MINISTRY OF TRANSPORT AND COMMUNICATIONS

DIRECTORATE OF ACCIDENT INVESTIGATION

AIRCRAFT ACCIDENT REPORT

REPORT ON THE ACCIDENT TO A EUROCOPTER AS 350 B3 REGISTRATION ZS-HDI WHICH OCCURRED AT FRANCISTOWN AIRPORT ON 31ST OCTOBER 2012

REF: MTC AIG 06/12

MINISTRY OF TRANSPORT AND COMMUNICATIONS

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CIVIL AIRCRAFT ACCIDENT REPORT

All times are in UTC unless stated otherwise

AIRCRAFT MANUFACTURER:	EUROCOPTER
AIRCRAFT MODEL:	AS 350 B3
REGISTRATION:	ZS-HDI
SERIAL NUMBER:	3259
REGISTERED OWNER:	SAFDEV SSDC (Pty) Ltd. P. O. Box 36039 MENLOPARK 0102
OPERATOR:	PRIVATE OPERATION
PLACE OF ACCIDENT:	FRANCISTOWN AERODROME S24° 21' E026° 05'
DATE AND TIME:	31ST OCTOBER 2012 AT 11:15 HOURS

In accordance with Annex 13 to the Convention on International Civil Aviation, it is not the purpose of aircraft accident investigation to apportion blame or liability. The sole objective of the investigation and the Final Report is the prevention of accidents and incidents.

Unless otherwise indicated, recommendations in this report are addressed to the Civil Aviation Authority of Botswana for the matters with which the recommendations are concerned. It is for the Civil Aviation Authority of Botswana to decide what action is taken.

EXECUTIVE SUMMARY

				Reference:	MTC/AIG 06/12	
Aircraft Registration	ZS-HDI	**Date of Accident**	31.10.12	**Time of Accident**	11:15hrs	
Type of Aircraft	AS 350 B3		**Type of Operation**	PRIVATE		
Pilot-in-command Licence Type	PPL – (H)	**Age**	60 years	**Licence Valid**	25/10/2019	
Pilot-in-command Flying Experience	Total Flying Hours	1566Hrs	Hours on Type	389Hrs		
Last point of departure	FRANCISTOWN AIRPORT					
Next point of intended landing	JACKS CAMP					
Location of the accident site with reference to easily defined geographical points (GPS readings if possible)						
FRANCISTOWN AIRPORT						
Meteorological Information	METAR FBFT 311100Z 13014KT 9999 SCT030 FE035TCU 30/14 Q1012					
No. of people on board	2	**No. of people injured**	0	**No. of people killed**	0	
Narration						

The helicopter, in company with another two helicopters arrived in Francistown from Pilanesburg, RSA with two persons on board on transit to Jacks Camp in the Makgadikgadi Pans. After customs and immigration clearance the aircraft was refuelled and took off at 11:15 hrs. immediately behind the other two helicopters which were airborne at the same time since they were to fly in formation. Reportedly, after lift-off the helicopter appeared to be pushed by a gust of wind suddenly, with an apparent loss of tail rotor compensation effectiveness. It started to spin out of control, lost height and struck a refuelling ladder which was stowed next to the fuel bay. The helicopter crashed beside the refuelling bay incurring substantial damage to the main rotors blades, main fuselage, the boom and tail rotor assembly. The two occupants of the helicopter were not injured by the accident.
Investigation of the engine did not reveal any pre-impact failure. The VEMD and DECU were taken to BEA in France for data download. The data obtained did not show any engine failure prior to impact.
Investigations revealed that the pilot had just done type conversion a day before the occurrence and there was a strong easterly wind prevailing at the time of the occurrence.

Probable Cause(s) of the accident

1. The pilot’s lack of sufficient experience on the helicopter.
2. The prevailing wind that could have caused Lack of Tail Rotor Effectiveness (LTE).
3. Encounter with wake turbulence from departing helicopters.

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1. FACTUAL INFORMATION

1.1 History of the Flight

1.1.1 On 31st October 2012 the helicopter, a Eurocopter A350 B3 departed from Grand Central airport in South Africa at 06:00 hours to Pilanesburg with the pilot and one passenger on board. It was part of three helicopters flying in formation to Jacks Camp, in Botswana on a holiday trip. The other two were piston-engine Robinson R44 helicopters. After customs and immigration clearance at Pilanesburg the aircraft departed at 07:00 hours to Francistown, Botswana and arrived at 09:30 hrs.

1.1.2 According to available report the flights from Grand Central airport to Francistown was uneventful. On arrival in Francistown, the three helicopters landed and parked at the fuel bay but a distance from the fuel pumps due to the prevailing windy conditions. The two R44 helicopters that were part of the formation flight were parked at the Avgas pump while the occurrence aircraft was at the Jet A1 pump.

1.1.3 Customs and immigration clearance was carried out at Francistown and the helicopter was refuelled to full tank. A group flight plan for the three helicopters was filed in Francistown using South African forms. At 11:15 hours the three helicopters were given clearance for take-off by Francistown Air Traffic Control. The flights were to be operated in Visual Flight Rules (VFR). They took off within a few seconds of each other and the recorded take off time of all the three helicopters was 11:15 hours. The occurrence helicopter was the last to lift off.

1.1.4 Reportedly, the occurrence helicopter powered up and lifted off and suddenly a gust of wind pushed the tail rotor onto an aluminium refuelling ladder. The rotor blades truck the ladder and disintegrated sending the blades in various directions. The helicopter lost control and started spiralling as it crashed to the ground.

1.1.5 According to available records, the pilot had his conversion to AS350 the week before the accident. However, the log book endorsement showed that the PPL renewal and AS350 endorsement were issued a day before the occurrence.

1.2 Injuries to Persons

INJURIES	CREW	PASSENGERS	OTHERS
FATAL	0	0	0
SERIOUS	0	0	0
MINOR/NONE	2	0	

1.3 Damage to Aircraft

The aircraft was substantially damaged.

1.4 Other Damage

Nil.

1.5 Personnel Information

1.5.1 The pilot was a 60 year old male with a South African nationality. He held a Private Pilot Licence (Helicopter) number 0270191830 issued by the South African Civil Aviation Authority. This licence was issued on 28th November 2006 and was to expire on 25th October 2019. He was also a holder of a General Radiotelephony Licence number 002409424 with a Level 6 English Language Proficiency.

1.5.2 The pilot was qualified with a night rating and class/type rating on Helicopter. He was also rated as pilot in command on Robinson RH22, RH44 and Eurocopter S350. The pilot's licence was revalidated on 30th October 2012 and was to remain valid until 30th November 2013.

1.5.3 The pilot held a class 1 (CPL) aviation medical certificate which was issued on 27th June 2012 and was valid until 31st December 2012. This certificate had limitations which stated that the pilot was a hypertension protocol and that he must wear suitable corrective lenses whenever in command of an aircraft.

1.5.4 According to available records, the pilot had been flying fixed wing piston engine aircraft until August 2006 when he started training on Robinson RH22 helicopters. He was tested on the RH22/RH44 type rating on 26th November 2006 and thereafter continued flying helicopters.

1.5.5 The pilot started training on the occurrence aircraft on 25th October 2012 which lasted up to 30th October 2012. Thereafter he did type conversion after attaining five (5) hours. The occurrence flight on 31st October 2012 was his first flight as pilot in command on the aircraft type.

1.5.6 There was no record indicating that the occurrence pilot had specific technical training to shift from piston engine helicopter to turbine.

1.5.7 The pilot's flying experience is summarised as follows:

	PAST 7 DAYS	PAST 30 DAYS	PAST 90 DAYS	TOTAL
FIXED WING	-	3.00	7.60	UNKWN
ROTORCRAFT	7.20	10.20	12.30	UNKWN
AS350	8.20	8.20	8.20	8.20
TOTAL	7.20	13.20	19.90	1379.78

1.6 Aircraft Information

1.6.1 The Aircraft

1.6.1.1 The AS350 B3 helicopter was manufactured by Eurocopter in France in 2006 under EASA type certificate number R.008 and was assigned with serial number 3259. It was imported into Kenya where it was registered as 5Y-ZUS. It was thereafter imported into South Africa in 2010 and entered into the South African register. It was assigned with registration marks ZS-HDI and issued with a standard Part 127 category Certificate of Airworthiness on 06th September 2010. This certificate was kept valid by following the recommended standard maintenance practices and renewal by the South African Civil Aviation Authority. At the time of the accident the Certificate of Airworthiness was valid until 05th September 2013.

1.6.1.2 Records showed that on 14th August 2012 the helicopter was bought by the SAFDEV SSDC (Pty) Ltd who owned it until the time of the occurrence. After the purchase, it was then taken for major maintenance and stayed in the hangar until 24th October 2012. The helicopter was used to train the occurrence pilot for type conversion which was completed on 30th October 2012.

1.6.1.3 At the time of the occurrence the helicopter had flown a total of 1724.77 hours and 3574 landings.

1.6.2 The Engine

1.6.2.1 The engine was an Arriel 2B which was manufactured in 2001 by Turbomeca in France under EASA type certificate number E.001 and was assigned with serial number 22210. Available records showed that the engine was installed in the helicopter on 22nd November 2008 after accumulation of 4450 hours total time. The engine has since been in this helicopter until the day of the occurrence.

1.6.2.2 At the time of the accident the engine had 5231.21 hrs. since new.

1.6.3 Helicopter Maintenance

1.6.3.1 Eurocopter Southern Africa Ltd (ESAL) was the Aircraft Maintenance Organisation contracted to carry out maintenance on this helicopter. ESAL is a subsidiary company of Eurocopter, the manufacturers of the occurrence helicopter. The company holds a South African CAA Aircraft Maintenance Approval number 177 which was current.

1.6.3.2 Available records indicated that scheduled maintenance work was being carried out on this helicopter by the contracted maintenance organisation.

1.6.3.3 According to available records, a 2 year/600 hr. inspection was carried out on the helicopter by ESAL from 14th August to 24th October 2012 at 1713.56 hours total time since new.

1.6.3.4 The helicopter was issued with a Certificate of Release to Service number 1007 on 24th October 2012 after the scheduled maintenance. This certificate was valid until 1813.56 hours flight time or 24 October 2013, whichever occurred first, unless the aircraft was involved in an accident, in which case the certificate would be invalid for the duration of that period. This certificate also specified that a 6 month inspection was due at 24 April 2013.

1.6.3.5 The European Aviation Safety Agency (EASA) issued an Airworthiness Directive (AD) No. 2010-0006 dated 7th January 2010 to correct an unsafe condition for the Eurocopter model AS350 series helicopters. The subject of this AD was to prevent failure of the T/R control rod, loss of T/R control and subsequent loss of control of the helicopter.

1.6.3.6 The AD was in response to Eurocopter’s Alert Service Bulletin No. 05.00.60 dated 09th December 2009 on the same subject. This was also followed with the US FAA Airworthiness Directive No. 2011-22-05. Compliance of the AD required moving the T/R blade in the flapping axis while monitoring the bearing for movement. The inspection was to be repeated before each flight (FAA AD), after the last flight of the day without exceeding 30 days (Eurocopter ASB) and 30 days (EASA AD). The actions required by this AD can be performed by the owner/operator (pilot) holding at least private pilot licence (PPL) and must be entered in the helicopter maintenance records.

1.6.3.7 Available records did not show if the Airworthiness Directive requirements were being performed within the time intervals. The EASA airworthiness Directive, from the State of design and manufacturing states that the continuing airworthiness of an aircraft shall be ensured by accomplishing any applicable ADs.

1.6.3.8 Further inspection of the T/R pitch change links showed that the ball joints were not excessively worn to the extent of initiating fatigue failure of the web.

1.7 Meteorological Information

1.7.1 The AFTN weather slip showed that the weather at Francistown airport on the day of the occurrence was supplied as follows: METAR FBFT 311100Z 13014KT 999 SCT030 FEW 035TCU 30/14 Q1012. However, the ATC reported that the METAR at the time of the accident was: FBFT 1100Z WIND RWY13 TDZ 110/13kts VRB BTN 080/and 140/end 110/KTS VRB BTN 080/AND 150/VIS 10KM CLD RWY 13 SCT2500 FT DP 13 QNH1012 QFE RWY 13 0897HPA.

