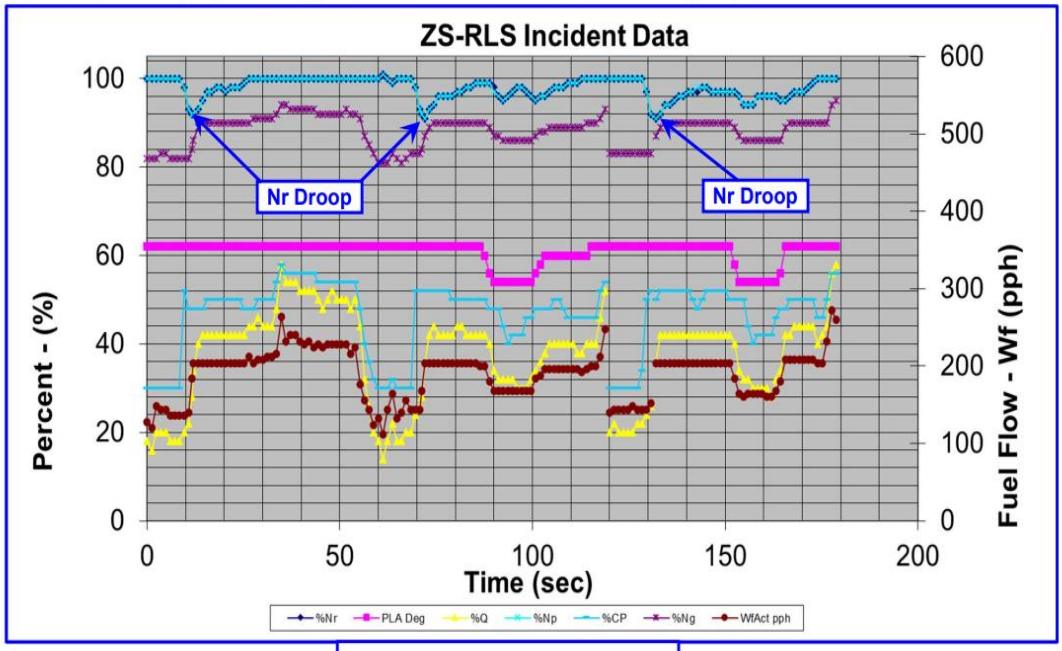
Maintenance Terminal Data

The ECU remained secured in its position on the aircraft and was visually undamaged. The unit was able to be powered up in the aircraft and was connected to a Rolls-Royce computer for downloading and examination of the ECU's memory. Upon application of aircraft battery power, the ECU Maintenance Terminal displayed no "Current RAM Faults, Last Engine Run Faults, or Accumulated Faults".

Incident Recorder Data

Data download was completed and a cursory review showed primary "snapshot triggers" for Nr (main rotor) droop, Ng (gas generator) under-speed, & Flameout. There was a total of 10 snapshots recorded. However, only the first 3 snapshots for main rotor droop (Nr) were recorded in the IR's allotted 3-minute total running buffer of non-volatile memory (NVM).

The following graph shows the first 3 triggers (Nr Droop) occurring within the total recorded time in the IR (180 sec). These triggers did not occur during the accident flight:



ECU Incident Recorder Plot

Incident Recorder Snapshot Data

Snapshot	Trigger	Time Stamp	Ng	Nr	MGT	Q	Np	WfAct	NDOTFilt	Mode	CP	PLA	NumStrtRcrd
		HH:MM:SS.mmm	%Ng	%Nr	Deg	%Q	%Np	pph	%Ng/Sec		%CP	Deg	Starts
1	Nr Droop	4503:45:02.000	84	92	980	28	92	184	3.9	5	48	62	6897
2	Nr Droop	4503:46:01.896	84	92	960	28	92	168	1.8	5	52	62	6897
3	Nr Droop	4505:05:00.672	83	92	940	26	92	160	1.2	5	52	62	6898
4	Nr Droop	4506:29:54.792	86	92	1040	32	92	192	3.1	5	54	62	6899
5	Flameout	4507:57:00.504	66	97	680	0	92	100	-10.8	1	6	4	6900
6	Ng Underspeed	4507:57:00.984	55	97	560	0	75	0	-8.6	3	8	12	6900
7	Nr Droop	4507:57:11.760	20	92	400	0	23	48	-1.2	1	38	64	6900
8	Ng Underspeed	4507:57:25.032	10	16	360	0	8	48	-0.4	1	8	64	6900
9	Flameout	4507:59:18.048	62	83	880	2	82	116	-8.3	1	6	0	6901
10	Flameout	4508:00:29.136	61	84	860	2	83	128	-8.9	1	6	0	6902

Incident Recorder Snapshot Extraction

Snapshots 1-4: All 4 triggers occurred while in manual throttle mode. Selection of manual mode is made by the pilot who selects manual via the auto/manual switch located in the

cockpit. Selection of manual mode allows the pilot to modulate fuel flow. While in manual mode, the ECU is still operational, will track HMU (hydromechanical unit) operation, perform diagnostics, monitor engine functions and provide overspeed protection and limiting for both N1 & N2.

