Papua New Guinea

FINAL REPORT

AIC 14-2518

PAPUA NEW GUINEA

ACCIDENT INVESTIGATION COMMISSION

SHORT SUMMARY REPORT

Manolos Aviation Limited

P2-NHW

Eurocopter Deutschland Gmb H BO 105 S CBS-4

Engine failure

Onggake, Morobe Province

PAPUA NEW GUINEA

23 June 2014

About the AIC

The Accident Investigation Commission (AIC) is an independent statutory agency within Papua New Guinea (PNG). The AIC is governed by a Commission and is entirely separate from the judiciary, transport regulators, policy makers and service providers. The AIC's function is to improve safety and public confidence in the aviation mode of transport through excellence in: independent investigation of aviation accidents and other safety occurrences within the aviation system; safety data recording and analysis; and fostering safety awareness, knowledge and action.

The AIC is responsible for investigating accidents and other transport safety matters involving civil aviation, in PNG, as well as participating in overseas investigations involving PNG registered aircraft. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

The AIC performs its functions in accordance with the provisions of the PNG Civil Aviation Act 2000 (As Amended), Civil Aviation Rules 2004 (as amended), and the Commissions of Inquiry Act 1951 (as amended), and in accordance with Annex 13 to the Convention on International Civil Aviation.

The object of a safety investigation is to identify and reduce safety-related risk. AIC investigations determine and communicate the safety factors related to the transport safety matter being investigated.

Readers are advised that in accordance with Annex 13 to the Convention on International Civil Aviation, it is not the purpose of an AIC 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. (Reference: ICAO Annex 13, Chapter 3, paragraph 3.1.)

However, it is recognised that an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the AIC endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why it happened, in a fair and unbiased manner.

About this report

Decisions regarding whether to conduct an investigation, and the scope of an investigation, are based on many factors, including the level of safety benefit likely to be obtained from an investigation.

The AIC was informed of a BO 105 S CBS-4 helicopter accident first by Civil Aviation Safety Authority of PNG (in accordance with Section 62 of the PNG Civil Aviation Act (2000)), and subsequently by the operator, Manolos Aviation Limited, on 24 June 2014. An investigation was commenced, with the investigators arriving at the occurrence site on 26 June 2014. The occurrence was subsequently determined to be a serious incident, and investigated by the AIC.

The AIC has produced a short summary report for greater industry awareness of potential safety issues and possible safety actions.

Engine failure involving a Eurocopter BO-105, P2-NHW

Occurrence details

On 23 June 2014, a Eurocopter BO105 S CBS-4 (BO105) helicopter, registered P2- NHW, operated by Manolos Aviation Ltd, departed Lae, Morobe Province, Papua New Guinea for Onggake village in the Kabwum area of the Morobe Province. There were two persons on board; the pilot and a loadmaster. The purpose of the flight was to position the helicopter to Onggake village to conduct sling operations of building materials from Onggake village to Dawot station a distance of about 2.2 nm (4.1 km).

Figure 1: Map of Onggake area in Morobe Province

On arrival overhead Onggake village the pilot overflew the landing zone to ascertain the conditions on the ground. He subsequently reported that there were building materials including roofing iron, plywood sheets, fence poles and bags of cement located on the eastern side of the landing zone; the building materials looked secure. There were two school buildings to the west of the landing zone. The approach to the landing zone was from the north with a light tailwind of less than 5 kt.

The pilot reported that when the helicopter was about 10 ft above the ground during the landing flare, he noticed the adjacent school building roofing structure lifting and building materials, including roofing iron, scattering caused by the rotor downwash. He said that he elected to go around and applied power, monitoring the engine instruments, the TOT[1] gauges in particular. The engine torque gauges were indicating 80% and the TOT gauges approximately 790°C. The pilot chose a go-around path down a gully to the south towards Dawot (see Fig. 2).

[1] Turbine outlet temperature (TOT). is the temperature of the turbine exhaust gases as they leave the turbine unit.

At about 0015 UTC[2] while still accelerating and prior to reaching translational lift, the pilot heard a loud noise. He said he saw a caution light and there was an increased sink rate, with the helicopter not responding to increased collective inputs. The pilot lowered the collective to maintain rotor RPM[3], however being too slow and with low altitude for the planned go-around route, the pilot made a turn to the right towards an area suitable for a forced landing, clear of buildings and people. The touchdown was made with a low residual forward speed and the helicopter sank into the soft ground up to the underside of the fuselage. The landing gear skids were damaged by the hard landing, with the left skid fractured forward of the left front strut (see Figure 3).