1.7.2 Reportedly, the meteorology office later issued a special weather report after the occurrence which was: SPECI 311129Z 12011KT 9999 SCT030 FEW035CB.

1.8 Aids to Navigation

1.8.1 The helicopter was fitted with standard navigation equipment and there was no report of defective equipment prior to the occurrence.

1.9 Communications

1.9.1 The helicopter was in constant communication with the other aircraft which they were flying in formation with. The crew did not report any difficulty in communication between the aircraft and the ATC prior to the occurrence. Communication was not considered as a contributing factor to this occurrence.

1.10 Aerodrome Information

1.10.1 Francistown international airport (FBFT) is located in North-Eastern Botswana with coordinates S 21°09’38”’and E027°28’55”. It has two active asphalt Runways with orientations 31/13 and 29/11 with runway lengths of 3000 meters and 2200 meters respectively. It also has a gravel runway with orientations 16/34 which is rarely used. The airport has an elevation of 1009 meters above sea level.

1.10.2 The airport is owned and operated by the Civil Aviation Authority of Botswana. A fuel bay for both Avgas and Jet A1 fuel pumps is located between the terminal building and the BDF hangars. There is no mobile fuel service at Francistown airport.

Francistown airport (Picture courtesy of Airfields Directory for Southern Africa)

1.11 Flight Recorders

1.11.1 Neither the Flight Data Recorder nor the Cockpit Voice Recorder was fitted in this aircraft, nor were they required by regulations.

1.12 Wreckage and Impact Information

1.12.1 Available information indicated that the helicopter was facing northerly direction as it was lifting off. It became airborne for a short time and climbed to about ten metres but at that moment it lost directional control. It started turning around and descending at the same time until the tail rotor struck the metal step ladder that was stowed vertically adjacent to the fuelling bay. It contacted the ground approximately 12 metres from the fuelling point and came to rest on its right hand side side.

1.12.2 The starboard skid broke in the middle, possibly being the first contact point on ground impact.

The helicopter rolled on its side

1.12.3 The tail rotor blades detached from the helicopter, the first being deposited next to the step ladder and the other approximately 15 metres from the main wreckage. The main rotors struck the ground and were damaged consistent with aircraft under little or no power (See fig below).

The damage to the main rotors suggests low rpm impact

1.12.4 The tail boom detached from the main fuselage at the bulkhead but remained with the main wreckage being held by cables.

The cabin area was not extensively damaged by impact forces

1.13 Medical and Pathological Information

1.13.1 The two occupants were not injured apart from being emotionally shaken by the event. The pilot was not subjected to any toxicological examination.

1.14 Fire

1.14.1 There was no fire.

1.15 Survival Aspects

1.15.1 Investigation at the accident site indicated that the helicopter cabin structure was not deformed by the impact forces. This was mainly due to the fact that the helicopter impacted the ground at low speed with low g-forces.

1.15.2 The pilot reported that both occupants were using their restraint systems during the occurrence, further increasing their survival chances. The harnesses were inspected and found to be functioning properly and their attachments to the aircraft structure were secure.

1.15.3 There were no loose objects or luggage in the cabin that could have injured the occupants. The impact did not release any components or items that could endanger the safety of the occupants.

1.15.4 There was no post impact fire that could endanger the occupants' lives nor were the doors jammed to prevent the occupants from exiting the helicopter.

1.15.5 There was fuel leakage from the helicopter that posed as a fire threat though this did not ignite.

1.15.6 Records showed that the airport rescue fire officials responded instantly and arrived at the scene within a very short time. They assisted in disconnecting the helicopter battery supply to avert any possibility of ignition of the spilling fuel.

1.15.7 The accident was survivable.

1.16 Tests and Research

1.16.1 Engine Investigation

1.16.1.1 The engine was removed from the wreckage and taken to SAFRAN Turbomeca in Johannesburg for a detailed investigation. This company is a subsidiary to the engine manufacturer, Turbomeca.

1.16.1.2 Investigations on the engine revealed that there was no evidence of a pre-accident mechanical failure. Signature marks on splined gears were consistent with those made on a tail rotor strike while engine was producing power.

1.16.1.3 The investigation also determined that the ingestion impact on the axial compressor blades and metal splatter on the engine hot end airflow parts were also consistent with engine operation at impact.

1.16.1.4 During this investigation it was determined that the Digital Electronic Control Unit (DECU) serial number 675 which was fitted to the engine did not have a log card in the engine log book. Nor could it be established where DECU SN 675 originated from. Similarly, the bleed valve SN 3042 which was installed to the engine did not have a log card in the engine log book. Different log cards for the bleed valve and DECU were found in the engine log book.

1.16.1.5 Review of the maintenance records showed that the required periodic inspections for the engine were carried out satisfactorily.

1.16.1.6 SAFRAN Turbomeca recommended that the DECU and Vehicle and Engine Malfunction display (VEMD) unit be sent for down-loading in order to determine the engine condition in the final moments before impact. SAFRAN Turbomeca report is attached to this report as Appendix 1.

1.16.2 DECU and VEMD Investigation

1.16.2.1 The DECU Part Number 70BMB02066 is a digital unit performing fuel regulation and engine condition management and monitoring. It is manufactured by SEXTANT AVIONIQUE for Turbomeca and was assigned with Serial Number 657. The VEMD, Part Number B19030MC02 is a multi-function screen installed on the instrument panel to manage and store vehicle and engine data. It was manufactured by THALES Avionics and assigned with Serial Number 1003.

1.16.2.2 The VEMD and DECU are essentially installed to compliment maintenance work. However, relevant data that is stored can also be used for determining the state of the helicopter and engine in particular at the time of an occurrence. This includes flight reports, failure messages and over-limitation reports.

1.16.2.3 The DECU and VEMD were sent to the Bureau d'Enquêtes et d'Analyses (BEA) in France for specialist investigation and data download to verify the engine condition at the time of impact. During the investigation, BEA worked in consultation with the units' manufacturers for the download and interpretation of the data.

1.16.2.4 Turbomeca facilities were used for the DECU computer readout and data retrieval. The VEMD main boards were powered up using the airframe manufacturer’s test bench with the recorded data being displayed directly on its screen. The DECU and VEMD data were successfully retrieved.

1.16.2.5 The event flight was identified in the recorded data for both computers. The BEA report indicated that the failure messages recorded in the DECU and VEMD are frequently encountered during accident impact phases. The BEA report is attached to this report as Appendix 2 while the Eurocopter VEMD read-out and analysis is attached as Appendix 3.

1.16.3 Tail Rotor Assembly Investigation

1.16.3.1 The tail rotor pitch control rods which were found broken and distorted were removed from the wreckage and taken to Crash Laboratory in Pretoria for a detailed analysis of the failure mode.

1.16.3.2 The investigation revealed that the failed blade pitch control rods and other subsequent damage were as a consequence of the tail rotor impact with a hard object. The detailed report is attached to this report as Appendix 4.

1.16.4 Loss of Tail Rotor Effectiveness (LTE) Research

1.16.4.1 The EASA Safety Information Bulletin EASA SIB No. 2010-12R1 states that Loss of Tail Rotor Effectiveness (LTE) has been determined to be a contributing factor in a number of accidents of various models of helicopters.

1.16.4.2 LTE or unanticipated yaw results from lack of yaw control margin encountered in certain flight conditions is not related to a failure or malfunction. The uncommanded yaw occurs to the right in helicopters with an anti-clockwise rotating main rotor and to the left in helicopters with a clockwise rotating main rotor.

1.16.4.3 To understand the LTE phenomenon it is necessary to understand the function of the anti-torque system. Helicopters manufactured in the USA have a main rotor that rotates **anti-clockwise** viewed from above. Some European and Russian helicopter main rotors rotate **clockwise** viewed from above. The main rotor torque tends to rotate the fuselage in a direction opposite to the rotation of the main rotor. The anti-torque system provides thrust to counteract this rotation and to provide directional control, particularly at low airspeeds.

1.16.4.4 Loss of tail rotor effectiveness (LTE) is a critical, low speed aerodynamic characteristic that can result in an uncommanded rapid yaw rate that does not subside of its own accord and can result in loss of control. LTE may occur in all single main rotor helicopters below 30 KIAS. It is not necessarily a function of control margin deficiency.

1.16.4.5 Helicopters can be subjected to constantly changing wind speed and direction. The tail rotor thrust required is modified by the effect of these wind variations. If an uncommanded right yaw occurs, it may be due to a reduction in the effective tail rotor thrust because of the wind effect. The wind effect can also add to the anti-torque thrust, producing an uncommanded left yaw. Certain relative wind directions are more likely to produce tail rotor thrust variations than others. These relative wind directions or regions form an environment conducive to LTE.

1.16.4.6 Any manoeuvre requiring the pilot to operate in a high-power, low-airspeed environment with a left crosswind or tailwind produces a situation where unanticipated right yaw may occur. There is a greater likelihood of LTE in right turns. Immediate application of additional left pedal is an essential response to an uncommanded right yaw. The pilot may not be able to stop the rotation at low airspeeds. Recovery may be impossible if the reaction is slow or incorrect.

1.16.4.7 Computer simulation has shown that if the pilot delays in reversing the applied pedal position when changing from a left crosswind situation (where a lot of right pedal is required to counteract sideslip) to a downwind situation, control would be lost and the aircraft would rotate rapidly through more than 360° before stopping. The pilot must anticipate these variations in pedal application, concentrate on flying the aircraft, and not allow a yaw rate to develop. Particular caution must be exercised when executing right turns in conditions conducive to LTE.

1.16.4.8 Flight and wind tunnel tests have identified four relative wind azimuth regions and aircraft characteristics that can, singly or in combination, create an environment conducive to LTE and loss of control. One result of these tests is that operating a helicopter at low airspeed dramatically increases the pilot’s workload. These characteristics occur only below 30 knots IAS and apply to all single rotor helicopters. The aircraft characteristics and relative wind azimuth regions are:

(a) Weathercock stability (120 to 240 degrees)
(b) Tail rotor vortex ring state (210 to 330 degrees)
(c) Main rotor disc vortex interference (285 to 315 degrees)

(d) Loss of translational lift (all azimuths)

1.16.4.9 The research on LTE concluded that aircraft can be operated safely in the above relative wind regions if proper attention is given to controlling the aircraft. However, if the pilot is inattentive for some reason and a right yaw rate is initiated in one of the above relative wind regions, the yaw rate may increase unless suitable corrective action is taken.

1.16.4.10 The National Transportation Safety Board on their Safety Recommendation(s) ref. A-84-67 and -68 to the Federal Aviation Administration issued on July 13, 1984 stated that the U.S. Army Safety Centre investigated 21 accidents within 3½ year period involving a single engine helicopter. The Army Safety Centre defined the conditions that lent themselves to the reduction or loss of tail rotor effectiveness and directional control as follows:

(1) The helicopter operated within the limits of approved flight manual and was relatively heavy.
(2) The helicopter was manoeuvring out of ground effect at low airspeed (below translational lift).
(3) Wind speed were 6 knots or greater.
(4) The engine was developing the maximum or near the maximum torque attainable, and main rotor RPM dropped by 2 per cent or more.

The Safety Centre cited insufficient information in the operator's manual and *inadequate pilot transition training* as contributing factors in the accidents.

1.16.4.11 The EASA Safety Information Bulletin likewise introduces a Training Leaflet on Safety Recommendations which is published by the European Helicopter Safety Team (HEST).

1.16.4.12 As a consequent to the above study, the U.S. Army requested that the manufacturer develop a more efficient tail rotor system and a detailed information on loss of tail rotor effectiveness be added to the operator's manual, including corrective actions to be taken by the pilot to alleviate the phenomenon when encountered.

