Australian Government
Australian Transport Safety Bureau

Birdstrike and engine failure involving Airbus A330, 9M-XXT

Gold Coast Airport, Queensland, 3 July 2017

ATSB Transport Safety Report
Aviation Occurrence Investigation
AO-2017-070
Final – 2 May 2018

Birdstrike and engine failure involving Airbus A330, 9M-XXT

What happened

On the night of 3 July 2017, AirAsia X[1] flight D7207, an Airbus 330 aircraft, registered 9M-XXT, taxied at Gold Coast Airport, Queensland for a scheduled passenger transport flight to Kuala Lumpur, Malaysia. On board the aircraft were two flight crew, 12 cabin crew and 345 passengers.

During the taxi to runway 32, all engine indications were normal.

At 2249 Eastern Standard Time, the flight crew commenced the take-off roll. Flight data recorder data shows that Engine 2 vibrations increased as the aircraft approached its take-off rotation speed. After take-off, passing approximately 2,300 ft, the electronic centralised aircraft monitor (ECAM) displayed an ENG 2 STALL alert. At the same time, loud banging noises associated with an engine stall could be heard in the aircraft. The flight crew commenced the ECAM actions for the ENG 2 STALL procedure and made a PAN PAN[2] call to air traffic control.

As the aircraft continued climb to 4,000 ft, the ECAM displayed an ENG 2 FAIL alert. About this time the flight crew received an interphone call from the cabin purser advising of a 'starboard engine fire', which was visible from the aircraft cabin and had been reported to the purser by a company pilot, who coincidentally was travelling as a passenger.

In response to the ECAM alert and report from the cabin purser, the flight crew carried out the ENG 2 FAIL procedure with damage actions, including discharging the fire suppression system.

The flight crew upgraded the distress phase to a MAYDAY[3] with air traffic control and requested a diversion and approach to runway 01 at Brisbane Airport for an overweight, single engine landing. The aircraft landed safely at 2310.

After the aircraft vacated the runway, the captain held the aircraft on the taxiway to allow the airport emergency services to inspect the engine before they taxied the aircraft to the arrival gate.

Information from the Gold Coast Airport operator

After the aircraft departed, the Gold Coast Airport operator performed a visual inspection of runway 32. Bird remains and engine debris were recovered on runway 32 around the intersection of taxiway D. This included one complete carcass, as well as additional debris from another bird. Other than the evidence of birds, no foreign objects were found with the potential to have resulted in the damage to the engine.

Video recordings of the runway were reviewed by the airport operator. That review identified flashes of flame emitted from the rear of engine 2 during the take-off ground roll, and the location of these flashes coincided with the area near where the bird remains and engine debris were collected. Tissue samples from the bird remains were sent to the Australian Museum, which identified the bird species as a masked lapwing (commonly known as a plover). A masked lapwing is a common medium-sized, 30–37 cm in length and weighing between 0.23–0.40 kg (see the *ATSB Bird information sheet number 3* for more detail).

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1 AirAsia X is the medium and long-haul, low-cost affiliate carrier of the AirAsia Group. AirAsia X is based in Malaysia and operates a core fleet of A330-300 aircraft.

2 PAN PAN: an internationally recognised radio call announcing an urgency condition which concerns the safety of an aircraft or its occupants but where the flight crew does not require immediate assistance.

3 MAYDAY: an internationally recognised radio call announcing a distress condition where an aircraft or its occupants are being threatened by serious and/or imminent danger and the flight crew require immediate assistance.

A post-mortem examination of the complete carcass by a veterinary specialist determined it was unlikely to have been struck by a moving object and its damage was likely the result of wake vortex. Examination of debris from the other bird identified no evidence of burning, which could be expected if the bird had been ingested into an aircraft engine.

Aerodrome bird hazard management

Part 139 of the Australian Civil Aviation Safety Regulations requires that aerodrome operators have procedures to deal with the danger to aircraft operations caused by the presence of birds on or near the aerodrome. This includes arrangements for assessing any bird or animal hazard and the removal of any such hazard. The operator of Gold Coast Airport had a comprehensive wildlife hazard management plan in place.