The pilot and loadmaster were not injured.

Figure 2: NHW at occurrence site viewed from intended landing area. Valley towards Dawat in immediate background.

Weight and balance

The investigation determined that aircraft was loaded according to the approved 'quick trim' system detailed in the Aircraft Flight Manual (AFM).

[2] The 24-hour clock, in Coordinated Universal Time (UTC), is used in this report to describe the local time as specific events occurred. Local time in the area of the accident, Papua New Guinea Time (Pacific/Port Moresby Time) is UTC + 10 hours.

[3] RPM-revolutions per minute

Figure 3: Left landing gear skid damaged as a result of the hard landing

Engine examination

Investigators from the AIC went to Onggake where an initial examination of the left engine revealed a substantial quantity of metallic shavings at the turbine outlet duct, originating from the liberated compressor turbine and stator blades. The compressor casing was punctured in several places. The left engine and its accessories were removed from the helicopter and the compressor was removed and shipped to the AIC office in Port Moresby.

Figure 4: Metallic shavings of the disintegrated turbine

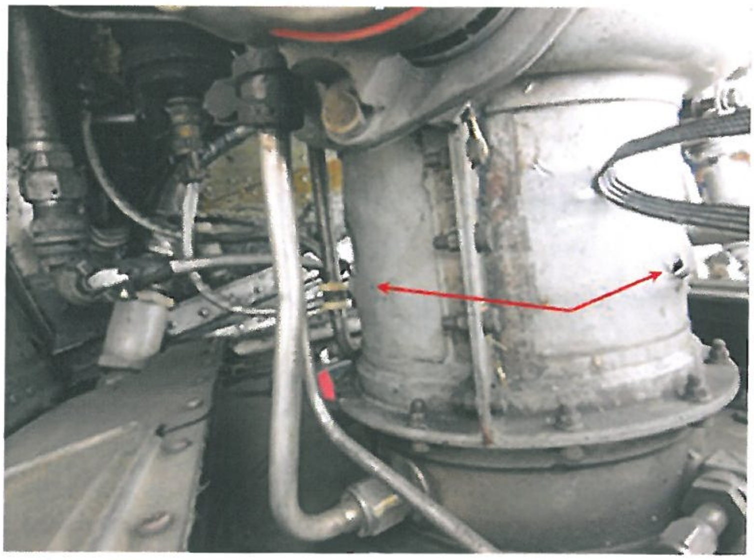


Figure 5: Compressor casing red arrows point to punctures through the case

Australian Transport Safety Bureau examination of compressor

The ATSB engineering laboratory in Canberra examined the compressor and found that a high temperature sealant had been applied to the sealing surfaces of the compressor case halves. The use of a sealant on the flanges of the compressor is not recommended by the engine manufacturer.