1.17 Organisational and Management Information

1.17.1 Air Traffic Services

1.17.1.1 According to available information the Flight Plan was made with South African forms. In this form three aircraft were identified, with a R44 helicopter registration marks ZS-RPZ bearing the aircraft identifications and the other two

(ZS-HJS and ZS-HDI) identified as flying in formation. This flight plan was submitted and signed by the R44 crew i.e. ZS-RPZ.

1.17.1.2 Since only one flight plan was submitted for the three helicopters, it was not possible to enter all the information required for each aircraft, e.g. number of persons on board, endurance, aircraft identification and emergency equipment.

1.17.1.3 The Francistown ATC officer cleared the three helicopters to take off at the same time. It was reported that they did not take-off simultaneously but rather one after another. The take-off time for the three helicopters was recorded as 11:15 hrs. but this was the time the first helicopter became airborne. The occurrence helicopter, being the last to take-off, was airborne later than the given time. However, this could not have been much longer since the second helicopter was recorded to have landed at 11:16 hrs. which was one minute after the occurrence.

1.18 Additional Information

1.18.1 Wake Turbulence

1.18.1.1 The Wikipedia states that helicopters also produce wake turbulence. Helicopter wakes may be of significantly greater strength than those from a fixed wing aircraft of the same weight. The strongest wake can occur when the helicopter is operating at lower speeds (20 to 50 knots). Some mid-size or executive class helicopters produce wake as strong as that of heavier helicopters. This is because two blade main rotor systems, typical of lighter helicopters, produce stronger wake than rotor systems with more blades.

1.18.1.2 Two R44 helicopters were flying in formation with the occurrence helicopter on the day of the accident.

1.18.1.3 On the fateful flight the occurrence helicopter was the last to depart at Francistown airport. The other two departed from the avgas fuel bay close to each other. The occurrence helicopter was parked in front of the two helicopters and slightly to their left.

1.19 Useful or Effective Investigative Techniques

None.

2. ANALYSIS

2.1 Compliance With Airworthiness Directives

2.1.1 The EASA Airworthiness Directive No. 2010-006 required an inspection to the T/R pitch change links every 30 days. The same inspection was required by the helicopter manufacturer to be carried out after the last flight of the day as detailed in sub section 1.6.3.6 above.

2.1.2 The mandatory inspection called by the manufacturer, the EASA and the FAA was intended to prevent failure of the tail rotor pitch change links, failure of which could result in loss of directional control, the condition which the occurrence pilot encountered.

2.1.3 There was no record in the aircraft log books/flight folio showing that this inspection was being carried out.

2.1.4 The EASA Airworthiness Directive, from the State of design and manufacturing stated that the continuing airworthiness of an aircraft shall be ensured by accomplishing any applicable ADs. Failure to comply with mandatory inspections rendered the helicopter not airworthy.

2.1.5 Non-compliance with the mandatory inspection was a serious omission but was not considered to be a contributory factor for this occurrence.

2.2 Medical and Toxicological Examination

2.2.1 The pilot was not subjected to any medical or toxicological examination after the occurrence as captured in sub section 1.14.1 above.

2.2.2 Regulation 7 (Powers of Accident Investigators) of the Civil Aviation (Aircraft Accident and Incident Investigation) Regulations, 2012 states in part that the accident Investigator-in-Charge shall have power to require the flight crew, passengers and aviation personnel involved in an accident or incident to undergo such other tests including breathalyser test within a reasonable time for the purpose of the investigation.

2.2.3 Accident investigators arrived at the scene of occurrence eight hours after the accident which was not reasonable to order a toxicological examination.

2.2.4 The Directorate of Accident Investigation of Botswana does not have any Memoranda of Agreement with the Civil Aviation Authority of Botswana or Botswana Police that would give them powers to subject a flight crew to a toxicological investigation after an occurrence.

2.2.5 Had there been such agreements the pilot would have been subjected to a toxicological check to rule out intake of drug or alcohol during the flight.

2.2.6 Lack of toxicological examination could not be ruled out as a contributing factor to the occurrence though nor could it be considered as a definitive contributing factor.

2.3 Wake Turbulence

2.3.1 The occurrence helicopter was the last to take-off on a formation flight of three helicopters as stated I sub section 1.1.3 above.

2.3.2 The take-off of the three helicopters was carried out in succession within one minute. The helicopter that preceded the occurrence helicopter was behind it (the occurrence helicopter) and its wake turbulence was directly towards the occurrence helicopter's tail rotor.

2.3.3 The wake turbulence can be avoided by not getting too close to the lead aircraft, not getting below the lead aircraft's flight path and being particularly wary when light wind conditions exist.

2.3.4 The occurrence helicopter was definitely close and below the lead helicopter which was flying at low speed; and the existing wind at that time made the environment conducive for encountering wake turbulence.

2.3.5 The possibility of encountering wake turbulence from the R44 helicopter on the occurrence helicopter could not be ruled out.

2.4 Loss of Tail Rotor Effectiveness

2.4.1 The LTE and loss of directional control is a phenomenon that can occur in all single main rotor helicopters being operated below 30 KIAS as captured in sub section 1.16.4.4 above.

2.4.2 The research indicated that among the conditions for occurrence of LTE and loss of directional control were manoeuvring out of ground effect at low airspeed, wind speed of 6 knots or greater and engine developing maximum or near maximum torque. These conditions are similar to those encountered by the occurrence helicopter.

2.4.3 The EASA Safety Information Bulletin No. 2010-12R recommends that theoretical and flight training of pilots should emphasise the characteristics and function of the anti-torque system. Emphasis should be given to those flight regimes where combinations of various elements (e.g. relative wind vector, yaw rate, etc.) could lead to potential LTE situation. Pilots should be able to recognise the possibility of experiencing LTE, its onset and be prepared to recover.

2.4.4 There was no evidence that the occurrence pilot was aware and equipped with proper training and knowledge on how to deal with LTE and loss of directional control.

2.4.5 The theoretical and flight training should be conducted by approved training organisations and instructors having appropriate experience and knowledge on this phenomenon.

2.4.6 Although the research is not conclusive, the possibility of the LTE and loss of directional control encounter by the occurrence helicopter cannot be ruled out.

2.5 Meteorological Factors

2.5.1 The weather forecast at the time of the accident was strong wind (14kt) from the South-easterly direction as captured in sub section 1.7.1 above. This was consistent with the witness report of Easterly wind of 10/15 knots.

2.5.2 The strong south-easterly wind (130°) is consistent with the relative wind velocity and wind azimuth region (Weathercock stability). Although the helicopter can be operated safely in this region, proper plot attention is required to control it. If the pilot was inattentive and a right yaw rate is initiated, the yaw rate may increase if suitable corrective action is not taken.

2.5.3 The weather prevailing at the time of the occurrence could have contributed to the circumstances of this accident.

2.6 Conversion From Piston to Turbine Engine Helicopter

2.6.1 Available records indicated that the conversion training was carried out a week before the occurrence flight and the occurrence flight was the pilot's first flight after type conversion as captured in sub section 1.5.5 above.

2.6.2 While the type conversion may have been carried out in accordance with the existing national regulations, it was evident that the pilot did not have sufficient experience of flying turbine engine helicopter and the associated handling characteristics.

2.7 The Pilot's Proficiency

2.7.1 The pilot had completed his type conversion training the day before the flight as detailed in sub section 1.6 above. This training was for five hours as required by the local and international regulations.

2.7.2 During the type conversion the pilot had not conducted any solo flight on the aircraft. The occurrence flight was his first solo flight on this type of helicopter. It was possible therefore that although the pilot had demonstrated competency during training and the final test, he had not got the confidence on handling the aircraft when he was the pilot in command, especially during a flight on trying conditions as the occurrence flight.

2.7.3 The pilot's lack of experience was considered as a factor to the circumstances of this occurrence.

3. CONCLUSIONS

3.1 Findings

3.1.1 The helicopter was registered in the Republic of South Africa with a valid Certificate of Registration.

3.1.2 The helicopter was issued with a valid Certificate of Airworthiness in Private Category in accordance with existing regulations.

3.1.3 The maintenance records indicated that the helicopter was maintained in accordance with the approved procedures.

3.1.4 The records also indicated that the HELICOPTER was undergoing major maintenance for the past three months preceding the occurrence.

3.1.5 The helicopter was on its first operational flight on the day of occurrence after undergoing major maintenance.

3.1.6 Examination of the engine did not reveal any evidence of defects suggesting that the engine was not capable to produce the designated power at the time of the occurrence.

3.1.7 Examination of the tail rotor transmission assembly did not reveal any evidence of pre-existing fractures/failure.

3.1.8 The tail rotor blades pith control rods failure was consistent with the tail rotor impacting with a hard object while under engine power.

3.1.9 Examination of the DECU and VEMD did not show any recorded fault existing prior to the occurrence.

3.1.10 The repetitive EASA mandatory Airworthiness Directive No. 2010-006 was not carried out on the required frequency.

3.1.11 The helicopter was on a formation flight with two R44 helicopters on the occurrence flight.

3.1.12 One flight plan was filed at Francistown airport for the three helicopters on the occurrence flight.

3.1.13 There was an easterly strong wind at the time of the occurrence.

3.1.14 The existing conditions at the time of occurrence were conducive to the phenomenon of Loss of Tail Rotor Effectiveness (LTE) and loss of directional control.

3.1.15 The existing environment at the time of occurrence was conducive for encountering wake turbulence.

3.1.16 The helicopter was airborne briefly before losing directional control and crashing at the fuel bay.

3.1.17 The fire rescue services reacted instantly and were at the crash site immediately after the occurrence.

3.1.18 There was no fire.

3.1.19 The helicopter was substantially damaged.

3.1.20 There were no injuries to the pilot and passenger.

3.1.21 The pilot was not subjected to any medical or toxicological examination.

3.1.22 The pilot was a holder of a South African Private Pilot Licence and a valid medical certificate.

3.1.23 The pilot was qualified for the intended flight under the existing regulations.

3.1.24 The pilot was on his first operational flight after type rating endorsement in his log book.

3.1.25 The pilot had no previous experience on turbine engine helicopter.

3.1.26 The aerodrome was properly licensed under the existing regulations.

3.2 Probable Causes of the Accident

3.2.1 Pilot’s lack of sufficient experience on the helicopter.

3.2.2 The possibility of existing conditions that could lead to Lack of Tail Rotor effectiveness (LTE) and loss of directional control.

3.2.3 Possibility of encountering wake turbulence from the R44 helicopters that were taking-off before the occurrence aircraft.

3.3 Other Contributing Factors

3.3.1 The existing easterly wind at the time of the occurrence.

3.3.2 Insufficient training for conversion from piston to turbine engine helicopter.

4. SAFETY RECOMMENDATIONS

4.1.1 The local regulatory authority to require private pilot licence holders receive adequate training for conversion, particularly when transiting from piston to turbine engine aircraft.

4.1.2 The regulatory authority to ensure that pilots are trained for avoidance of LTE and wake turbulence.

4.1.3 The aircraft manufacturer to ensure that the pilot’s operating handbook has procedures on how to deal with LTE and wake turbulence.

APPENDIX 1

SAFRAN
Turbomeca

INVESTIGATION REPORT	Preliminary ☐ Final ☒

Accident ☒ Incident ☐

Reference	T13-FR0445E-1	Commercial File	-
Accident report	2012 / 293	Preliminary Information report A(I)	-

Data

Date of occurrence	Occurrence place	Operator
October 31, 2012	Botswana	SAFDEV SSDC (PTY) LTD

Aircraft type	S/N	Registration
AS350B3	3259	ZS-HDI

Engine type	S/N	TSN	TSO
ARRIEL 2B	22210	5231	-

Accessories

Designation, P/N	S/N	Work performed	TSN	TSO
DECU	657	Dump	nc	nc

Circumstances reported to TURBOMECA

The aircraft crashed to the ground for reasons as yet unknown.

Conclusion

The DECU was found in good condition and a data download was possible.

No fuel control system discrepancy message was recorded in the "failure" message block recorded during the accident flight. The discrepancies found in this block were all the consequence of the crash sequence.