The Mode column shows (5) indicating manual mode. The trigger was set once Nr (main rotor rpm) hit 92%. The column labelled (NumStrtRcrd) shows the total number of starts in the engine's history. Therefore, this indicates that these triggers occurred on 3 separate flights (6897, 6898, 6899) with the first 2 triggers occurring on the same flight (6897). The first 3 rotor droops are shown in the ECU Incident Recorder Plot on the previous page. Following these rotor droop occurrences, main rotor speed was regained as shown in the plot through appropriate pilot inputs.

None of the remaining 4-10 snapshots were captured in the running buffer memory of the IR. As previously discussed, in order to clear the IR, an "incident free" flight must be performed and also accompanied by a successful engine start. In this scenario, triggers 1-3 were not followed with an incident free flight resulting in the 180 seconds of data remaining in the data section of the Incident Recorder. The IR continued to record triggers 4-10 but were beyond the 180 second capacity and therefore, only the single line snapshot parameter values were populated. Likewise, the preceding 10 records (taken at 1.2 second intervals) were not captured.

Snapshots 5-8: All 4 of these triggers occurred on the same flight as indicated by 6900 in the (NumStrtRcrd) column. Torque (Q) was "0" while collective pitch (CP) was very low as well as splits in Np & Nr indicating the aircraft was in an autorotation. Snapshots 5 & 6 happened almost simultaneously per their respective time stamps with the flameout followed immediately by Ng under-speed. Snapshot 5 shows the ECU in Auto per "1" in the Mode column at the time the throttle was rolled down to 4° PLA (power lever angle). This is well below the ground idle position on the collective lever throttle control (36 +/- 1° per the Bell 407 Manual) and below the point at which the HMU will cut off fuel flow (5° PLA and below).

At ground idle, the Ng speed on the M250-C47B engine is 63%. While in Auto mode, the automatic relight sequence will initiate from detection of flameout until the Ng speed decays to 50%. Once the Ng decays below 50% the ECU will no longer attempt to relight the engine. During the accident sequence, the rapidly decreasing Ng speed & rate of Ng deceleration (NDOTFilt) was so great (- 10.8 to -8.6%Ng/Sec), the ECU was incapable of performing a relight.

Snapshot 7: (Nr droop) occurred about 11 seconds after the flameout likely indicating collective pitch pull during the flare to landing. Throttle (PLA) was rolled to 64° perhaps in anticipation of an auto-relight but the engine had been commanded to shut down, and the only way to re-light it was to push the start button.

Snapshots 9 & 10: These reflect consecutive engine starts (6901-6902) following the accident to verify proper functionality of the HMU (hydromechanical unit). These were conducted with the main rotor blades removed & the tail rotor drive shaft disconnected aft of the oil cooler drive section.

Cockpit Controls Check Control system continuity was established from the collective twist grip on both right and left seat collective levers to the HMU. When the throttle was rolled to

the ground idle stop, which is established by the push-button detent on the right seat collective lever, neither twist grip could be moved lower than the detent without first depressing the button.

As part of the ECU examination process, the throttle was manipulated through various positions: Off, Idle, Fly, & Full Open. Observations were made while monitoring the HMU pointer position and the PLA 1 sensor reading on the ECU Maintenance Terminal with a computer plugged into the ECU (FADEC) port in the cockpit. The ECU readings indicated that the throttle positions for Idle, Fly, & Full Open were lower than the published limits in the Bell 407 Maintenance Manual throttle rigging parameters. A scan of the PLA movement using Maintenance Terminal also showed minor hysteresis when the throttle was rolled through its full range of movement (Off to Full Open to Off).

Mechanical throttle rigging was checked against the Bell Maintenance Manual by rolling throttle to the Idle stop position and confirming alignment of the HMU lever & HMU rigging pin holes. The procedure states to install a rigging pin of 0.156-inch (3.96 mm) diameter through the HMU lever (3) into the rig pin hole on the HMU (7). The rig pin hole is located at the 35° PLA marking on the HMU. The rigging holes were misaligned by approximately 5° (30° vs 35°), which corresponded with the real-time PLA sweep using the ECU Maintenance Terminal.