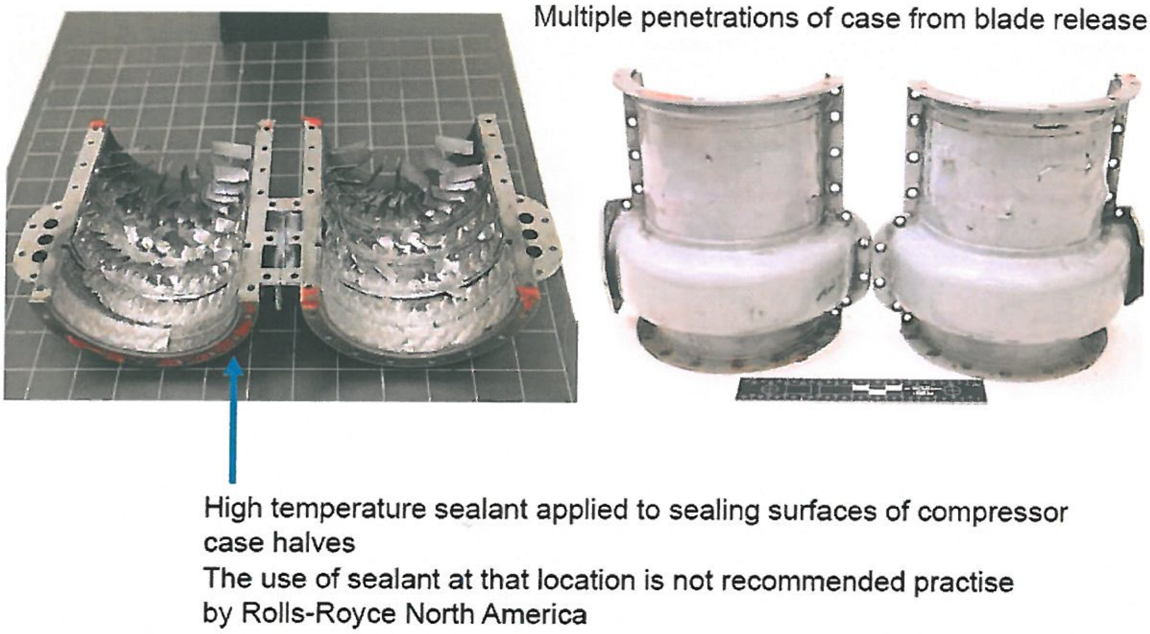
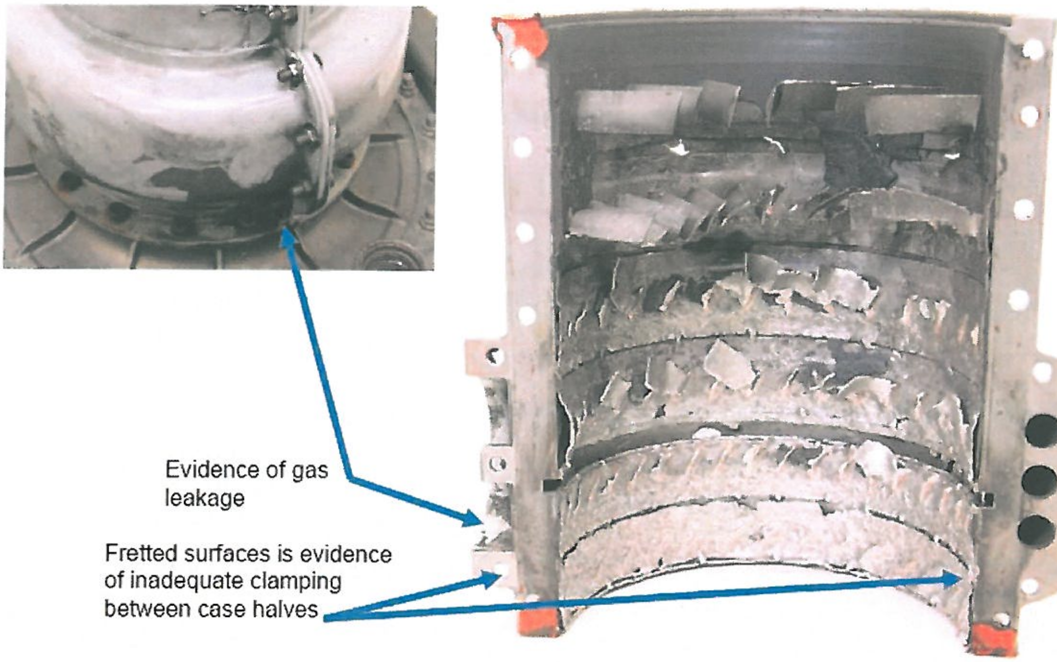


Figure 6: Compressor case flanges showing sealant on flanges (photo ATSB)

The compressor case flanges showed evidence of fretting indicating that they had been inadequately clamped. This was probably as a result of the sealant on the mating surfaces.

Figure 7: Compressor flange showing fretted surfaces (photo ATSB)



The blades on all stages of the compressor had failed with stage one showing evidence of trailing edge damage and erosion damage on the tips. The blade bending was found to be consistent with failure under engine power loads.

Stage-1

- Damage confined primarily to trailing edge of blade surface
- Damage is consistent with hard body impact from liberated downstream engine fragments
- Erosion of leading edge tips noted
- Bending of aerofoils was opposite to direction of rotation, consistent with failure under engine power

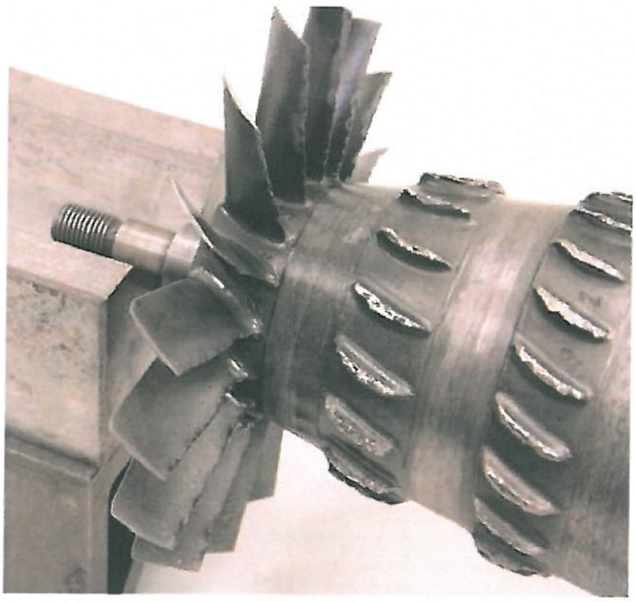


Figure 8: Stage 1 damaged blades (photo ATSB)

The blades on stages two to five showed evidence of corrosion. The ATSB report picture explains.