VALIDATION		APPROVAL	
DATE		DATE	
July 4th 2013	Validated by DVOTEA	4th of July, 2013	Approved by DJO/TEA

SUMMARY

1 HISTORY

1.1 TECHNICAL DOCUMENTATION

Remarks:

The DECU had no log card. Its P/N 70BMB02066 does not exist; “2066” was manually engraved (probably during the embodiment of SB 292732066).
Thales P/N is C12380GA02 associated with the date 06/99.

P/N manually engraved

1.2 DECU EXAMINATION

1.2.1 Findings on arrival

The DECU was brought by a BEA representative in a box without any caps on the connectors.
BEA representative informed us that they had performed visual inspection of the boards: no discrepancy was detected.

DECU in its box

External condition: good

1.2.2 Electrical tests

Before powering up the DECU, electrical checks were carried out; the results were compliant with the specifications (see "tests results").

The electrical connectors were in good condition

1.2.3 Dump

Note: the DECU is not a “black box”-type data recorder as available on airliners. Data are recorded for maintenance purposes and only when the DECU detects a discrepancy (named “panne” in the Dump).

DECU S/N 657 was connected to tool Ref TL0248G017 and its dump performed; 32 “failure” message blocks were recorded.

DECU connected to the dump tool

1.2.4 Dump Analysis

The “failure” message blocks are numbered from the oldest (number 32) to the most recent one (number 1). They are associated to powering-ups 10777 to 12786.

In relation to the flight sequence (crash occurring during take off) and with the flight time issued from the VEMD (5mn 1 sec), we could determine that **block 3 at powering-up 12784 was recorded during the accident**.

Block 3 at powering-up 12784 was recorded at diagnostic time 418 seconds i.e. 6 minutes and 58 seconds (diagnostic time is the time between the powering-up and the block recording time).

Blocks 2 and 1 at respective powering-ups 12785 and 12786 were recorded at a diagnostic time of 7 seconds. These blocks were either recorded:

- during the crash, probably due to micro cut-out which could have occurred on the DECU supply unit, or
- during powering-up carried out after the accident (with the discrepancy message still on).

The following messages were recorded:

In Block 3 at 6 minutes and 58 seconds after powering up:

T1 measurement / OSS; T1 Sensor

This message indicates that the helicopter T0 (ambient temperature) measurement has reached an out-of-limit value (min, max or gradient). The control system then triggers an amber “GOV” signal that indicates a “degraded” automatic operation of the control system.
“OSS” means that the discrepancy is detected by the operating system.
“T1 sensor” indicates that the discrepancy is located at the sensor level.
The control system remains in automatic mode.

Raw torque measurement/ AS; DECU

This message indicates that the torque value measurement reached an out-of-limit value (min, max or gradient). The control system then triggers an amber “GOV” signal that indicates a “degraded” automatic operation of the control system.

“AS” means that the discrepancy is detected by the applicative system.
“DECU” means that the discrepancy is localized in the DECU.

Collective pitch measurement / AS; DECU

This message indicates that the collective pitch measurement (= XPC) has reached an out-of-limit value (mini, maxi or gradient). The control system then triggers an amber “GOV” signal that indicates a “degraded” automatic operation of the control system which takes a back-up law for the collective pitch values.
The control system remains in automatic mode.

“AS” means that the discrepancy is detected by the applicative system.

“DECU” or “collective pitch potentiometer”: when there is only a “collective pitch measurement” message detected, the DECU gives the information “Collective pitch potentiometer”. When there are several messages detected with the “collective pitch measurement”, then the DECU gives the information “DECU”. This is an arbitral choice which does not always match the reality.

In Blocks 2 and 1 at 7 seconds after powering up:

Collective pitch measurement / AS; Collective pitch potentiometer

See above (Collective pitch measurement / AS; DECU).

.

2 ANALYSIS

The dump analysis has shown that the discrepancies recorded in the accident flight had no operational effect on the fuel control system. One of the first discrepancy codes recorded was linked to the collective pitch signal. From our experience this discrepancy is frequently encountered during accidents at the impact phase.

3 TEST RESULTS

Electrical checks
Dump

PN 70B7B0xxxx 2066

SN 657

Procédure de test d'isolement des calculateurs Fadec B avant mise sous tension.

But :

S'assurer de l'absence de court circuit sur les entrées / sorties des ressources liées aux faisceaux hélicoptère (J202 et J204) avant début de l'expertise.

Moyens d'essais :

- deux boîtes de coupure J202 et J204
- multimètre de table
- cordons de test

Tests :

Contrôle de l'alimentation 28V voie A:

Après branchement des boîtes de coupure au calculateur, vérifier :

Connecteurs		Impédance théorique	Impédance mesurée
J2-55 (commun de la mesure)	J2-54 (point chaud de la mesure)	>100Ω	OK

Contrôle de l'alimentation 28V voie B:

Connecteurs		Impédance théorique	Impédance mesurée
J4-62 (commun de la mesure)	J4-63 (point chaud de la mesure)	>100Ω	OK

Contrôle de l'alimentation 28Vvoyant voie B:

Connecteurs		Impédance théorique	Impédance mesurée
J4-3 (commun de la mesure)	J4-2 (point chaud de la mesure)	>100Ω	OK

Contrôle de l'alimentation 28V survitesse:

Connecteurs		Impédance théorique	Impédance mesurée
J4-58 (commun de la mesure)	J4-51 (point chaud de la mesure)	>100Ω	OK

Commande de puissance :

Connecteurs		Impédance théorique	Impédance mesurée
J4-24	J4-63	>1MOhm	∞
J4-24	J4-62	>1MOhm	∞

Sorties commandes de voyants:

Connecteurs		Impédance théorique	Impédance mesurée
J4-5	J4-3	>1MOhm	∞
J4-7	J4-3	>1MOhm	∞
J4-11	J4-3	>1MOhm	∞
J4-12	J4-3	>1MOhm	∞
J4-14	J4-3	>1MOhm	∞
J4-15	J4-3	>1MOhm	∞
J4-20	J4-3	>1MOhm	∞
J4-23	J4-3	>1MOhm	∞
J4-32	J4-3	>1MOhm	∞
J4-40	J4-3	>1MOhm	∞
J4-41	J4-3	>1MOhm	∞
J4-5	J4-2	>1MOhm	∞
J4-7	J4-2	>1MOhm	∞
J4-11	J4-2	>1MOhm	∞
J4-12	J4-2	>1MOhm	∞
J4-14	J4-2	>1MOhm	∞
J4-15	J4-2	>1MOhm	∞
J4-20	J4-2	>1MOhm	∞
J4-23	J4-2	>1MOhm	∞
J4-32	J4-2	>1MOhm	∞
J4-40	J4-2	>1MOhm	∞
J4-41	J4-2	>1MOhm	∞

Evénements techniques - ARINC 429 - TL0248G107

Ack/Status OK　　Réception : Bonne　　

Traitement

Désignation	Unité	Valeur
Diagnostic time	s	7
Block number		1
Power up number		12786
Fault over flow		0

Panne - Identification;Localisation;
Panne 1 - Collective pitch measurement / AS;Collective pitch potentiometer;
Panne 2 - No failure ;No failure;
Panne 3 - No failure ;No failure;
Panne 4 - No failure ;No failure;
Panne 5 - No failure ;No failure;
Panne 6 - No failure ;No failure;
Panne 7 - No failure ;No failure;
Panne 8 - No failure ;No failure;

Traitement

Désignation	Unité	Valeur
Diagnostic time	s	7
Block number		2
Power up number		12785
Fault over flow		0

Panne - Identification;Localisation;
Panne 1 - Collective pitch measurement / AS;Collective pitch potentiometer;
Panne 2 - No failure ;No failure;
Panne 3 - No failure ;No failure;
Panne 4 - No failure ;No failure;
Panne 5 - No failure ;No failure;
Panne 6 - No failure ;No failure;
Panne 7 - No failure ;No failure;
Panne 8 - No failure ;No failure;

Evénements techniques - ARINC 429 - TL0248G107

Traitement

Désignation	Unité	Valeur
Diagnostic time	s	418
Block number		3
Power up number		12784
Fault over flow		0

Panne - Identification;Localisation;
Panne 1 - T1 measurement / OSS;T1 Sensor;
Panne 2 - Raw torque measurement / AS;DECU;
Panne 3 - Collective pitch measurement / AS;DECU;
Panne 4 - No failure ;No failure;
Panne 5 - No failure ;No failure;
Panne 6 - No failure ;No failure;
Panne 7 - No failure ;No failure;
Panne 8 - No failure ;No failure;

Traitement

Désignation	Unité	Valeur
Diagnostic time	s	450
Block number		4
Power up number		12572
Fault over flow		0

Panne - Identification;Localisation;
Panne 1 - FMU resolver measurement / AS;DECU;
Panne 2 - No failure ;No failure;
Panne 3 - No failure ;No failure;
Panne 4 - No failure ;No failure;
Panne 5 - No failure ;No failure;
Panne 6 - No failure ;No failure;
Panne 7 - No failure ;No failure;
Panne 8 - No failure ;No failure;

Traitement

Désignation	Unité	Valeur
Diagnostic time	s	5
Block number		5
Power up number		12523
Fault over flow		0

Panne - Identification;Localisation;
Panne 1 - T1 measurement / OSS;T1 Sensor;
Panne 2 - Collective pitch measurement / AS;Collective pitch potentiometer;
Panne 3 - No failure ;No failure;
Panne 4 - No failure ;No failure;
Panne 5 - No failure ;No failure;
Panne 6 - No failure ;No failure;
Panne 7 - No failure ;No failure;
Panne 8 - No failure ;No failure;

Traitement

Désignation	Unité	Valeur
Diagnostic time	s	7
Block number		6
Power up number		12488
Fault over flow		1

Panne - Identification;Localisation;
Panne 1 - T4 Measurement / AS;T4 Sensor;
Panne 2 - P3 Measurement / AS;P3 Sensor;
Panne 3 - Raw torque measurement / AS;Torque sensor;
Panne 4 - T4 Slope measurement / AS;T4 slope resistance;
Panne 5 - Torque slope measurement / AS;Torque slope resistance;
Panne 6 - FMU resolver measurement / AS;DECU;
Panne 7 - E/L PVD / AS;DECU;
Panne 8 - N2 measurement sensor1 / AS;N2 sensor 1;

Evénements techniques - ARINC 429 - TL0248G107

Traitement

Désignation	Unité	Valeur
Diagnostic time	s	7
Block number		7
Power up number		12487
Fault over flow		0

Panne - Identification;Localisation;
Panne 1 - T4 Measurement / AS;T4 Sensor;
Panne 2 - P3 Measurement / AS;P3 Sensor;
Panne 3 - Raw torque measurement / AS;Torque sensor;
Panne 4 - T4 Slope measurement / AS;T4 slope resistance;
Panne 5 - Torque slope measurement / AS;Torque slope resistance;
Panne 6 - FMU resolver measurement / AS;DECU;
Panne 7 - E/L PVD / AS;DECU;
Panne 8 - N2 measurement sensor1 / AS;N2 sensor 1;

Traitement

Désignation	Unité	Valeur
Diagnostic time	s	7
Block number		8
Power up number		12486
Fault over flow		0

Panne - Identification;Localisation;
Panne 1 - T4 Measurement / AS;T4 Sensor;
Panne 2 - P3 Measurement / AS;P3 Sensor;
Panne 3 - Raw torque measurement / AS;Torque sensor;
Panne 4 - T4 Slope measurement / AS;T4 slope resistance;
Panne 5 - Torque slope measurement / AS;Torque slope resistance;
Panne 6 - FMU resolver measurement / AS;DECU;
Panne 7 - E/L PVD / AS;DECU;
Panne 8 - N2 measurement sensor1 / AS;N2 sensor 1;

Traitement

Désignation	Unité	Valeur
Diagnostic time	s	7
Block number		9
Power up number		12485
Fault over flow		0

