

Inquiry AO-2012-002: Airbus A320 ZK-OJQ, Bird strike and subsequent engine failure,
Wellington and Auckland International Airports, 20 June 2012

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Final Report

Aviation inquiry 12-002
Airbus A320 ZK-OJQ
Bird strike and subsequent engine failure
Wellington and Auckland International Airports
20 June 2012

Transport Accident Investigation Commission

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The Transport Accident Investigation Commission (Commission) is an independent Crown entity responsible for inquiring into maritime, aviation and rail accidents and incidents for New Zealand, and co-ordinating and co-operating with other accident investigation organisations overseas. The principal purpose of its inquiries is to determine the circumstances and causes of the occurrences with a view to avoiding similar occurrences in the future. Its purpose is not to ascribe blame to any person or agency or to pursue (or to assist an agency to pursue) criminal, civil or regulatory action against a person or agency. The Commission carries out its purpose by informing members of the transport sector, both domestically and internationally, of the lessons that can be learnt from transport accidents and incidents.

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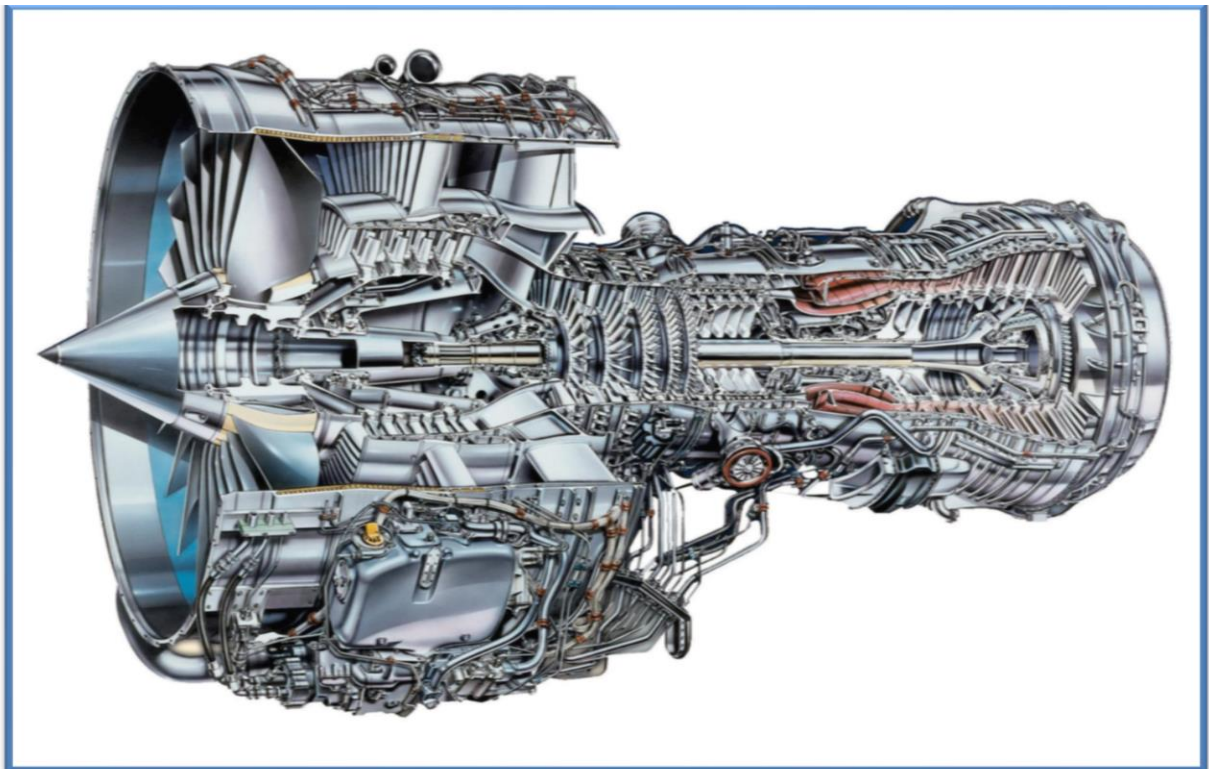
Information derived from interviews during the Commission's inquiry into the occurrence is not cited in this final report. Documents that would normally be accessible to industry participants only and not discoverable under the Official Information Act 1980 have been referenced as footnotes only. Other documents referred to during the Commission's inquiry that are publicly available are cited.

Photographs, diagrams, pictures

Unless otherwise specified, photographs, diagrams and pictures included in this final report are provided by, and owned by, the Commission.



Airbus A320 – ZK-OJQ
(Courtesy of Colin Hunter)



International Aero Engines V2500 turbofan engine



Location of incidents

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Abbreviations

°C	degree(s) Celsius
AAIB	Air Accident Investigations Branch (United Kingdom)
ACARS	aircraft communication addressing and reporting system
ACMS	aircraft condition monitoring systems
AGL	above ground level
AIRCOM	aircraft communications ground server
AMM	aircraft maintenance manual
ATC	air traffic control
BEA	Bureau d'Enquêtes et d'Analyses (France)
CAA	Civil Aviation Authority (New Zealand)
DNA	deoxyribonucleic acid
EASA	European Aviation Safety Agency
ECM	engine condition monitoring
EEC	electronic engine control
EGT	exhaust gas temperature
FADEC	full authority digital electronic control
FOD	foreign object damage
HPC	high pressure compressor
HPT	high pressure turbine
IAE	International Aero Engines
ICA	Instructions for Continued Airworthiness
ICAO	International Civil Aviation Organization
LPC	low pressure compressor
LPT	low pressure turbine
MOC	maintenance operations control
NTSB	National Transportation Safety Board (United States)
RPM	revolutions per minute
VHF	very high frequency
VIGV	variable inlet guide vanes
VSV	variable stator vanes