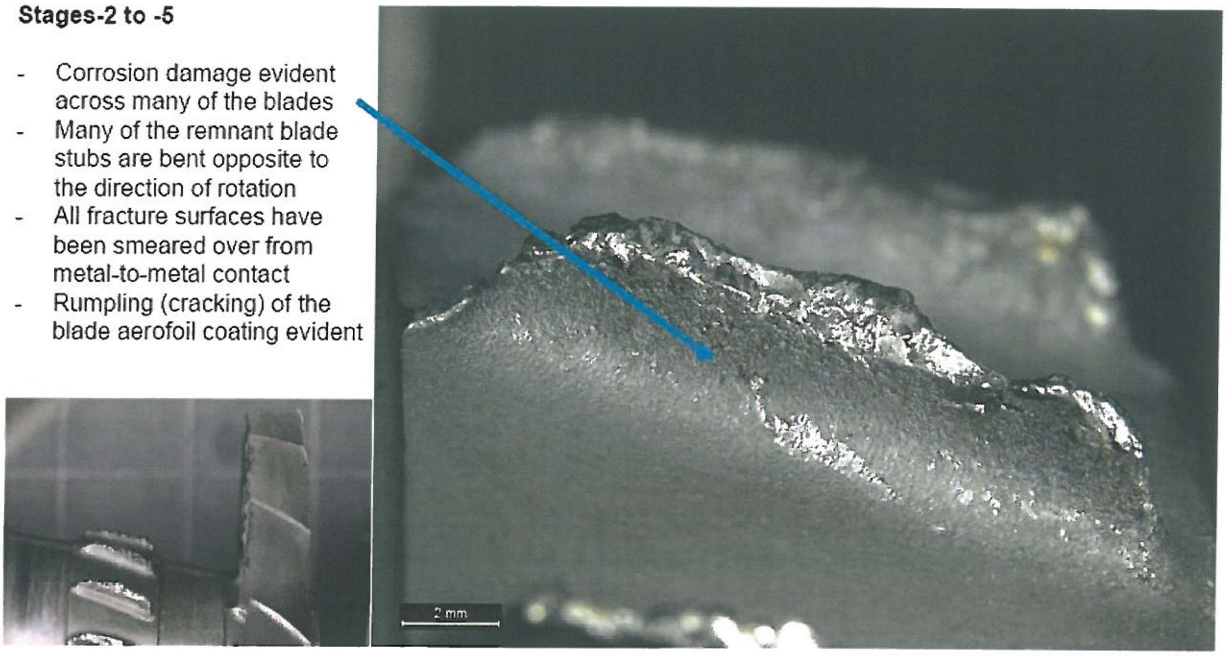


Figure 9: Indicative of compressor blade corrosion stages two to five (photo ATSB)

The following picture provides a magnified image of the failure of a blade in stage six of the compressor.