5.2. Appendix B

Extract from the testing data that was conducted on the engine at an approved engine facility.

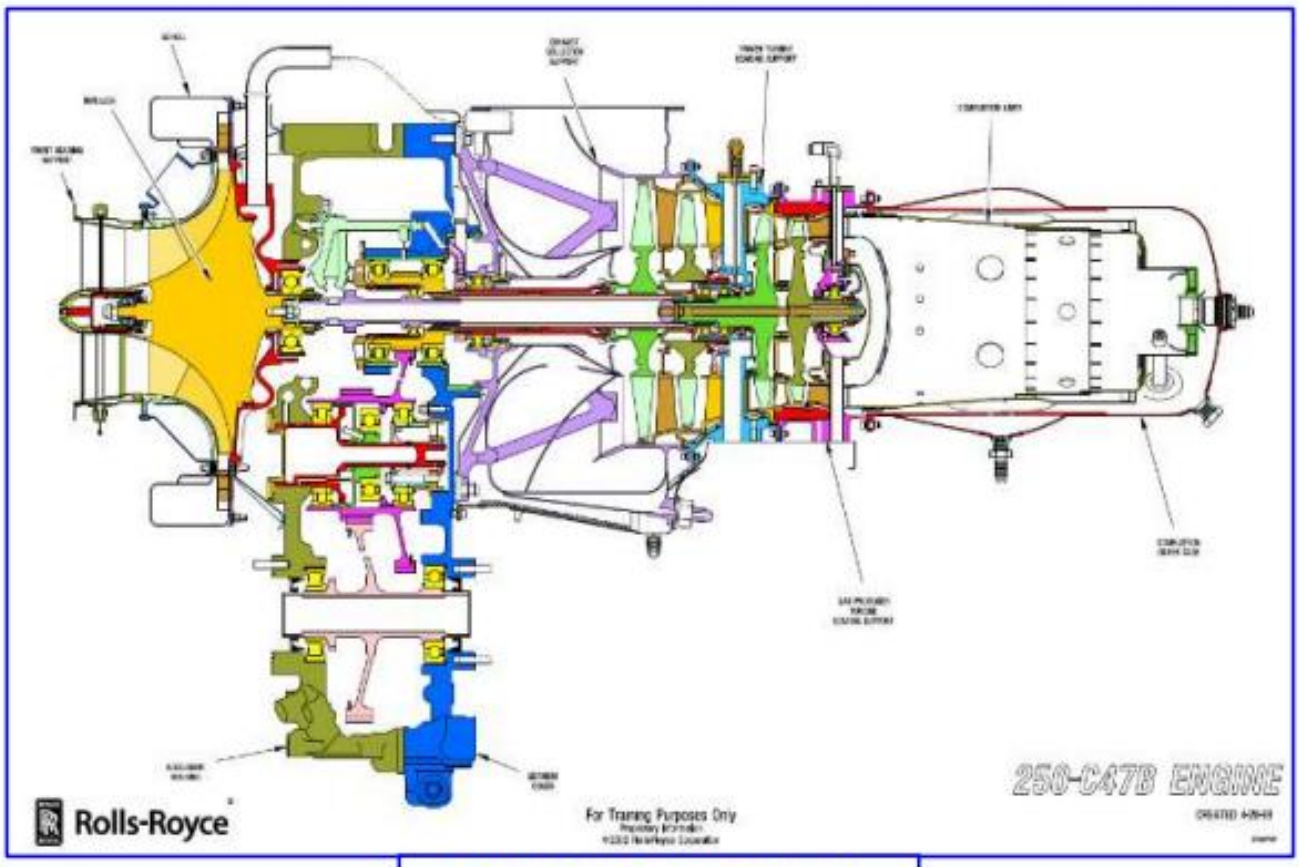
The engine & ECU from the accident aircraft were installed on a test cell & a 6-point performance test was conducted to new engine production standards (Model M250-C47B) in accordance with Rolls-Royce M250-C40B, -C47, & -C30R/3 Series Overhaul Manual (Publication ref. CSP22001) Revision 20 dated 15 September 2019.