In 2017, the ATSB published a research report (AR-2016-063) titled *Australian aviation wildlife strike statistics.* The report provided information to pilots, aerodrome and airline operators, regulators, and other aviation industry participants to assist them with managing the risks associated with bird and animal strikes. For the 10-year period 2006 to 2015, this report stated that 480 birdstrikes (average of 48 per year) were reported to have occurred in the aerodrome confines at Gold Coast Airport. This equated to an average of 5.15 birdstrikes per 10,000 movements[4] at Gold Coast Airport.

Most birdstrikes involving large air transport aircraft do not result in damage (about 95 per cent). About 10 per cent of birdstrikes involving aircraft with turbofan engines result in the bird being ingested into an engine.

Across Australia, the lapwing/plover family of birds has been the third most common bird/bat struck by aircraft across the 10-year period (868 strikes). About 5 per cent of strikes involving lapwing/plover birds have resulted in some aircraft damage, and about 15 per cent involved more than one bird being struck.

The Australian Airports Association published *Managing bird strike risk species information sheets* focused on managing the strike risk of several bird species at Australian airports. The information sheet for the masked lapwing stated that risk assessments often ranked these birds as moderate to very high risk due to their presence on airfields, particularly in critical aircraft movement areas such as flight strips, and their highly territorial behaviour. The sheet also noted that masked lapwings often loaf at off-airport locations during daylight hours before moving to airports at night to forage. This results in increased numbers flying on and around airports during periods of decreased visibility, thereby increasing the probability of a strike.

Masked lapwings can occur in large flocks in periods just prior to their breeding season. The ATSB *Australian aviation wildlife strike statistics* report states that birdstrikes involving lapwing/plover birds peak between 1900 and 2100 in the evening and 0700 to 1000 in the morning.

Statistics provided by Gold Coast Airport indicated that over the previous 12 months (July 2016 to June 2017), 237 masked lapwings had been dispersed and 34 culled. The figures for previous years were generally similar, although the figures for the period July 2015 to June 2016 were much higher. It was not unusual for the birds to not require active management for several days at a time, and none had been dispersed or culled in the 4 days prior to the occurrence. Throughout the remainder of July 2017, 35 were dispersed and 45 culled.

Engineering examination of the engine

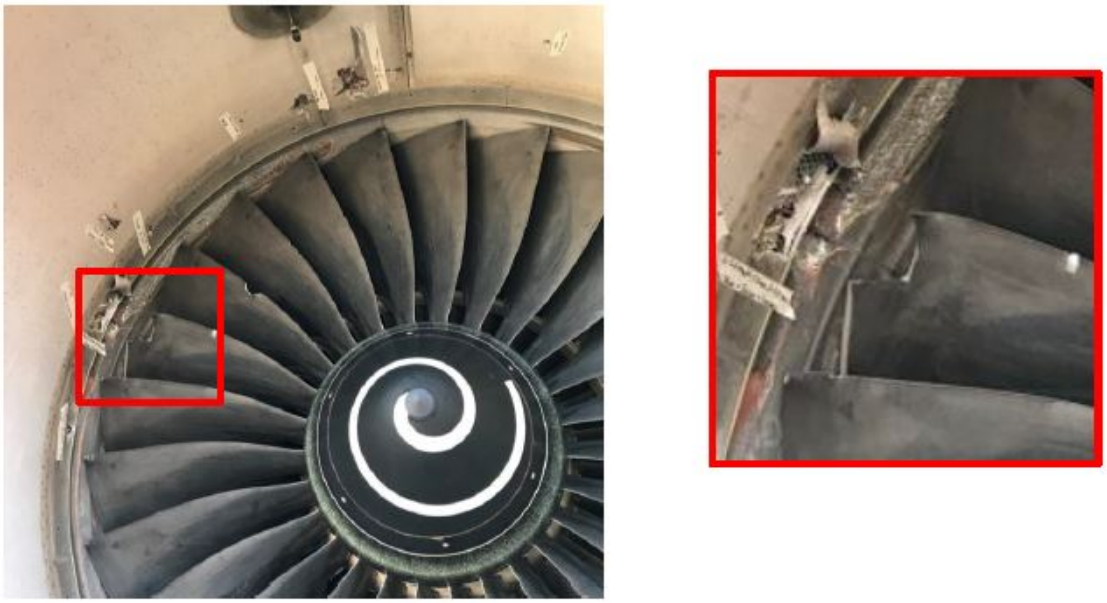
The aircraft was fitted with two Trent 700 engines, manufactured by Rolls Royce.

