



© Mark McEwan/Altliners.net

Fractured Gear

BY LINDA WERFELMAN

A metallic particle was the only sign of the impending fatal failure of the AS332's main rotor gearbox.

Twelve seconds after a routine radio transmission, the commander of a Eurocopter AS332 L2 Super Puma was back at the microphone, declaring an emergency as his helicopter fell 2,000 ft from cruise flight to the surface of the North Sea. The two pilots and all 14

passengers were killed, and the helicopter, which lost its main rotor during the plunge to the sea, was destroyed in the April 1, 2009, crash.

The U.K. Air Accidents Investigation Branch (AAIB), in its final report, said the crash followed the catastrophic failure of the main rotor gearbox,

which resulted from a fatigue fracture of “a second stage planet gear in the epicyclic module.”

The report added that the only indication of a pre-existing problem was the discovery during maintenance on March 25, 2009 — 36 flight hours before the accident — of a metallic particle on the epicyclic chip detector and that “the possibility of a material defect in the planet gear or damage due to the presence of foreign object debris could not be discounted.”

The report cited as a contributing factor actions taken after discovery of the magnetic particle, which “resulted in the particle not being recognized as an indication of degradation of the second stage planet gear.”

The report cited two additional contributing factors:

- After the March 25 maintenance, “existing detection methods did not provide any further indication of the degradation of the second stage planet gear”; and,
- “The ring of magnets installed on the AS332 L2 and EC225 main rotor gearboxes reduced the probability of detecting released debris from the epicyclic module.”

The accident flight was one of a series of flights on April 1 between Aberdeen, Scotland, and

various North Sea oil platforms (Figure 1, p. 38). The helicopter’s only known mechanical problem was a deferred defect involving the ice detection system, but this was not a factor on a day when there were no clouds below 3,000 ft and the temperature was about 13 degrees C (55 degrees F), the report said.

The pilots who had flown the helicopter immediately before the accident flight said they had no problems during their round-trip flight between Aberdeen and the Bruce Platform and had observed no abnormalities during their inspection of the helicopter.

The accident crew boarded the helicopter, in a “rotors-running crew change,” when it returned from the Bruce Platform. The commander of the previous flights told the commander of the accident flight that the helicopter was serviceable, except for the deferred defect, and that the daily in-flight checks had been completed satisfactorily.

After refueling and passenger-boarding, the helicopter took off at 1042 local time for the 67-minute flight to the Miller Platform, where the outbound passengers disembarked. Several told investigators later that, five or 10 minutes before landing, they heard a sound “similar to a heater or air conditioning unit being turned off” but did not consider this a problem and did not mention it to the crew, the report said.

After 14 passengers boarded for the flight to Aberdeen, the helicopter took off at 1203, and climbed to 2,000 ft.

“Approximately 20 minutes before the expected arrival time at Aberdeen, the copilot made a routine call to the operating company, stating that the helicopter was inbound with 14 passengers, it was serviceable and was expected to arrive at 1314 hours,” the report said.

Two “mayday” calls — one from the commander and one from the copilot — followed seconds later.

Two nm (4 km) away, a worker on the vessel Normand Aurora heard the helicopter and then saw it in a rapid descent to the water. He told investigators that the main rotor blades had separated from the helicopter before it fell

The main rotor blades separated from the helicopter before impact and were pulled from the North Sea during the recovery effort.





Figure 1

into the sea and that he saw no smoke until after the impact.

He sounded an alarm and turned the Normand Aurora toward the accident site, 11 nm (20 km) northeast of Peterhead; a Normand Aurora fast rescue boat arrived “very promptly,” as did a nearby helicopter whose crew had been asked by air traffic control to “examine the sea in the area where the helicopter was last seen on radar,” the report said. Other search and rescue equipment arrived within 40 minutes, and recovery efforts began later the same day.

Pilot Training

The helicopter’s commander, who had an air transport pilot license for helicopters, had accumulated 2,575 flight hours, including 1,870 hours in type. The copilot held a commercial pilot license for helicopters and had 395 flight hours, including 140 hours in type. Both pilots

had AS332 L2 type ratings and had completed all required training and testing.

The helicopter was manufactured in 2004 and owned by Bond Offshore Helicopters; it had 7,728 total airframe hours. It was equipped with two Turbomeca Makila 1A2 turboshaft engines. Accident investigators said it was certified, equipped and maintained according to regulations in place at the time. Calculations performed after the accident confirmed that the helicopter was being operated within weight and balance limitations when the crash occurred.