Panne - Identification;Localisation;
Panne 1 - T4 Measurement / AS;T4 Sensor;
Panne 2 - P3 Measurement / AS;P3 Sensor;
Panne 3 - Raw torque measurement / AS;Torque sensor;
Panne 4 - T4 Slope measurement / AS;T4 slope resistance;
Panne 5 - Torque slope measurement / AS;Torque slope resistance;
Panne 6 - FMU resolver measurement / AS;DECU;
Panne 7 - E/L PVD / AS;DECU;
Panne 8 - N2 measurement sensor1 / AS;N2 sensor 1;

Evénements techniques - ARINC 429 - TL0248G107

Ack/Status OK   Réception : Bonne

Traitement

Désignation	Unité	Valeur
Diagnostic time	s	110
Block number		10
Power up number		11637
Fault over flow		0

Panne - Identification;Localisation;
Panne 1 - T1 measurement / OSS;T1 Sensor;
Panne 2 - E/L PVD / AS;DECU;
Panne 3 - No failure ;No failure;
Panne 4 - No failure ;No failure;
Panne 5 - No failure ;No failure;
Panne 6 - No failure ;No failure;
Panne 7 - No failure ;No failure;
Panne 8 - No failure ;No failure;

Traitement

Désignation	Unité	Valeur
Diagnostic time	s	310
Block number		11
Power up number		11635
Fault over flow		0

Panne - Identification;Localisation;
Panne 1 - T1 measurement / OSS;T1 Sensor;
Panne 2 - E/L PVD / AS;DECU;
Panne 3 - No failure ;No failure;
Panne 4 - No failure ;No failure;
Panne 5 - No failure ;No failure;
Panne 6 - No failure ;No failure;
Panne 7 - No failure ;No failure;
Panne 8 - No failure ;No failure;

Traitement

Désignation	Unité	Valeur
Diagnostic time	s	322
Block number		12
Power up number		11631
Fault over flow		0

Panne - Identification;Localisation;
Panne 1 - T1 measurement / OSS;T1 Sensor;
Panne 2 - E/L PVD / AS;DECU;
Panne 3 - No failure ;No failure;
Panne 4 - No failure ;No failure;
Panne 5 - No failure ;No failure;
Panne 6 - No failure ;No failure;
Panne 7 - No failure ;No failure;
Panne 8 - No failure ;No failure;

Traitement

Désignation	Unité	Valeur
Diagnostic time	s	146
Block number		13
Power up number		11625
Fault over flow		0

Panne - Identification;Localisation;
Panne 1 - T1 measurement / OSS;T1 Sensor;
Panne 2 - E/L PVD / AS;DECU;
Panne 3 - No failure ;No failure;
Panne 4 - No failure ;No failure;
Panne 5 - No failure ;No failure;
Panne 6 - No failure ;No failure;
Panne 7 - No failure ;No failure;
Panne 8 - No failure ;No failure;

Evénements techniques - ARINC 429 - TL0248G107

Traitement

Désignation	Unité	Valeur
Diagnostic time	s	3950
Block number		14
Power up number		11616
Fault over flow		0

Panne - Identification;Localisation;
Panne 1 - T1 measurement / OSS;T1 Sensor;
Panne 2 - E/L PVD / AS;DECU;
Panne 3 - No failure ;No failure;
Panne 4 - No failure ;No failure;
Panne 5 - No failure ;No failure;
Panne 6 - No failure ;No failure;
Panne 7 - No failure ;No failure;
Panne 8 - No failure ;No failure;

Traitement

Désignation	Unité	Valeur
Diagnostic time	s	5191
Block number		15
Power up number		11604
Fault over flow		0

Panne - Identification;Localisation;
Panne 1 - T1 measurement / OSS;T1 Sensor;
Panne 2 - E/L PVD / AS;DECU;
Panne 3 - No failure ;No failure;
Panne 4 - No failure ;No failure;
Panne 5 - No failure ;No failure;
Panne 6 - No failure ;No failure;
Panne 7 - No failure ;No failure;
Panne 8 - No failure ;No failure;

Traitement

Désignation	Unité	Valeur
Diagnostic time	s	52
Block number		16
Power up number		11497
Fault over flow		0

Panne - Identification;Localisation;
Panne 1 - T1 measurement / OSS;T1 Sensor;
Panne 2 - N2 measurement sensor 2 / AS;N2 sensor 2;
Panne 3 - No failure ;No failure;
Panne 4 - No failure ;No failure;
Panne 5 - No failure ;No failure;
Panne 6 - No failure ;No failure;
Panne 7 - No failure ;No failure;
Panne 8 - No failure ;No failure;

Traitement

Désignation	Unité	Valeur
Diagnostic time	s	5
Block number		17
Power up number		11461
Fault over flow		0

Panne - Identification;Localisation;
Panne 1 - T1 measurement / OSS;T1 Sensor;
Panne 2 - N2 measurement sensor 2 / AS;N2 sensor 2;
Panne 3 - No failure ;No failure;
Panne 4 - No failure ;No failure;
Panne 5 - No failure ;No failure;
Panne 6 - No failure ;No failure;
Panne 7 - No failure ;No failure;
Panne 8 - No failure ;No failure;

Traitement

Désignation	Unité	Valeur
Diagnostic time	s	46
Block number		18
Power up number		11426
Fault over flow		0

Panne - Identification;Localisation;
Panne 1 - T1 measurement / OSS;T1 Sensor;
Panne 2 - N2 measurement sensor 2 / AS;DECU;
Panne 3 - No failure ;No failure;
Panne 4 - No failure ;No failure;
Panne 5 - No failure ;No failure;
Panne 6 - No failure ;No failure;
Panne 7 - No failure ;No failure;
Panne 8 - No failure ;No failure;

Evénements techniques - ARINC 429 - TL0248G107

Traitement

Désignation	Unité	Valeur
Diagnostic time	s	7
Block number		19
Power up number		11282
Fault over flow		0

Panne - Identification;Localisation;
Panne 1 - T4 Measurement / AS;T4 Sensor;
Panne 2 - P3 Measurement / AS;P3 Sensor;
Panne 3 - Raw torque measurement / AS;Torque sensor;
Panne 4 - T4 Slope measurement / AS;T4 slope resistance;
Panne 5 - Torque slope measurement / AS;Torque slope resistance;
Panne 6 - FMU resolver measurement / AS;DECU;
Panne 7 - E/L PVD / AS;DECU;
Panne 8 - N2 measurement sensor1 / AS;N2 sensor 1;

Ack/Status OK Réception : Bonne

Traitement

Désignation	Unité	Valeur
Diagnostic time	s	7
Block number		20
Power up number		11281
Fault over flow		0

Panne - Identification;Localisation;
Panne 1 - T4 Measurement / AS;T4 Sensor;
Panne 2 - P3 Measurement / AS;P3 Sensor;
Panne 3 - Raw torque measurement / AS;Torque sensor;
Panne 4 - T4 Slope measurement / AS;T4 slope resistance;
Panne 5 - Torque slope measurement / AS;Torque slope resistance;
Panne 6 - FMU resolver measurement / AS;DECU;
Panne 7 - E/L PVD / AS;DECU;
Panne 8 - N2 measurement sensor1 / AS;N2 sensor 1;

Evénements techniques - ARINC 429 - TL0248G107

Traitement

Désignation	Unité	Valeur
Diagnostic time	s	5
Block number		21
Power up number		11262
Fault over flow		0

Panne - Identification;Localisation;
Panne 1 - T1 measurement / OSS;T1 Sensor;
Panne 2 - N2 measurement sensor 2 / AS;N2 sensor 2;
Panne 3 - No failure ;No failure;
Panne 4 - No failure ;No failure;
Panne 5 - No failure ;No failure;
Panne 6 - No failure ;No failure;
Panne 7 - No failure ;No failure;
Panne 8 - No failure ;No failure;

Evénements techniques - ARINC 429 - TL0248G107

Traitement

Désignation	Unité	Valeur
Diagnostic time	s	961
Block number		22
Power up number		10874
Fault over flow		0

Panne - Identification;Localisation;
Panne 1 - Aircraft 28V / OSS;DECU;
Panne 2 - Helicopter ARINC / AS;DECU;
Panne 3 - No failure ;No failure;
Panne 4 - No failure ;No failure;
Panne 5 - No failure ;No failure;
Panne 6 - No failure ;No failure;
Panne 7 - No failure ;No failure;
Panne 8 - No failure ;No failure;

Traitement

Désignation	Unité	Valeur
Diagnostic time	s	954
Block number		23
Power up number		10874
Fault over flow		0

Panne - Identification;Localisation;
Panne 1 - Aircraft 28V / OSS;DECU;
Panne 2 - Helicopter ARINC / AS;DECU;
Panne 3 - T1 measurement / OSS;T1 Sensor;
Panne 4 - Alternator power input / AS;DECU;
Panne 5 - No failure ;No failure;
Panne 6 - No failure ;No failure;
Panne 7 - No failure ;No failure;
Panne 8 - No failure ;No failure;

Traitement

Désignation	Unité	Valeur
Diagnostic time	s	3407
Block number		24
Power up number		10873
Fault over flow		0

Panne - Identification;Localisation;
Panne 1 - Aircraft 28V / OSS;DECU;
Panne 2 - Helicopter ARINC / AS;DECU;
Panne 3 - No failure ;No failure;
Panne 4 - No failure ;No failure;
Panne 5 - No failure ;No failure;
Panne 6 - No failure ;No failure;
Panne 7 - No failure ;No failure;
Panne 8 - No failure ;No failure;

Evénements techniques - ARINC 429 - TL0248G107

Traitement

Désignation	Unité	Valeur
Diagnostic time	s	3386
Block number		25
Power up number		10873
Fault over flow		0

Panne - Identification;Localisation;
Panne 1 - Aircraft 28V / OSS;DECU;
Panne 2 - Helicopter ARINC / AS;DECU;
Panne 3 - T1 measurement / OSS;T1 Sensor;
Panne 4 - E/L EMAN / OSS;DECU;
Panne 5 - Alternator power input / AS;DECU;
Panne 6 - No failure ;No failure;
Panne 7 - No failure ;No failure;
Panne 8 - No failure ;No failure;

Ack/Status OK   Réception : Bonne

Traitement

Désignation	Unité	Valeur
Diagnostic time	s	121
Block number		26
Power up number		10787
Fault over flow		0

Panne - Identification;Localisation;
Panne 1 - T1 measurement / OSS;T1 Sensor;
Panne 2 - P3 Measurement / AS;DECU;
Panne 3 - No failure ;No failure;
Panne 4 - No failure ;No failure;
Panne 5 - No failure ;No failure;
Panne 6 - No failure ;No failure;
Panne 7 - No failure ;No failure;
Panne 8 - No failure ;No failure;

Traitement

Désignation	Unité	Valeur
Diagnostic time	s	5
Block number		27
Power up number		10786
Fault over flow		0

Panne - Identification;Localisation;
Panne 1 - T1 measurement / OSS;T1 Sensor;
Panne 2 - P3 Measurement / AS;P3 Sensor;
Panne 3 - No failure ;No failure;
Panne 4 - No failure ;No failure;
Panne 5 - No failure ;No failure;
Panne 6 - No failure ;No failure;
Panne 7 - No failure ;No failure;
Panne 8 - No failure ;No failure;

Evénements techniques - ARINC 429 - TL0248G107

Traitement

Désignation	Unité	Valeur
Diagnostic time	s	5
Block number		28
Power up number		10785
Fault over flow		0

Panne - Identification;Localisation;
Panne 1 - T1 measurement / OSS;T1 Sensor;
Panne 2 - P3 Measurement / AS;P3 Sensor;
Panne 3 - No failure ;No failure;
Panne 4 - No failure ;No failure;
Panne 5 - No failure ;No failure;
Panne 6 - No failure ;No failure;
Panne 7 - No failure ;No failure;
Panne 8 - No failure ;No failure;

Evénements techniques - ARINC 429 - TL0248G107

Traitement

Désignation	Unité	Valeur
Diagnostic time	s	5
Block number		29
Power up number		10782
Fault over flow		0

