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- independent investigation of transport accidents and other safety occurrences
- safety data recording, analysis and research
- fostering safety awareness, knowledge and action.

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Publication Date: May 2011  
ISBN 978-1-74251-170-2  
ATSB-May 11/ATSB43

Released in accordance with section 25 of the Transport Safety Investigation Act 2003

ATSB TRANSPORT SAFETY REPORT  
Aviation Occurrence Investigation A0-2010-089  
Interim-factual

# In-flight uncontained engine failure Overhead Batam Island, Indonesia 4 November 2010 VH-OQA Airbus A380-842

## Abstract

The Australian Transport Safety Bureau is investigating an occurrence involving a Qantas A380 aircraft that experienced an uncontained engine failure over Batam Island, Indonesia on 4 November 2010. The aircraft landed safely in Singapore having returned with the aircraft's No 2 engine shut down. There were no injuries.

The investigation team has inspected the damaged engine and components and determined the sequence of events that led to the failure of the engine disc.

The investigation is also examining the airframe and systems damage that resulted from the engine disc burst to understand its effect on those systems and the impact on flight safety. That includes their effect on the aircraft's handling and performance and on crew workload. A flight simulator program was used to conduct a number of tests in a certified A380 flight simulator. Analysis of the flight simulation test data is ongoing.

The investigation is continuing.

## FACTUAL INFORMATION

### Investigation update

The investigation team has developed into a large multi-agency group consisting of the Australian Transport Safety Bureau (ATSB) as the lead investigation agency with assistance from the

French Bureau d'Enquêtes et d'Analyses (BEA), the Air Accident Investigation Branch of United Kingdom (UK AAIB), the Air Accident Investigation Bureau of Singapore (AAIB Singapore), the National Transport Safety Committee of Indonesia (NTSC), and advisors to the various investigation bodies from Rolls-Royce, Airbus, SAFRAN Sagem, Honeywell (USA and UK), Aerolec UK and Singapore Aero Engine Services Private Limited.

### Regulatory action

Since the on-site phase of the investigation, the European Aviation Safety Agency (EASA) has facilitated a meeting between EASA, Rolls-Royce, Airbus and the Civil Aviation Safety Authority of Australia (CASA) with the ATSB, BEA and UK AAIB attending as observers. That meeting was to establish if the Rolls-Royce Trent 900 engine and the Airbus A380 airframe met the design certification requirements for the engine and airframe in light of the significant damage that resulted from this event. The engine manufacturer - Rolls-Royce - and the airframe manufacturer - Airbus - presented technical data and findings to that group. EASA and CASA agreed that, based on the information supplied, the airframe and engine meet the certification requirements. However, further investigation into the aircraft's structure and systems and engine behaviour is continuing to fully understand this event and establish if there are safety issues that need to be addressed.

### Disc failure

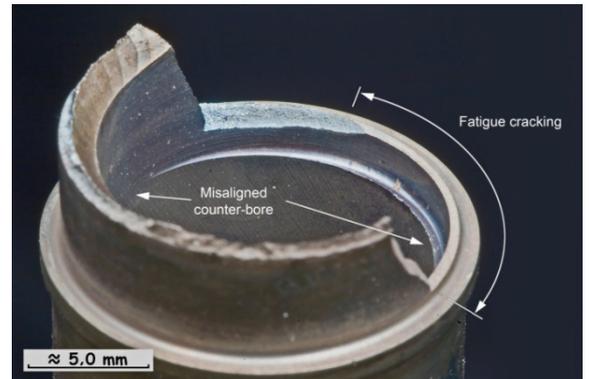
The ATSB, UK AAIB and Rolls-Royce have inspected the damaged engine and components

and determined the sequence of events that led to the failure of the engine disc. As a result of those findings, Rolls-Royce published a series of non-modification service bulletins (NMSB) with various amendments and a Service Bulletin (SB) to manage the continued serviceability of the Rolls Royce Trent 900 engine and EASA issued two Emergency Airworthiness Directives and one Airworthiness Directive. Qantas Airways initially placed operational restrictions on the Australian A380 fleet in conjunction with CASA. Commencing on 16 January 2011, those restrictions were progressively removed, as the fleet's continued airworthiness was established.

The investigation has found that the intermediate pressure (IP) turbine disc failed as a result of an overspeed condition, liberating sections of the IP turbine disc that then penetrated the engine case and wing structure. The disc failure was initiated by a manufacturing defect in an oil feed pipe that resulted in a wall thickness reduction in an area that is machined to receive a coarse filter. That section of the oil feed pipe sustained a fatigue crack during engine operations that led to an internal engine oil fire that weakened the IP turbine disc. In turn, a circumferential fracture was induced around the disc, allowing it to separate from the IP turbine shaft. The unrestrained disc accelerated to critical burst speed. This led to the No 2 engine failure and subsequent significant penetration damage to the airframe structure and systems.