After the occurrence, an engineering examination at Brisbane Airport found a single fan blade-tip section, approximately 140 mm x 125 mm, had fractured from one fan blade and the fan rear seal

[4] Movement refers to the combination of departures and landings.

was found broken into pieces and scattered throughout the bypass areas of the engine (Figure 1). There was also evidence of fire within the engine.

Figure 1: Damage to Rolls Royce Trent 700 engine fan blades



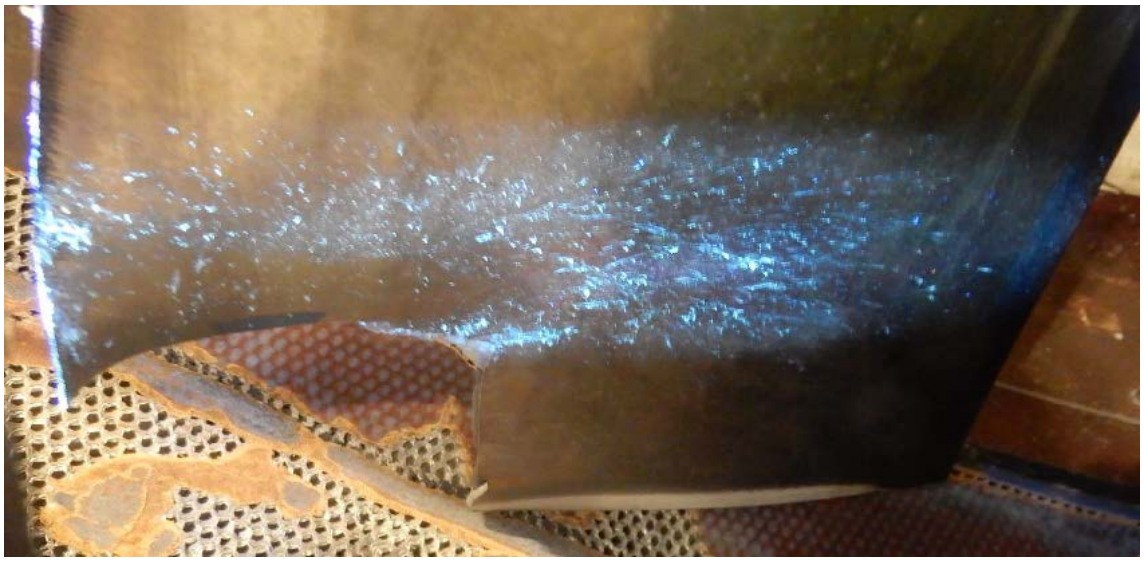
Source: Rolls Royce

A sample of visible organic debris was taken from engine 2 in Brisbane and sent for DNA analysis. Testing of this sample was unable to provide a result. The reasons for this could not be determined, but are usually associated with a sample being affected by heat or storage conditions.

The engine was later shipped to Hong Kong for a controlled engine strip and detailed inspection by the engine manufacturer. Some key results of the inspection related to the fan blades included:

- The front section of the engine was subjected to an ultraviolet (UV) light inspection to highlight areas of organic debris for swabbing for DNA evidence of bird ingestion. The UV light identified that organic debris was present in a number of locations around the circumference of the fan blade set and in other areas of the engine. DNA analysis identified that this debris was from masked lapwing bird(s).
- UV light inspection identified that blade 1 (the blade with the released tip) had organic debris in the area near the blade-tip release (Figure 2), and there was also organic debris on the blade-tip that was recovered at Brisbane Airport. DNA analysis confirmed the debris from the blade and the blade-tip was from a masked lapwing.
- Based on the distribution of the debris and engine speed conditions, the engine manufacturer concluded that multiple birds had impacted the fan. However, the damage on or near blade 1 was consistent with impact with a single bird.
- Blade 1 exhibited cupping damage consistent with soft body impact close to the point of material release. The radial height of the fracture on the blade was in a leading edge impact cup at approximately 84 per cent blade-height (Figure 1 and Figure 2).
- Laboratory analysis of the fracture surface of blade 1 confirmed the fracture mode as overload. There was no evidence of fatigue or pre-existing material deficiencies that could have contributed to the release of the blade-tip.
- There was blade damage on a blade adjacent to blade 1 (see to the right of the red square in Figure 1). This damage to the adjacent blade was consistent with impact from a hard body, and laboratory analysis did not identify that any foreign object had impacted that blade.