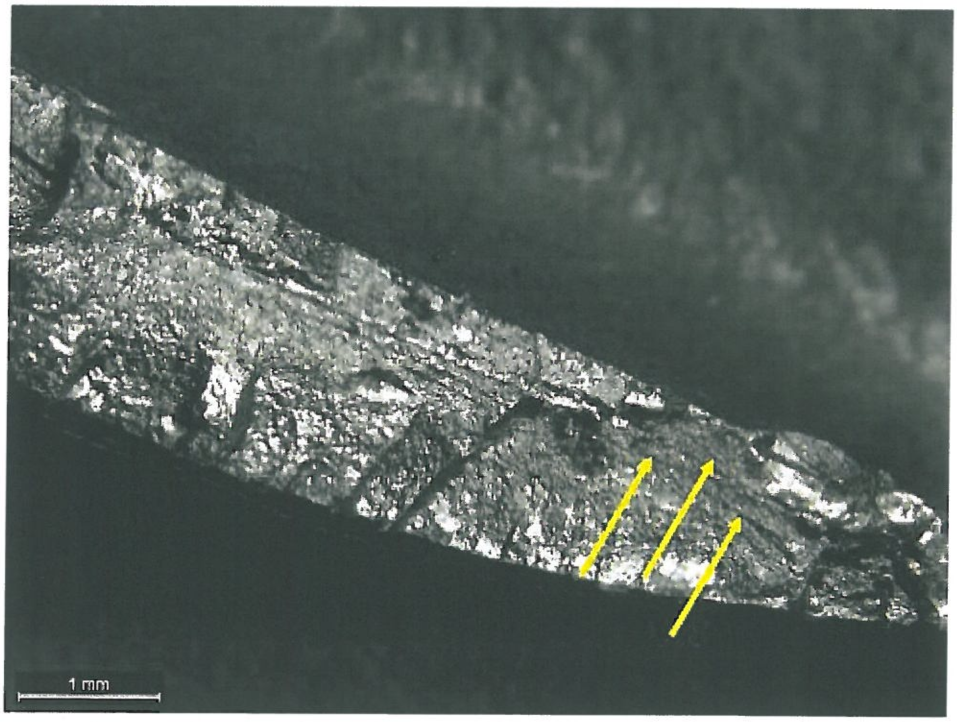


Figure 10: Stage six compressor blade failure (photo ATSB)

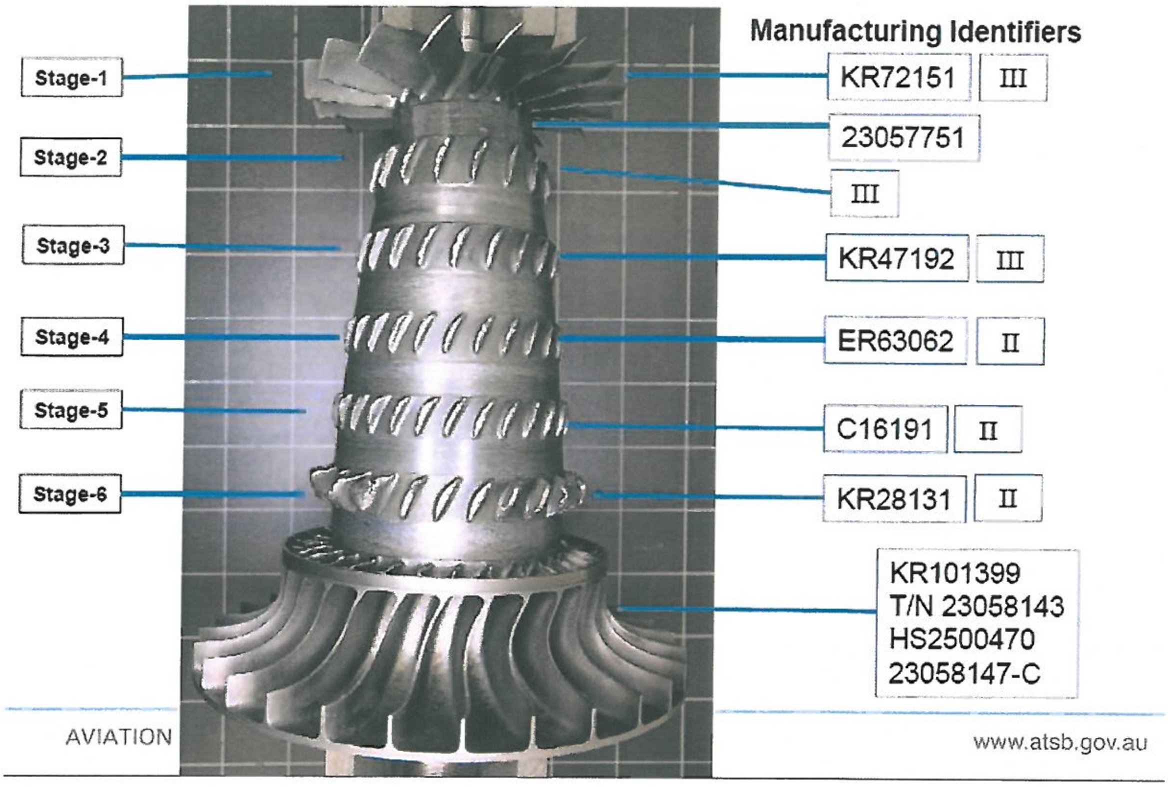


Figure 11: Compressor turbine stages (photo ATSB)

Rolls-Royce Corporation examination of the compressor

After further examination at the Australian Transport Safety Bureau's engineering facility in Canberra, Australia, the compressor was shipped to the Rolls Royce Corporation facility in Canada for further detailed engineering examination and analysis. The manufacturer's findings were as follows:

Findings on M250-C20B Loss of Power (extracted from report by Rolls Royce Corporation on Aircraft Operated by Manolos Aviation 16 June 2015)

The findings of the investigation are as follows:

1. Damage observed on the compressor rotor (Figure 1) [Figure 6 AIC report] is consistent with primary release of 2nd stage airfoils. Damage to the fracture surfaces of the 2nd stage airfoil remnants precluded identification of a primary failed airfoil, a specific fracture origin, and a fracture mode prior to airfoil separation.
2. Corrosion damage was found in the airfoil to hub fillet area of most 2nd stage airfoils. Figure 2 [Figure 7 AIC report] shows representative damage found in this area.
3. The microstructure, hardness and composition of the 2nd – 3rd stage compressor wheel were consistent with an AMS 5355 (17-4PH) type material as required by engineering drawing.
4. Corrosion damage was also observed on the 1st stage compressor. This level of corrosion damage is consistent with improper compressor maintenance when operating in a severe corrosive environment.

Engine Operation and Maintenance History

Maintenance documents supplied to Rolls-Royce indicate that the subject compressor was installed 91.1 hours prior to the event but that it was a used compressor with 2680 hours TSO.

No mention is made of the number of cycles accumulated on the compressor prior to installation but the maintenance log does indicate that the compressor was washed after installation in accordance with 100 hour inspection requirements. No indication of daily rinse or other compressor maintenance was made available for this investigation.

Conclusion

The cause of the loss of power associated with the subject event was determined to be 2nd stage compressor blade failure. The damage to the blade fractures precluded identification of a primary failed airfoil, a specific fracture origin, and a fracture mode prior to airfoil separation. However, in view of corrosion pitting found on the 2nd stage rotor hub, 1st stage compressor rotor and that the aircraft was operating in an area that has been designated as a severe environment (Ref. CSL 1135), the root cause of the event is judged to be improper compressor maintenance during operation in a corrosive environment.

Figure 6: Second stage compressor rotor (Photograph courtesy of Rolls Royce Corporation)

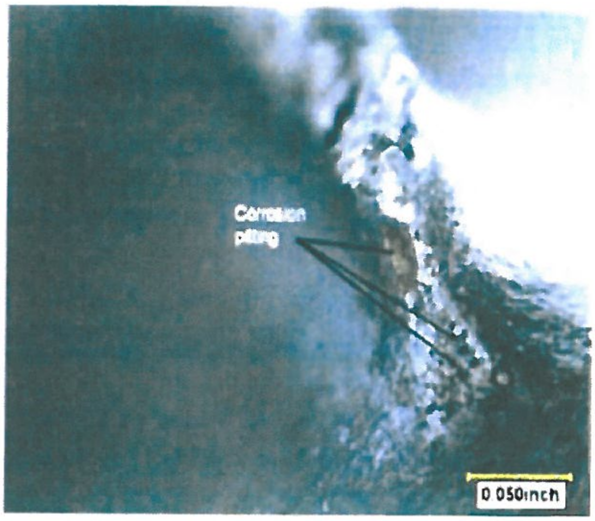


Figure 7: Representative corrosion pitting (Photograph courtesy of Rolls-Royce Corporation)

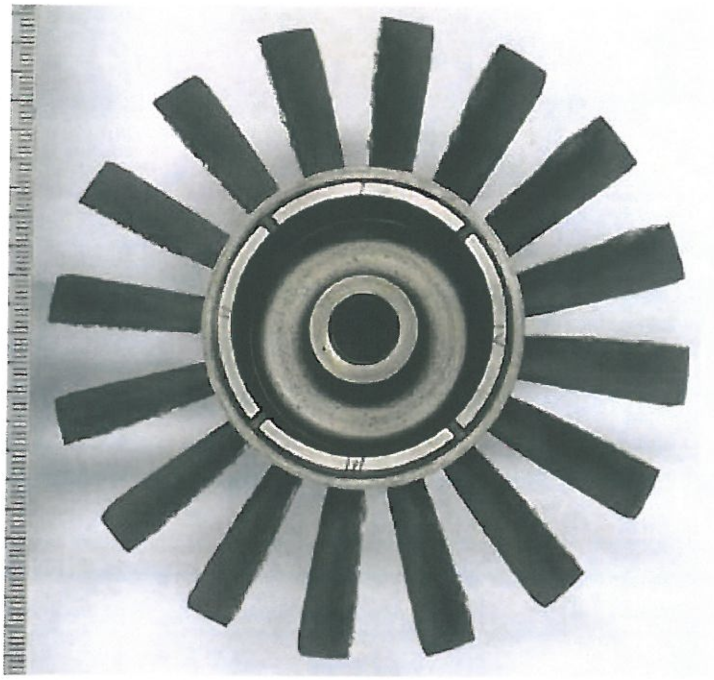


Figure 8: 1st stage compressor rotor impact damage to the trailing edges of the blades. Divisions = mm