Panne - Identification;Localisation;
Panne 1 - T1 measurement / OSS;T1 Sensor;
Panne 2 - P3 Measurement / AS;P3 Sensor;
Panne 3 - No failure ;No failure;
Panne 4 - No failure ;No failure;
Panne 5 - No failure ;No failure;
Panne 6 - No failure ;No failure;
Panne 7 - No failure ;No failure;
Panne 8 - No failure ;No failure;

Traitement

Désignation	Unité	Valeur
Diagnostic time	s	5
Block number		30
Power up number		10779
Fault over flow		0

Panne - Identification;Localisation;
Panne 1 - T1 measurement / OSS;T1 Sensor;
Panne 2 - T4 Slope measurement / AS;T4 slope resistance;
Panne 3 - No failure ;No failure;
Panne 4 - No failure ;No failure;
Panne 5 - No failure ;No failure;
Panne 6 - No failure ;No failure;
Panne 7 - No failure ;No failure;
Panne 8 - No failure ;No failure;

Evénements techniques - ARINC 429 - TL0248G107

Traitement

Désignation	Unité	Valeur
Diagnostic time	s	5
Block number		31
Power up number		10778
Fault over flow		0

Panne - Identification;Localisation;
Panne 1 - T1 measurement / OSS;T1 Sensor;
Panne 2 - N1 measurement sensor / AS;N1 sensor;
Panne 3 - No failure ;No failure;
Panne 4 - No failure ;No failure;
Panne 5 - No failure ;No failure;
Panne 6 - No failure ;No failure;
Panne 7 - No failure ;No failure;
Panne 8 - No failure ;No failure;

Traitement

Désignation	Unité	Valeur
Diagnostic time	s	5
Block number		32
Power up number		10777
Fault over flow		0

Panne - Identification;Localisation;
Panne 1 - T1 measurement / OSS;T1 Sensor;
Panne 2 - T4 Measurement / AS;T4 Sensor;
Panne 3 - No failure ;No failure;
Panne 4 - No failure ;No failure;
Panne 5 - No failure ;No failure;
Panne 6 - No failure ;No failure;
Panne 7 - No failure ;No failure;
Panne 8 - No failure ;No failure;

APPENDIX 2

Technical document

Computer examination

Document ID: **BEA_zs-i121031_tec01**
Date of occurrence: 31/10/2012
Place of occurrence: AD Francistown (Botswana)
Aircraft type: AS 350 B3
Registration number: **ZS-HDI**
Equipments examined:

Thales Sextant DECU P/N : 70BMB02066 S/N : 657	**Thales Sextant VEMD** P/N : B19030MC02 S/N : 1003
	

Note: These avionics computers are not flight data recorders as may be installed on some aircraft. Data are only recorded for maintenance purposes.

The DECU is a single channel digital control unit performing fuel regulation, engine parameter management and failure recording. On each channel (or module), an internal 32 kBytes EEPROM stores failure blocks.

The VEMD is a multifunction screen installed on the instrument panel and designed to manage essential and non-essential vehicle and engine data. The VEMD is a dual channel system. In each channel (or module), an internal 32 kBytes EEPROM stores failure information and data.
The relevant VEMD data for accident investigations are:
• Flight reports
• Failure messages with associated dated parameters
• Overlimitation reports - Overlimitations are not dated

Work performed:

- **DECU**

External and internal visual inspections were performed at BEA. The computer was in good condition. Turbomeca P/N 70BMB02066 does not correspond to any standard DECU reference. “2066” was manually engraved (probably during the embodiment of the SB 0292732066). The purpose of this SB is to increase tolerance to pitch loss during strong accelerations.
Thales P/N is C12380GA02 associated with the date code 06/99.

P/N manually engraved

The two boards were visually inspected and were in good condition. The results of insulation tests performed at Turbomeca facilities were in accordance with the manufacturer documentation. The computer was read out on the dedicated Turbomeca test bench. Data were successfully retrieved.

- **VEMD**

The VEMD was in good condition. Two main internal boards were visually inspected under magnification. Both boards were in good condition. The avionics computer was powered up on the Eurocopter test bench. All the data recorded by the VEMD were directly displayed on its screens in accordance with the BEA/Eurocopter procedure. Data were successfully retrieved.

Results:

- **DECU**

The most recent failure blocks were numbered 1, 2 and 3 and were respectively associated to the powering-ups 12786, 12785 and 12784. Those were relevant regarding the event.

The blocks 1 and 2 (respectively powering-ups 12786 and 12785) were both recorded 7 seconds after the power-up of the DECU. These blocks were either recorded:

- during the accident, probably due to micro cut-out which could have occurred on the DECU supply unit, or
- during powering-up carried out after the accident (with the discrepancy message still on).

The block 3 (powering-up 12784) was recorded 418 seconds (i.e.6 minutes and 58 seconds) after the power-up of the DECU.

The following messages were recorded:

➢ **In block 3, at 6 min 58 s:**

✓ ***T1 measurement / OSS; T1 Sensor***

This message indicates that the helicopter T0 (= T1) (ambient temperature) measurement has reached an out-of-limit value (min, max or gradient). The control system then triggers an amber “GOV” signal that indicates a “degraded” automatic operation of the control system.
“OSS” means that the discrepancy is detected by the Operating system.
“T1 sensor” indicates that the discrepancy is located at the sensor level.
The control system remains in automatic mode.

✓ ***Raw torque measurement/ AS; DECU***

This message indicates that the torque value measurement has reached an out-of-limit value (min, max or gradient). In this case, the control system triggers an amber "GOV" signal that indicates a "degraded" automatic operation of the control system.
"AS" means that the discrepancy is detected by the Applicative System.
"DECU" means that the discrepancy is localized at the DECU level.

✓ ***Collective pitch measurement / AS; DECU***

This message indicates that the collective pitch measurement (= XPC) has reached an out-of-limit value (mini, maxi or gradient). In this case, the control system triggers an amber "GOV" signal that indicates a "degraded" automatic operation of the control system which takes a back-up law for the collective pitch values.
The control system remains in automatic mode.

➢ **In Blocks 1 and 2, seven seconds after powering up:**

✓ **Collective pitch measurement / AS; Collective pitch potentiometer**

See above (Collective pitch measurement / AS; DECU).

Note: "DECU" or "collective pitch potentiometer": when there is only a "collective pitch measurement" message detected, the DECU gives the information "Collective pitch potentiometer". When there are several messages detected with the "collective pitch measurement", then the DECU gives the information "DECU". This is an arbitral logic choice that does not always match the reality.

- **VEMD**

The accident flight was identified as the flight numbered 1313 which lasted 5 minutes. Three failures and two overlimitations were recorded during that flight.

Note: Computation of VEMD flight duration begins when NG[1] is above 60% and ends when is below 50%.

➢ **Failures**

Time	Code	Description	NG (%)	TRQ (%)	T4 (°C)	NF (RPM)	NR (RPM)
5 min 1 s	53	Invalid TRQ – A	94.5	104.4	804	337	363
5 min 1 s	122	Collective pitch anticipator potentiometer (XPC)	94.6	95.1	798	320	-
5 min 1 s	126	Torque sensor – TRQ decrease strongly	95.3	44.2	801	462	-

The failures could be synchronized with DECU failure with a time difference of 1 min 57 s.

[1] NG (or N1) refers to gas generator rotation speed

Note : This time difference is explained by the fact that the DECU's time starts at helicopter electrical power "on", and the VEMD's time starts at 60% of NG.

- **Overlimitations**

Two overlimitations were recorded:

- Over Torque that lasted 1 second and reached a maximum value of107 %,
- NF Overlimitation that lasted 1 second and reached a maximum value of 510 RPM.

Conclusion:

The event flight was identified in the recorded data of both computers. Three failures and two overlimitations were recorded in the VEMD. Three failures were recorded in the DECU. The results from both sources were synchronised and were found consistent.

The data recorded in the VEMD and the DECU were discussed with the manufacturers. Experience showed that those failure messages are frequently encountered during accident impact phases. The overlimitations may be explained by the main rotor strike on the ground and by a loss of MGB/engine coupling.

Note from Turbomeca: This latter led the free turbine to overspeed without reaching the blade sheding threadshold and was reduced back to 100% speed by the fuel control system. No more power being requested, the engine gas generator was certainly running at reduced rating before the pilot activated the fuel shut off valve.

The reports issued by Turbomeca (Document T13-FR0445E-1.pdf) and Eurocopter (ReadOut VEMD_ZS-HDI_Bostwana_2021.pdf) were provided to the Investigator-in-Charge.

APPENDIX 3
Note

Marignane 18h of June, 2013
Note EAI - MG xxx/2013

Marc GREILLER
FLEET SAFETY – Eurocopter Group
Accident Investigator and Flight Data Analyst
Dept. EAI – Investigation & Product Integrity

<u>Subject:</u> AS350 B3 Accident – S/N 3259 – ZS-HDI - “PHILLIP SAUNDER” (Private)

VEMD READ-OUT & ANALYSIS

Accident date**: 31st of October 2012**

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1. *V.E.M.D data (Vehicle and Engine Multifunction Display)*

The V.E.M.D. is a multifunction screen which ensures the display of vehicle and engine parameters.
"THALES avionics" is the manufacturer of this equipment:

- VEMD Part/Number of the accident = **B19030MC02**
- VEMD Serial/Number of the accident = **1003**

In the P/N the two last digits (**02**) indicate the software version.

Important NOTA:
VEMD architecture and the associated sensors are not compliant with any Flight Data Recorder specifications. Raw data provided by the system only, can't be sufficient to confirm a possible scenario. These data must be confirmed by wreckage's information, and/or testimonies.
There are two types of available data for maintenance:

- **Over limits** of parameters: Values of over limits are available but they are not dated. In this case, it's not possible to associate strictly the data with a known event.
- **Failures** information: For each failure, the system provides a probable list of items which could be the cause of the problem, and the list of the associated parameters. These parameters are very interesting as a complement of investigation data.

2. *DATA SOURCES*

2.1 PICTURES SOURCE

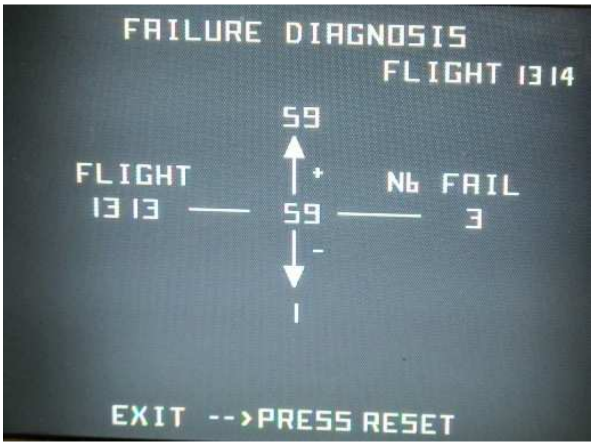
All the pictures shown in this document are issued from the VEMD N° 1003, which was powered on the Eurocopter bench, with the participation of a Technical Investigator from BEA.

2.2 APPLIED PROCESS

- Power on in "Maintenance mode" and verifying and noting the possible failures.
- During this operation, the accident flight was already closed, so, it was not necessary to close it with EC bench.

3. *“MAINTENANCE MODE”*

The VEMD was opened in “Maintenance mode”. The last flight with failure (#1313) was not the same than the opened session (#1314). That’s means that the event flight was already closed. The EC closure process was not necessary in this case and the flight report was available.



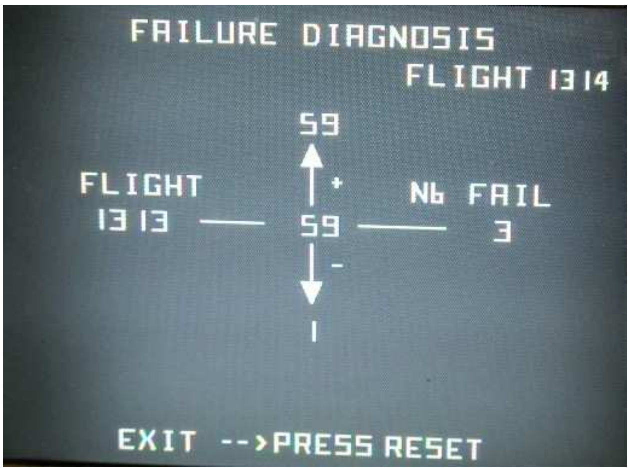
3.1 FLIGHT REPORT

The flight report page was directly available, as the flight was already closed.