Figure 2: Ultraviolet light showing bird remains on damaged fan blade



Source: Rolls Royce

The engine manufacturer conducted a theoretical analysis to determine under what conditions an impact with a bird with a mass of 0.85 lb (0.39 kg), such as a masked lapwing, could have resulted in the discovered condition of the engine fan blade. The analysis used the engine and aircraft speed conditions at the time of the event (88 per cent N1[5] and an aircraft speed of 120–140 kt) and modelled variations of strike position (radial height) and angle of incidence (bird orientation). Only one of the modelled scenarios matched the results of the occurrence event. This was a strike from a bird with the bird's longitudinal axis aligned with the relative velocity of the blade[6] at a radial height of 83 per cent.

The engine manufacturer concluded that the release of the blade-tip was the result of an impact from a masked plover.

In terms of other aspects of the engine examination, the engine manufacturer advised:

- The loss of material from a single blade caused the fan to run out of balance while the engine was at take-off thrust. This out of balance operation generated high levels of N1 vibration, as recorded on the aircraft's flight data recorder.
- It is most likely that the outboard section of the fan rear seal released following contact between the rotating and static members, as a result of high thrust engine operation with the fan out of balance. Fragments of this seal likely entered the core of the engine leading to significant damage to the compressors. This resulted in a series of compressor stalls, which prompted the flight crew to reduce the engine thrust setting to idle in response to the ECAM ENG 2 STALL alert.
- At about the time of the ENG 2 STALL alert, the oil quantity on the affected engine diverged from that on engine 1. There was a loss of clamping across the front bearing chamber elastomeric oil seal, as a result of bolt unwinding. This loss of clamping allowed oil to leak from this location, and the oil ignited either by the frictional heat from the rubbing seals or the relative movement between the front bearing housing and the low pressure roller bearing housing.
- The resulting oil fed fire established in the cavity between the front bearing housing and the fan disc. This fire caused failure and melting of aluminium alloy components in this cavity but was not sufficient to affect the structural engine parts made from materials with higher melting

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5 N_1: the rotational speed of the low pressure compressor in a turbine engine.

6 This vector is a combination of the blade's rotational speed and the aircraft's forward speed. It will generally be significantly different to the aircraft's flight path.

points that were in the same region. It is likely that once the bolts had fully unwound, the air pressure and oil feed conditions changed sufficiently so that the fire self-extinguished.

Engine design requirements

The Rolls Royce Trent 700 engine met the engine certification standards for the ingestion of birds. These requirements were outlined in the European Joint Aviation Regulation JAR-E 800. For medium-sized and small birds, these requirements stated that:

> It shall be established that when the front of the Engine is struck by a number of medium sized birds… or small birds… there is no unacceptable immediate or ultimate loss of Engine performance, no serious increase of Engine operating temperatures or deterioration of Engine handling characteristics, over the full range of Engine operating conditions, and no dangerous physical damage…

Medium sized birds were considered to have a weight of 0.7 kg (or 1.5 lb) and small birds up to 0.11 kg. The specified test required the impact with a number of birds to be tested over a short duration (not more than 1 second), with the number of birds dependent on the size of the engine and the size of bird.

According to the engine manufacturer, what occurred to the engine during the occurrence flight:

- …is not as experienced during the medium bird certification test when 8 birds of at least 1.5lbs [0.68 kg] were fired into the engine at >168 kts with the bird trajectory longitudinally aligned with the engine...
- The certification test point is intended to demonstrate a level of capability in a worst case situation of aircraft above decision speed (V_1[7]) but below 1500 ft, where the aircraft is committed to flight but has minimum amount of forward speed and is therefore dependent on engine thrust to climb safely…
- The certification birdstrike test is a benchmark test which demonstrates a level of engine capability as required by certifying authorities. The findings of this event do not undermine the capability of the Trent 700 engine with respect to birdstrike and the engine today would be expected to replicate the behaviour demonstrated during the previous test. The Trent 700 has experienced over 430 reported in-service birdstrike events with only five events resulting in fan blade material loss, all except this event were caused by birds greater than 2.5lb [1.14 kg].
- It is concluded that in this event a rare combination of 0.85lb bird ingestion at adverse forward speed during the take-off roll (close to V_1 but lower than V_R[8]) and angle of incidence combined to cause the release of a small section of blade which [led] to the engine producing only idle thrust after approximately 2 minutes and leading to commanded shutdown approximately 4 minutes after the release of fan blade material.