The engine successfully started, ran, and shut down. The engine successfully completed ground idle, flight-idle, max-continuous-power and take-off power runs. When corrected for standard atmospheric conditions, the engine yielded performance +2.9% above new-production standards at "low cruise" (450 horsepower), +1.3% above new-production standards at "high cruise" (540 horsepower), +1.0% above new-production standards at max continuous (600 horsepower), and +0.5% above new-production standards at maximum (Take-Off) power (650 horsepower).

To replicate the Incident Recorder flameout (Snapshot 5), the engine was tested to examine the throttle (PLA) point where the engine would shut down. The NAC test stand technician stabilized the engine at the ground idle position (36°). From ground idle, throttle control to the HMU was slowly rolled down to determine the point at which the engine would flame out. This occurred at 7° PLA on the Maintenance Terminal, well below the ground idle stop position. The 7° position was also verified with the pointer indicator on the HMU lever. Comparing this to the 4° PLA position from the IR data, the throttle rigging condition on the accident aircraft did not influence the point at which normal engine shutdown would be expected. Additionally, the observed damage noted during the wreckage examination suggests that impact forces were not sufficient to alter the throttle control to HMU rigging.

ENGINE MODULE & COMPONENT DETAILS

Component	Serial Number	Part Number	TSO (hrs)	Total Time (hrs)
Engine	CAE-847010	23063392	N/A	3828.0
Gearbox	CAG-47075	23063393	New	3828.0
Compressor	CAC-44018	23063379	New	3828.0
Turbine	CAT-44016	23063354	New	3828.0
HMU	JGALM0880	23078029	1728.5	1941.5
ECU	JG5ALK0892	M250-10696	New	1713.6
Bleed Valve	FF58537	23073353	655.5	Unknown
Fuel Nozzle	IZJ03837	23077067	1843.7	Unknown



Engine Cross-Section - Reference

5.3 Appendix C

Foreign approval by the Indian Directorate General of Civil Aviation on 8 February 2024.

भारत सरकार
नागर विमानन महानिदेशालय,
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Extension : 503

सत्यमेव जयते

GOVERNMENT OF INDIA
DIRECTORATE GENERAL OF CIVIL AVIATION,
OPP. SAFDARJUNG AIRPORT,
NEW DELHI-110 003, INDIA.

मिसिल संख्या File No.: DGCA-22018/17/2023-FSD

दिनांक Dated : 8th February, 2024

To,

The Accountable Manager,
ATO National Airways Corporation (Pty) Ltd ,
Ultimate Heliport, 1 Ultimate Road,
Midrand, South Africa.

Subject: Permission to undertake Type Rating Course and Recency Flying at ATO NAC, South Africa on Bell-407 type of helicopter – regarding.

Sir,

Wg. Cdr. Malay Kumar Singh (Retd.) 30513-G & F(P)H is a retired member of the Indian Defence Forces. It has been verified from the records submitted to this office, that he is a qualified military helicopter pilot & as per records, his flying experience is as follows:-

Type of Aircraft	Single Engine Aircraft				Multi Engine Aircraft						Sheep/ Shephered	Instr/Cloud Flying	
	Day		Night		Day			Night					
	Dual	Pilot	Dual	Pilot	Dual	1st Pilot	2nd Pilot	Dual	1st Pilot	2nd Pilot		Sim	Act
HPT-32, Chetak, Mi-8, Mi-17-V5,Mi-17	53:05	10:25	-	-	165:40	965:00	470:50	66:50	113:05	56:50	-	150:00	-
Total Hrs.	53:05	10:25	-	-	165:40	965:00	470:50	66:50	113:05	56:50	-	150:00	-

As per the provision of DGCA Civil Aviation Requirements Section-7, Series-G, Part-IV (Issue III dated 30th July 2023), this office does not have any objection for the above mentioned military pilot, to undertake the complete Type Rating Course and Recency Flying at aforesaid ATO on Bell-407 type of helicopter. The Ground Course, simulator and / or Flying Training and Skill Tests (Day & Night) shall be flown as per the training syllabus, as approved by the South African Civil Aviation Authority for ATO.

This issues with the approval of the Competent Authority.

Yours faithfully,

8/2/24

(माधिंद्र जी नेवसे)
(Machhindra G. Nevase)
उप-निदेशक प्रचालन (उड़ान मानक निदेशालय)
Dy. Director of Operations (FSD)
कृते महानिदेशक नागर विमानन
for Director General of Civil Aviation

Copy to: Wg. Cdr. Malay Kumar Singh (Retd.), Villa 24, Pocket-6 AWHO, Vasant Vihar Billamaranahalli, Yelahanka Bengaluru, Karnataka-562157. / Guard file