This page indicates that the accident flight was the flight number 1313.
The cycle counting is not normal (NG=1.38 and NF=5.50). The value is too high for a standard flight, but could be explained due to the NF over limit recorded.
This counting is made during the VEMD flight closure process.
"Over limit" and "Failure" are detected during this flight.

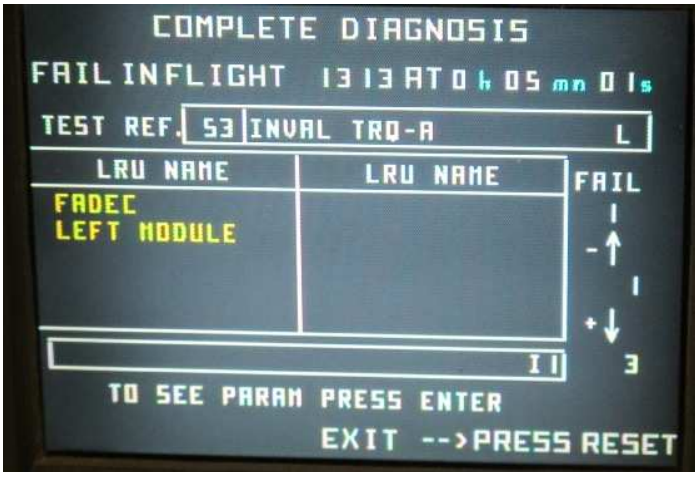
3.2 FAILURE PAGE

This page provides the number of failures which occurred during the flight.



During the flight number 1313 (flight of the event), 3 failures were recorded. The "Enter" button was pressed in order to obtain the details of these failures.

3.2.1 Failure N°01: Test Ref 53



Failure code 53: In this case, excessive value of torque (104.4%) at 05'01"
This failure occurs consistently at the time of impact of the helicopter.
Associated parameters are the following ones:

3.2.2 Failure N°02: Test Ref 122

Failure code 122: Failure of collective pitch anticipator potentiometer (XPC) at 05’01”
This failure occurs consistently at the time of impact of the helicopter.
The low level of NF (320 rpm) could be the consequence of the main rotor strike with the ground.
Associated parameters are the following ones:

LABEL 350 - FAIL1 = 0010:
Bit 18 → Collective pitch failure

LABEL 351 - FAIL2 = 0000:
All Bits → 0

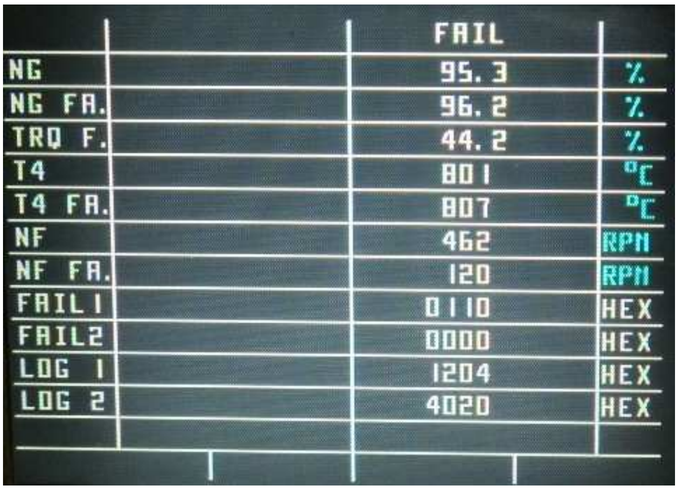
LABEL 353 - LOG1 = 0204:
Bit 23 → Control mode = Flight
Bit 16 → Self-test ended

LABEL 354 - LOG2 = 1000:
Bit 26 → Automatic mode activated

3.2.3 Failure N°03: Test Ref 126

Failure code126: In this case, the torque decrease strongly (44,2%) at the same second (05’01”).
The system estimates that it’s not possible in normal operation to have this kind of variation without a failure of the torque sensor (See Label 350 – Fail 1 hereunder).
This failure occurs consistently at the time of impact of the helicopter.

Associated parameters are the following ones:



		FAIL	
NG		95.3	%
NG FA.		96.2	%
TRQ F.		44.2	%
T4		801	°C
T4 FA.		807	°C
NF		462	RPM
NF FA.		120	RPM
FAIL1		0110	HEX
FAIL2		0000	HEX
LOG 1		1204	HEX
LOG 2		4020	HEX

LABEL 350 - FAIL1 = 0110:
Bit 18 → Collective pitch failure
Bit 22 → Raw torque failure

LABEL 351 - FAIL2 = 0000:
All Bits → 0

LABEL 353 - LOG1 = 1204:
Bit 26 → Bleed valve closed
Bit 23 → Control mode = Flight
Bit 16 → Self-test ended

LABEL 354 - LOG2 = 4020:
Bit 28 → Manual out neutral notch
Bit 19 → Degraded control

3.3 OVERLIMIT

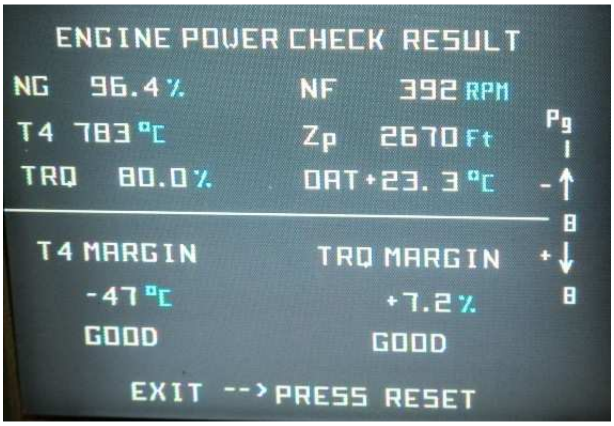
Two over limits were recorded:

- Over Torque TRA during 1s at 107% (For information, TRA is for between 105 & 110%, MED is for between 110 & 118%, and EXT is for above 118%). This over torque is consecutive to the main rotor blade strike on ground.

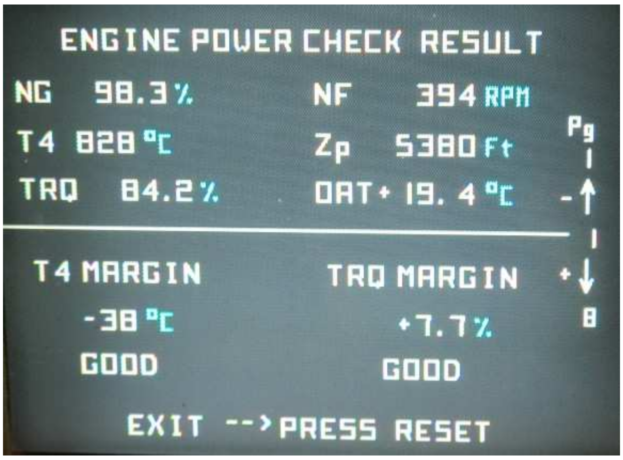
- Over limit of 510 RPM is compliant with the over speed of the NF due to the loss of MGB/Engine coupling at the impact of main rotor blades. (510 rpm is maximum value which could be displayed, the real value could be more than 510).

3.4 ENGINE POWER CHECK

Here is the last Engine Power Check performed by the crew. The Engine was in good condition at the moment of the EPC.



The first Engine Power Check performed by the crew has also a good result… No degradation of the engine between the first and the last EPC.



4. CONCLUSION

- The failures were recorded at 05’ 01”.
- The failures are most probably a consequence of the accident.
- The engine was in “flight” mode (NG around 95%).

No failure or Over limit has been recorded before the crash.

APPENDIX 4

COMPILED BY	Crash LAB Aviation Accident Investigation & Metallurgy	PAGE 1 OF 7
COMPILED FOR: Botswana D. of A. Inv.	INVESTIGATION REPORT: EUROCOPTER AS350 TAIL ROTOR ASSY. FAILURE	DOCUMENT NUMBER MET-009-02-13
		DATE 2013-02-08 / ISSUE 1

ITEM: **TAIL ROTOR TRANSMISSION ASSY., EUROCOPTER AS350B3 HELICOPTER, AIRCRAFT NUMBER ZS-HDI**

1. INTRODUCTION

1.1. Selected parts from the failed Tail Rotor Transmission Assembly from a crashed Eurocopter (Aérospatiale) AS350B3 “Squirrel” Helicopter, aircraft number ZS-HDI, (Photo’s 1 and 2) were submitted by the Botswana Directorate of Accident Investigation to determine the possible failure mode/s during operation.

Photo 1: ZS-HDI crash site (courtesy SACAA)

Photo 2: ZS-HDI crash site (courtesy SACAA)

Photo 3: ZS-HDI crash site (courtesy SACAA)

1.4. This report is divided into the following sections:

(a)	INTRODUCTION	Par. 1
(b)	APPLICABLE DOCUMENTS	Par. 2
(c)	DEFINITIONS	Par. 3
(d)	INVESTIGATOR	Par. 4
(e)	APPARATUS AND METHODOLOGY	Par. 5
(f)	BACKGROUND INFORMATION	Par. 6
(g)	INVESTIGATION	Par. 7
(h)	DISCUSSION AND CONCLUSIONS	Par. 8
(i)	RECOMMENDATIONS	Par. 9
(j)	DECLARATION	Par. 10

2. APPLICABLE DOCUMENTS

(a) Illustrated Parts Catalogue: Eurocopter AS350B3
(b) Eurocopter Alert Service Bulletin No 05.00.60

3. DEFINITIONS

(a)	OEM	Original Equipment Manufacturer
(b)	SACAA	South African Civil Aviation Authority
(c)	SEM	Scanning Electron Microscope
(d)	EDS	Energy Dispersive X-ray Analysis
(e)	BDAI	Botswana Directorate of Accident Investigation

4. PERSONNEL

(a) The investigative member and compiler of this report is Mr C.J.C. Snyman, ID number 6406105057080. Mr Snyman is a qualified Physical Metallurgist (H.N.Dip Metallurgical Engineering, Tech. PTA), Radiation Protection Officer (RPO) registered with the National Nuclear Regulator (NNR) and Aircraft Accident Investigator (SCSI).

5. APPARATUS AND METHODOLOGY

(a) The apparatus employed for this investigation are Stereo- and Scanning Electron (With EDS) Microscopes and Digital Camera.
(b) The methodology included a visual investigation of supplied parts followed by a Stereoscopic and SEM investigation.

6. INVESTIGATION RESULTS

The visual examination revealed the assembly indicating multiple fractures (Photo 4) and impact marks.

The yellow blade pitch control rod failed on the big-end bearing housing (Photo's 4 and 7) side.

The red blade pitch control rod revealed impact marks corresponding with the connecting position onto the blade (Photo 6, red arrow) as well as the drive shaft ends (Photo 6, blue arrow). These damages proved to be similar in position to the yellow blade pitch control rod (Photo 7, red arrow).

The yellow pitch control rod revealed a fracture surface (Photo 7, green arrow) as well as bending damages (Photo 8). The big-end bearing (Photo 9, blue arrow) revealed no indications of seizure or other discrepancies.

The SEM fracture analysis revealed no clear indications of pre-existing fractures (Photo's 10 and 11). At higher magnification the fracture surface analysis revealed a ductile failure (Photo's 12, 13 and 14) consistent for the alloy under a single over-load resulting in a primary tensile fracture with a small area revealing shear (Photo 13).