(Photograph courtesy of Rolls-Royce Corporation)

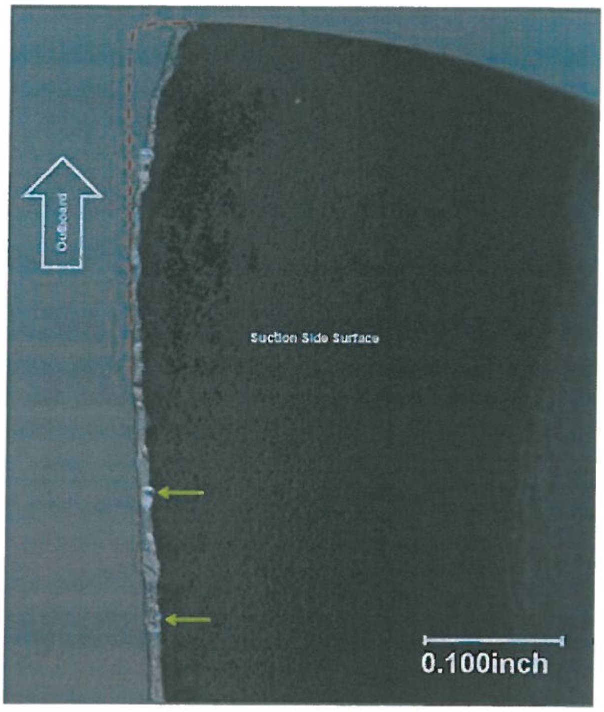


Figure 9: Representative erosion of the outboard tip leading edge of a 1st stage compressor blade. The red dashed line indicates a typical leading edge profile. Impact damage to the leading edge is indicated by yellow arrows. (Photograph courtesy of Rolls-Royce Corporation)

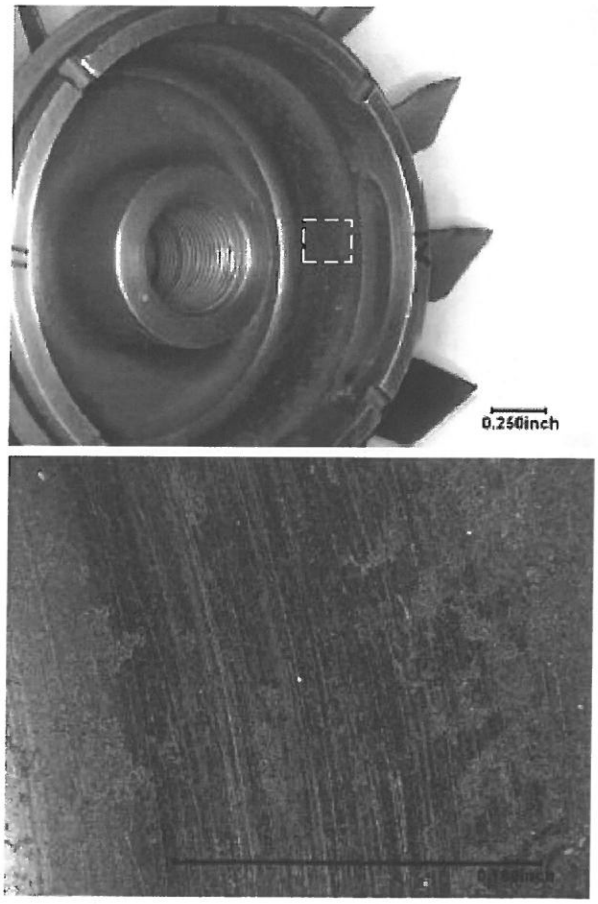


Figure 10: Corrosion damage on the inner diameter surface of the 1st stage compressor rotor.

(Photograph courtesy of Rolls Royce Corporation)

Operator's maintenance organisation

The Manolos Aviation Additional Worksheet for NHW Job No. AFM 243 dated 5 January 2014 referred to the replacement of the number-one engine assembly serial number CAE 830863 with engine assembly serial number CAE 831360 on 29 January 2014 and a Turbine replacement on the number-one engine, serial number CAE 831360 (14 January 2014). However, on 30 January the number-one engine assembly on NHW was listed as Part No. 6893660 Serial No. CAE 830863.