Since the ATSB's Preliminary Report was issued, analysis of the oil feed pipe fracture surface has progressed and the investigation team has a better understanding of the failure mechanism. Technical reviews to date of the available evidence have established that the location of the fatigue cracking that was depicted in Figure 9 of the Preliminary Report<sup>1</sup> is not the area of interest. The area of fatigue cracking and misaligned counter bore is now understood to be as shown in Figure 1 below.

**Figure 1: Updated location of fatigue cracking**



At the time of the accident, there were three oil feed pipe modification standards in the IP turbine module case (module 51) of Rolls-Royce Trent 900 engines. Oil feed pipe modules were manufactured to those modification standards as follows:

- FW48020 standard modules, between October 2005 and May 2008 (42 units).
- FW59326 standard modules, between July 2007 and March 2009 (67 units).
- FW64481 standard modules, March 2009 and January 2011 (97 units).

As a result of this accident, Roll-Royce instigated the removal of Rolls-Royce Trent 900 engines from service with the following module 51 standards:

- all FW48020 standard modules, which included the accident engine
- 10 FW59326 standard modules
- one FW64481 standard module.

A lack of measurement records for the FW48020 standard oil feed pipes meant that Rolls-Royce was unable to establish whether those oil feed pipes had been manufactured to specification. A subsequent risk assessment by Rolls-Royce determined that there should be a fleet wide removal of the FW48020 standard engines from service.

The measurement records for a number of FW59326 standard engines were also not available. An on-wing measurement technique identified seven of those modules with an oil feed pipe wall thicknesses of less than the Rolls-Royce stipulated minimum acceptance limit of 0.5 mm. Those engines were removed from service. In addition, three other FW59326 standard engines

1 See [www.atsb.gov.au/media/2888854/ao-2010-089%20preliminary%20report.pdf](http://www.atsb.gov.au/media/2888854/ao-2010-089%20preliminary%20report.pdf)

were removed from service after an evaluation of their manufacturing measurement records.

Measurement records were available for all FW64481 standard module 51's. However, the oil feed pipe wall thickness on one FW64481 standard module was found to be less than the minimum acceptable limit and that engine was removed from service.

The oil feed pipe wall thickness for all remaining Trent 900 engines in operation was found by Rolls-Royce to either meet or exceed the minimum acceptable manufacturing limit.

The ATSB, in conjunction with the UK AAIB and Rolls-Royce, is examining the circumstances and missed opportunities with the potential to have detected the reduced wall thickness and offset counter bore of the oil feed pipe prior to, during and after the manufacture of the module 51 assemblies. The ATSB is also reviewing the quality audits undertaken of, and the quality assurance system affecting, the module 51 design and manufacturing process and their effectiveness in detecting deficiencies in that process.

### **Aircraft response to the disc failure**

The ATSB, in conjunction with Airbus, BEA and AAIB UK is also examining the airframe and systems damage that resulted from the engine disc burst to understand the effect on those systems and the impact on flight safety. That includes their effect on the aircraft's handling and performance and on crew workload.

As part of the investigation, a flight simulator program was developed by Airbus from data that was obtained from the aircraft's digital flight data recorder and cockpit voice recorder, from the aircraft's fuel quantity management system, and from pilot interviews conducted by the investigation team. An A380 test pilot and group of experienced A380 flight crews from Airbus, the BEA and the ATSB conducted a number of tests using that simulator program in a certified A380 flight simulator at the Airbus facility in Toulouse, France. Those tests sought to establish the aircraft's handling capabilities with the simulated damaged fuel transfer system, damaged flight controls and lift augmentation devices, and damaged electrics and electronic systems having effect. Various speeds and flight profiles were examined that simulated the

workload that was experienced by the crew during the event. The simulation found that the aircraft had operated in 'normal control law'<sup>2</sup>, in which, regardless of a flight crew's input, computers prevent the exceedance of a predefined safe flight envelope. If there are certain types or combinations of failures within the flight control system or its components, the control law automatically changes to a different configuration level: alternate law or direct law.

### **Ongoing investigation activities**

The investigation is continuing and will include:

- the testing and analysis of the black-coloured soot residue that was found in the left wing internal (No 2) fuel tank.
- additional analysis of the flight simulation test data
- the examination of the airframe and systems damage that resulted from the engine disc failure
- the ongoing review of the quality control and quality assurance system affecting the Trent 900 module 51 design and manufacturing process
- analysis of the flight crew work load
- the review of the aircraft's maintenance, including engine workshop visits.

At the time of this update, the aircraft remained in Singapore, where repair schemes were being developed by Airbus and relevant components were being manufactured to facilitate that repair.

The gathering and compilation of the large amount of complex factual information is anticipated to be concluded by the end of July 2011. The analysis of that information and development and review of the investigation, including by directly involved parties in accordance with international protocols, is anticipated for completion by May 2012.

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<sup>2</sup> In Airbus products, the relationship between a flight crew order (or control input) and the aircraft response is termed a 'flight control law'. The main objective of the normal control law is to provide instinctive and comfortable handling characteristics and comfort to those on board.