Chip Detection

The AS332 L2 was designed so that the shafts from the two engines drive the main and tail rotors by way of the main gearbox, which is divided into two sections — the main module and the epicyclic reduction gearbox module. The epicyclic module planet gears had an operational life of 6,600 flight hours.

The main gearbox contains magnetic chip detectors, designed to “detect and retain any chips of magnetic material shed, for example, from the gears or their bearings,” the report said, noting that the main module detector generates a warning when “a chip of sufficient size, or an accumulation of small chips, is detected.”

As part of normal turnaround maintenance on March 25, maintenance personnel observed a health and usage monitoring system (HUMS) alert about an epicyclic module chip detection

warning. They conducted a subsequent inspection of all main gearbox magnetic chip detectors and found no particles. Nevertheless, they replaced the body of the main module chip detector because it appeared to be loose.

After a second alert, a maintenance technician found “a small metallic particle” on the magnetic chip detector but believed this probably was associated with the replacement of the conical housing/rotor head earlier in the month.

“He informed the engineering supervisor of the presence of the magnetic particle,” the report said. “As he had already removed and inspected the epicyclic chip detector, he informed another engineer, who had been tasked with inspecting the magnetic chip detectors as part of the 25-hour check, that he would inspect the remaining magnetic chip detectors. He then checked the other two magnetic chip detectors. The work card for the completion of this task was subsequently signed off later that evening.”

Although the particle was removed from the epicyclic chip detector, maintenance personnel did not remove the epicyclic module or recover any particles that might have accumulated on the magnets that were part of the gearbox separator plate. “However,” the report said, “as a result of the discovery of the magnetic particle, the operator had initiated a plan to remove [the helicopter’s main gearbox] and replace it with a unit from another helicopter undergoing heavy maintenance.”

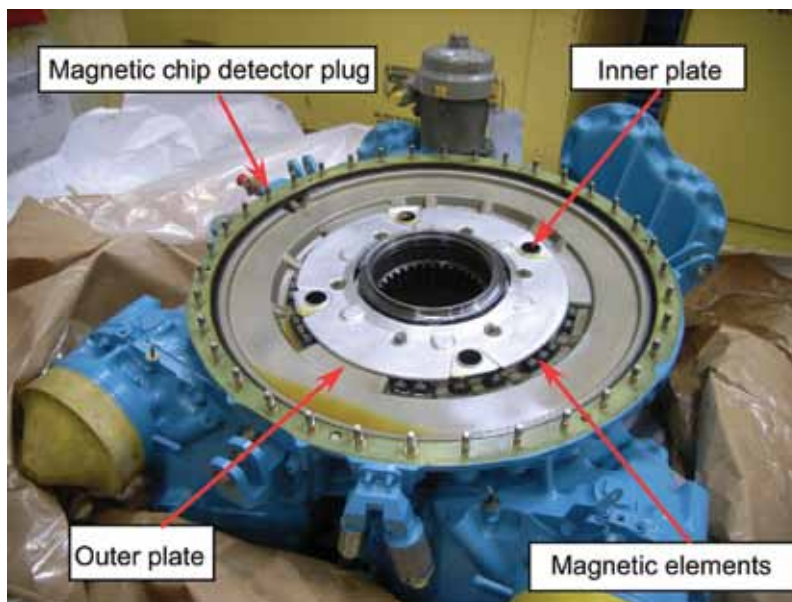
Manufacturer’s representatives, in phone calls and emails, issued several recommendations to the operator’s maintenance personnel and said that “if nothing abnormal is found [while carrying out the recommended actions], there is no need to ground the aircraft and you can go flying tomorrow morning.”

Manufacturer’s representatives later told accident investigators that they believed all three relevant tasks described in the aircraft maintenance manual had been completed. However, the final write-up of the problem and the related work did not mention one of the three tasks, which called for removal of the epicyclic module and examination of the ring of magnets on the oil separator plates.

The maintenance personnel examined the particle in accordance with the manufacturer’s recommended maintenance task information and concluded that it was “a piece of scale,” probably silver or cadmium plating, and therefore required neither close monitoring nor replacement of the gearbox, the report said, noting that the planned replacement was canceled. Subsequent testing determined that the particle was not silver or cadmium but 16NCD13 steel, planet gear outer race/gear material.