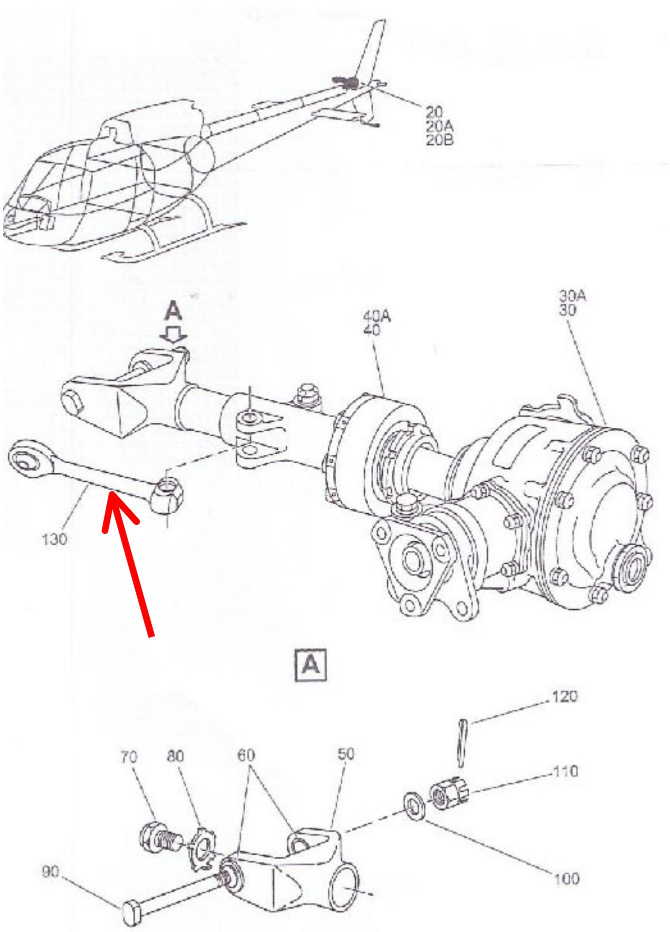


Diagram 1: Tail Rotor Transmission Assembly (Eurocopter IPC AS350B3)

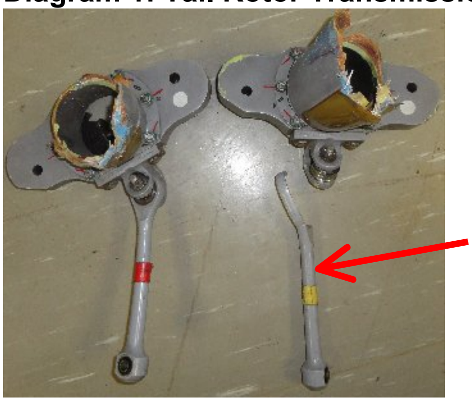


Photo 4: Supplied parts (digital)

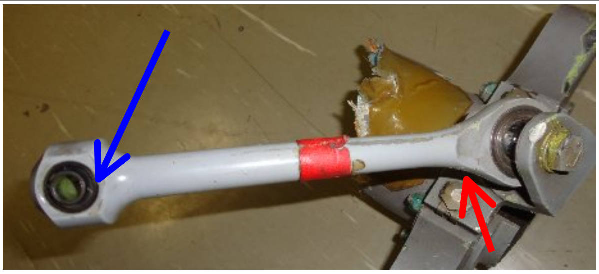


Photo 5: Impact marks, red pitch control rod (digital)

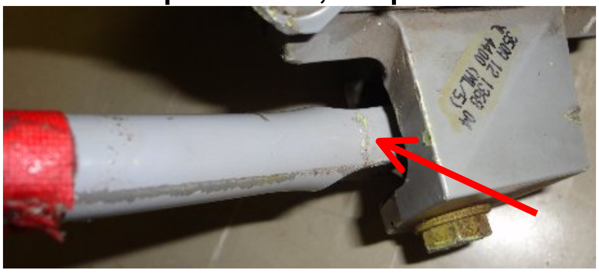


Photo 6: Impact marks, red pitch control rod (digital)

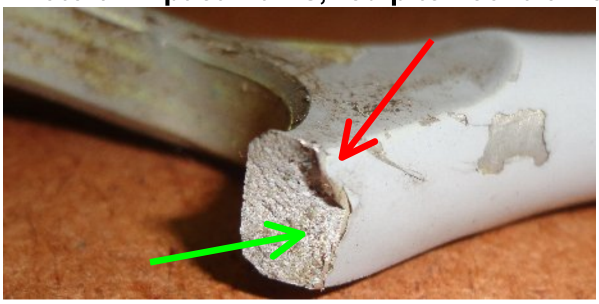


Photo 7: Fracture surface, yellow pitch control rod (digital)

Photo 8: bending damages, yellow pitch control rod (digital)

Photo 9: Big-end bearing at blade connector, yellow pitch control rod (digital)

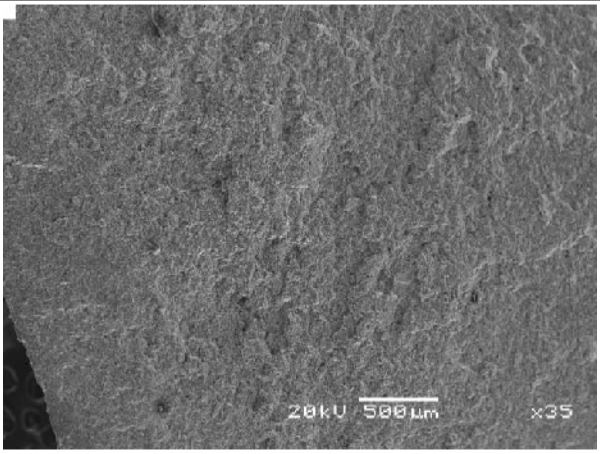


Photo 10: Fracture surface, yellow pitch control rod (x35, SEM)

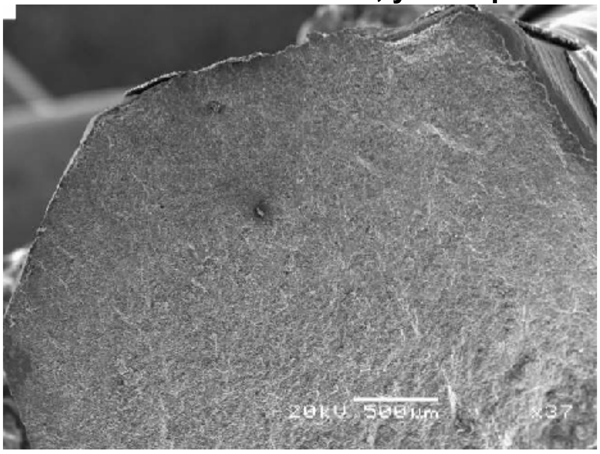


Photo 11: Fracture surface, yellow pitch control rod (x37, SEM)

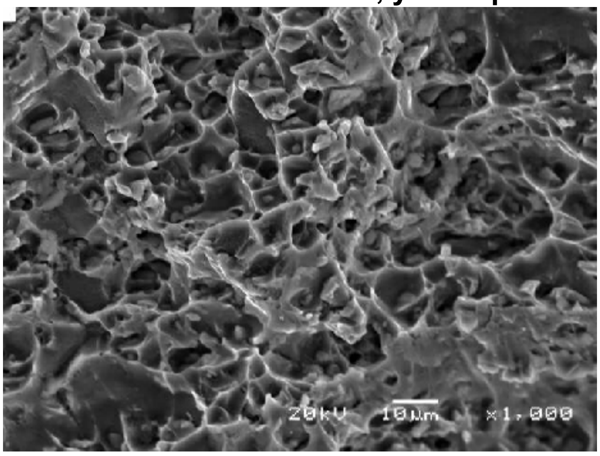


Photo 12: Fracture surface, yellow pitch control rod (x1000, SEM)

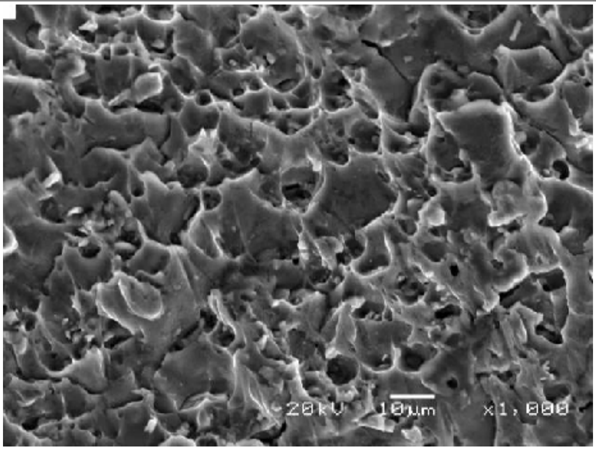


Photo 13: Fracture surface, yellow pitch control rod (x1000, SEM)

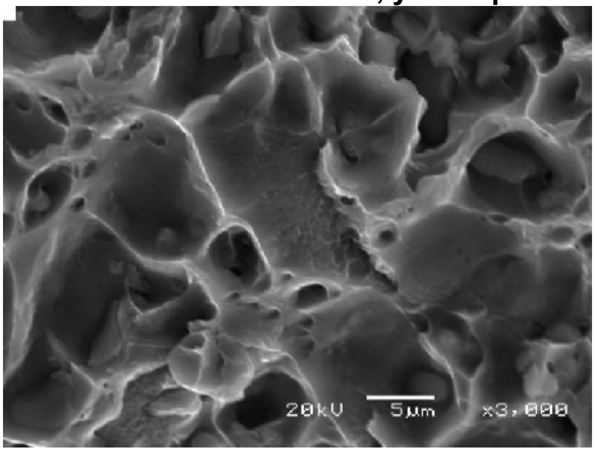


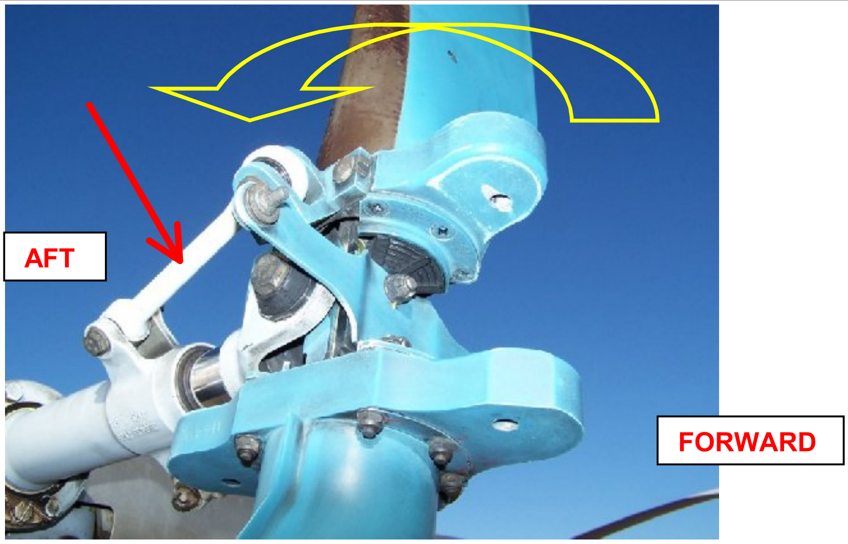
Photo 14: Fracture surface, yellow pitch control rod (x3000, SEM)

8. DISCUSSION AND CONCLUSIONS

Note: All conclusions are based on the investigation results obtained from the supplied parts only.

8.1. The direction of failure of the yellow blade pitch control rod as well as other damages inflicted proved to be consistent with the tail rotor impacting with a hard object (Photo 3) while under engine power (Consider the rotating direction of the tail rotor, Diagram 1 and Reference Photo 1, yellow arrow). No indications were present suggesting a failure mode originating due to non-compliance of Eurocopter Alert Service Bulletin No 05.00.60. The red blade pitch control rod revealed similar damages but without failure at the big-end bearing side.

8.2. The fracture surface analysis revealed a ductile failure under tensile over-load conditions. No evidence of pre-existing fracture/s are present and it can be derived that the yellow blade pitch control rod failed due to the tail rotor impacting with a hard object during operation.



Reference Photo 1: AS350 Tail Rotor Assembly (courtesy Eurocopter)

9. RECOMMENDATIONS

9.1. None applicable.

10. DECLARATION

10.1. All digital images has been acquired by the author and displayed in an un-tampered manner.