> **Items 54 and 55** dated 29 January 2014 list:
>
> The number-one engine assembly Part No. 6893660 Serial No. CAE 830863 was replaced with engine assembly Part No. 6893660 Serial No. CAE 831360 [from another Manolos Aviation BO105 helicopter, registered P2-WOW].
>
> **Item 56** dated 14 January 2014 lists:
>
> Turbine part number 23038241 Serial No. CAT-30805F on engine assembly Serial No. CAE 831360 was replaced with turbine part number 23038241 serial number CAT 34375.
>
> **Items 58 to 63** dated 30 January 2014 documented various components fitted to engine assembly Part No. 6893660 Serial No. CAE 830863 that was listed as the number-one engine on NHW.

The investigation noted that P2-WOW (see maintenance worksheet item 1 above) had been lying idle for some time in a highly corrosive environment at the apron at Manolos Aviation's main base at Ulaveo near Tokua airport. Ulaveo and Tokua locations are near the sea and in close vicinity of Mt. Tavuvur, an active volcano.

The Engine Maintenance Certification Log Book has a hand written notation *'NO PAGE #6'*. Paper remnants in the binding of the Log Book show that the page was removed, as distinct from being a log book printing/publishing error. There was no entry in the Engine Maintenance Certification Log Book for work carried out between 9 April 2013 page 5 and 18 March 2014 page 7.

Page 7 dated 18 March 2014 referred to Job No. AFM 243, for aircraft Serial No. S-425, P2-NHW.

Under the heading Unscheduled Maintenance it stated:

> B3500-TURB. Turbine – Replaced OFF P/N 2303824 S/N CAT33321 TSO: 2382.00
>
> ON: P/N 23032841 S/N CAT34375 TSO: 1204.40

These details were copied in the Aircraft Maintenance Certification Log Book at page 14.

No further details of engine turbine or compressor defect rectifications were recorded in the maintenance documentation leading up to the date of the serious incident involving NHW. Details of engine hours and cycles for both engines were also requested, but those supplied were incomplete and/or only up to 18 March 2014.

AIC comment

The AIC accepts the findings of the Australian Transport Safety Bureau (ATSB), which are further expanded in the Rolls-Royce Corporation's report, following the detailed examinations of the failed engine compressor components.

The AIC's examination of the maintenance documentation found many discrepancies and disconnects, some of which are highlighted above.

Accordingly, the AIC determined that the maintenance defects identified by the ATSB and the Rolls-Royce Corporation, and documentation recording anomalies found by the AIC are indicators of serious maintenance deficiencies that affected the safety of the operation of NHW.

The Civil Aviation Safety Authority of PNG (CASA) safety oversight of the operator's maintenance procedures did not detect that the operator's facilities in Rabaul and Lae were not CASA approved Part 145 facilities.

The operator informed the AIC that while the maintenance facilities in Rabaul and Lae were not CASA approved Part 145 facilities, the maintenance engineer was CAR 145 certified. However, CAR 145 is specific, requiring the maintenance to be performed by a CAR 145 certified engineer, in a CAR 145 approved facility.

General details

Date and time:	23 June 2014 0015 UTC	
Occurrence category:	Accident	
Primary occurrence type:	Engine failure	
Location:	Onggake, Morobe Province, Papua New Guinea	
	Latitude: 6°08' 00"S	Longitude: 147° 04' 08"E

Crew details

Nationality	South African
Licence type	Commercial Helicopter (PNG)
Licence number	P20641
Total hours	7,664 hours (to May 2014)
Total hours on type	723 hours (to May 2014)

Aircraft details

Aircraft manufacturer and model	Eurocopter	
Registration:	P2-NHW	
Serial number:	S-426	
Engine number one (Left)		
Engine manufacturer and model	Rolls-Royce Corporation M250-C20B	
Engine serial number	CAE-831360	
At 18 March 2014	Hours since new: 9,656.42	Hours since overhaul: 1,106.08 hours
At 18 March 2014	Requested not provided	Cycles since overhaul: 1,136
Engine number two (Right)		
Engine manufacturer and model	Rolls-Royce Corporation M250-C20B	
Engine serial number	CAE-832943	
	Hours since new: 8,354.25 (18/3/14)	Hours since overhaul: 1,284.05 (18/3/14)
	Cycles since new requested not provided	Cycles since overhaul requested not provided
Persons on board:	Crew: 2	Passengers: 0
Injuries:	Crew: 2 Nil	Passengers: 0
Damage	Substantial damage to landing gear skid and number-one engine compressor	
Type of operation:	Charter	

Approved

Nemo Yalo

Chief Commissioner

Accident Investigation Commission