Safety analysis

Based on the available evidence, the engine failure was concluded to be the result of a birdstrike involving a masked lapwing. As the remains of the two birds found on the runway did not show signs of being involved in an engine ingestion, the engine failure was almost certainly a result of an additional bird.

The ATSB reviewed the aircraft's flight data recorder, cockpit voice recorder and statements from the flight crew. From these data sources the ATSB determined that the flight crew effectively managed the abnormal situation and diversion. The cabin purser relayed to the flight crew

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7 V_1: the critical engine failure speed or decision speed required for take-off. Engine failure below V_1 should result in a rejected take off; above this speed the take-off should be continued.

8 V_R: the speed at which a positive, nose-up, movement of an aircraft about the lateral (pitch) axis is commenced immediately before becoming airborne.

relevant information about a possible number 2 engine fire observed from within the cabin. This information assisted the decision-making of the captain.

Although aircraft engines are designed to withstand most types of birdstrikes, including those involving medium-sized birds such as a masked lapwing, this event appeared to involve a rare scenario comprising a combination of aircraft and engine speeds, the height of the fan blade at which the birdstrike occurred, and its angle of incidence. It is extremely unlikely such a scenario would occur on multiple engines simultaneously.

Findings

These findings should not be read as apportioning blame or liability to any particular organisation or individual.

- During the take-off the number 2 engine was subjected to a birdstrike, which resulted in the release of a small section of a fan blade.
- Following an ECAM ENG 2 FAIL alert, the flight crew shut down number 2 engine, advised air traffic control of the situation and diverted to land as soon as possible at Brisbane Airport.

Safety action

Whether or not the ATSB identifies safety issues in the course of an investigation, relevant organisations may proactively initiate safety action in order to reduce their safety risk. The ATSB has been advised of the following proactive safety action in response to this occurrence.

Rolls Royce

Following this occurrence, the engine manufacturer met with the European Aviation Safety Agency, the certifying authority for the engine, to discuss the event and the manufacturer's investigation.

The engine manufacturer also advised that its Trent 700 project team will review the design of the fan rear seal and the low pressure roller bearing bolts to determine if there is a feasible solution to prevent the loss of a small section of fan blade leading imminently to an engine shutdown.

AirAsia X

As a result of this occurrence, AirAsia X advised the ATSB that it had conducted its own internal investigation. The occurrence information will be shared with flight crew in recurrent training programs and used to enhance simulator training exercises.

Safety message

This occurrence highlights the importance of effective crew resource management techniques, including cabin crew passing on pertinent information to flight crew, and robust emergency procedures. Additionally, regular proficiency checks in the simulator, including engine failure scenarios, allow flight crew to respond appropriately in the event of such an occurrence in flight.

General details

Occurrence details

Date and time:	3 July 2017 – 2235 EST	
Occurrence category:	Incident	
Primary occurrence type:	Birdstrike	
Location:	Near Gold Coast Airport	
	Latitude: 28° 09.87' S	Longitude: 153° 30.28' E

Aircraft details

Manufacturer and model:	Airbus A330	
Registration:	9M-XXT	
Operator:	AirAsia X	
Serial number:	1549	
Type of operation:	Air Transport High Capacity - Passenger	
Persons on board:	Crew – 14	Passengers – 345
Injuries:	Crew – 0	Passengers – 0
Aircraft damage:	Minor	

About the ATSB

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The ATSB is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; and fostering safety awareness, knowledge and action.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to operations involving the travelling public.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

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

It is not a function of the ATSB to apportion blame or determine liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, 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. For this occurrence, a limited-scope, fact-gathering investigation was conducted in order to produce a short summary report, and allow for greater industry awareness of potential safety issues and possible safety actions.