The operator ordered inspections of the epicyclic and main module chip detectors after every

Photographs from the accident report show the main module of an AS332 L2’s main rotor gearbox, with the epicyclic module removed, above, and the epicyclic module ring gear from the accident helicopter, soon after it was recovered from the sea, below.



shutdown for the next 25 flight hours. The inspections continued for 31 flight hours — until the day of the accident — and no additional particles were found.

When the accident occurred, the epicyclic module had accumulated 4,467 operating hours since new, and its planet gears had accumulated 3,623 hours since new. It had been overhauled and installed in the accident helicopter in April 2008.

A review of HUMS data revealed no recorded chip detector warnings from the installation date until March 23, 2009. On March 24, an epicyclic module chip detector warning was recorded while the helicopter was in cruise flight.

“The cumulative chip detection warning count then increased for the remainder of the operations of 24 March 2009, reaching a total of 667,” the report said. “The helicopter manufacturer considered such a high chip warning count as unusual. ... They considered the most likely explanation was a chip of a size which only just bridged the chip detector elements, making or breaking the electrical contact, depending on the oil flow in the gearbox.”

The HUMS card “did not close down normally” on March 24, so any alerts that were generated were not displayed on the ground station, the report said.

Multiple epicyclic chip detection warnings were recorded during each of two operations on March 25; none was recorded from March 26 through March 31. During the accident flight, recorded data indicated damage to the second stage epicyclic ring gear, and HUMS recorded four chip detector warnings in the four minutes preceding the crash. Other data showed a main gearbox oil low pressure warning, a master warning and the loss of right engine torque as the helicopter deviated from cruise flight. The last four seconds of the cockpit area microphone

recording included a “grinding noise,” and the combined voice and flight data recorder (CVFDR) recording and radio transmission recording contained the commander’s voice “expressing alarm.”

The CVFDR recording ended before the impact, limiting the data available for the latter part of the accident sequence, but HUMS data showed “a number of status and warning indications, including [main gearbox] chip detections, engine Ng¹ difference warnings, engine 2 oil chip detections and engine bleed air selections,” the report said.

Debris Contamination

The accident investigation focused on the failure of the gearbox epicyclic module. Investigators found considerable damage throughout the epicyclic module, “consistent with it operating for a period of time whilst contaminated with debris,” the report said.

Examination of the metallic particle that had been removed on March 25 from the epicyclic module magnetic chip detector confirmed that it had come from the surface of the outer race of a second stage planet gear bearing, the report said. The same area was the point of origination for a fatigue crack, which grew until the gear failed and broke into several sections. The section where the crack originated was not recovered from the sea.

The accident investigation did not determine the reason for initiation of the crack, but “the possibility of a material defect within the gear or foreign object debris could not be discounted,” the report said.

The report noted a similar accident in 1980 involving the failure of a stage two planet gear on an SA330J Puma. In that accident, “large quantities of metallic debris had been collected over a number of weeks, and the inner race had typical evidence of severe spalling”


— the breaking off of chips or scales, the report said.²

The report also noted that the introduction of a ring of magnets on the main rotor gearbox in AS332 L2s and EC225s “reduced the possibility of [detecting] metallic debris, generated in the epicyclic module, by the main module magnetic chip detector or by inspection of the oil filter.”

Safety Recommendations

The AAIB issued 17 safety recommendations as a result of its investigation, including those calling on Eurocopter to “introduce a means of warning the flight crew of the AS332 L2 helicopter in the event of an epicyclic magnetic chip detector activation” and to “introduce further means of identifying in-service gearbox component degradation, such as debris analysis of the main gearbox oil.”

The European Aviation Safety Agency (EASA) should research methods for “improving the detection of component degradation in helicopter epicyclic planet gear bearings,” the AAIB said.

Other recommendations said that EASA and the U.S. Federal Aviation Administration should take steps to minimize the loss of data from helicopter cockpit voice recorders and flight data recorders in the event of an accident. 

This article is based on AAIB Aircraft Accident Report 2/2011, Report on the Accident to Aero-spaciale (Eurocopter) AS332 L2 Super Puma, Registration G-REDL, 11 nm NE of Peterhead, Scotland on 1 April 2009. The report, issued Nov. 24, 2011, is available at <www.aaib.gov.uk/sites/aaib/publications/formal_reports.cfm>.

Notes

1. The report defined Ng as engine gas generator shaft rotational speed.
2. The helicopter crashed into a swamp forest in Brunei, killing both pilots and all 10 passengers.