Glossary

borescope	an optical device consisting of a lens connected by a flexible fibre-optic cable to an eyepiece or LCD screen. Used for inspecting the internal condition of a component or engine
clapper	a compressor blade mid-span support designed to prevent aerodynamic instability and vibrations
compressor stall	the disruption of normal airflow through the compressor section of an engine resulting from a stall of the aerofoils. The event may vary from a minor power loss that occurs too quickly to be seen on engine instruments, to a complete breakdown of airflow through the compressor (surge) requiring a reduction of fuel flow to the engine
cycle	one take-off and one landing
engine core	the central portion of an engine containing the compressor, combustion and turbine sections. The outer section or bypass duct contains the frontal fan and bypass components the speed of the fan or low- pressure spool expressed as a percentage of the RPM.
N1 rotor speed:	the speed of the fan or low-pressure spool expressed as a percentage of the RPM
N2 rotor speed:	the speed of the high-pressure spool expressed as a percentage of the RPM
shingling	the overlapping movement of the blade clapper platform mating edge with the adjacent blade clapper platform edge
teardown	the disassembly of an item for examination or repair

Data summary

Aircraft particulars

Aircraft registration:	ZK-OJQ
Type and serial number:	Airbus A320, 232
Number and type of engines:	two International Aero Engines V2527-A5
Year of manufacture:	2011
Operator:	Air New Zealand
Type of flight:	scheduled passenger
Persons on board:	172 (including the crew)
Captain's qualifications:	airline transport pilot licence with category C and D instructor qualifications
Captain's flying experience:	16,464 hours total (including 2,183 hours on type)

Date and time 20 June 2012, 1515¹

Location of incident

Wellington International Airport

latitude: 41° 19' 38" south
longitude: 174° 48' 19" east

Auckland International Airport

latitude: 37° 00' 29" south
longitude: 174° 47' 30" east

Injuries

nil

Damage

significant to right engine

¹ Times in this report are New Zealand Standard Time (co-ordinated universal time [UTC] + 12 hours) and are expressed in the 24-hour mode.

1. Executive summary

- 1.1. On 20 June 2012 an Air New Zealand Airbus A320 was landing at Wellington International Airport when it suffered a bird strike to its right engine. The bird strike did not affect the landing. The bird was later identified as a black-backed gull.
- 1.2. Maintenance engineers inspected the engine in accordance with the Airbus aircraft maintenance manual and released it back into revenue service later the same day for a flight to Auckland with 172 persons on board, including five crew members.
- 1.3. The Airbus aircraft maintenance manual required parts of the engine to be inspected using a borescope.² However, as the bird strike had involved only one engine and no damage had been observed, the aeroplane was allowed to continue in service for up to 10 hours' flying or one more sector (one more take-off and landing), whichever came first. The engine was then required to undergo the borescope inspection. The aeroplane was released to fly to Auckland under this "continued operating allowance".³
- 1.4. On approach to land at Auckland International Airport the same engine suffered a failure. The captain reduced the engine thrust to idle and continued with the landing. Although damaged internally, the engine continued to run and was used during the landing.
- 1.5. An inspection of the failed engine revealed damage to components caused by the bird being ingested down the core of the engine.⁴ This damage had led to cracking in a compressor blade in the third-stage compressor. The crack in this blade grew further under the stress of continued engine operation in a damaged state. It finally fractured completely and caused significant damage to other components as it passed through other compressor stages in the jet engine.
- 1.6. This was the first reported occurrence worldwide where a V2500 engine had failed while operating under the continued operating allowance having had a bird strike down the engine core. The Transport Accident Investigation Commission (Commission) reviewed the operating parameters and airworthiness requirements that underpinned the authority to continue operating the engine. The Commission **found** that the resultant risk to aviation safety was reasonable, so made no recommendations.
- 1.7. The aeroplane systems would normally have generated automatic reports to the operator's maintenance operations control during the flight, which could have alerted it that the damage to the engine from the bird strike was worse than initially thought. However, these did not reach the control centre as intended. The reasons that gave rise to this have now been rectified.
- 1.8. The Commission also reviewed the Wellington International Airport Limited's measures to control bird life around the aerodrome, and **found** that these met industry best practice.
- 1.9. The Commission has made no new recommendations arising from this inquiry. However, it notes the following **key lessons**:
 - Although the safety of the aeroplane and the persons on board was not unduly compromised by releasing the aeroplane to service knowing that a bird had been ingested into the core of one engine, operators will need to balance the cost of having inspection services available at key aerodromes into which they fly with the cost of an engine failure of this scale.

² A borescope is an optical device consisting of a lens connected by a flexible fibre-optic cable to an eyepiece or LCD screen. Used for inspecting the internal condition of a component or engine.

³ Also referred to as a "fly on" allowance.

⁴ The engine core is the central portion of an engine containing the compressor, combustion and turbine sections. The outer section or bypass duct contains the frontal fan and bypass components.

- Even if the minimum mandatory checks are made to an engine that has suffered a bird strike down the core, if the aeroplane is released to service before the required full inspection has been undertaken, the pilots and ground engineering services should maintain increased vigilance of engine performance until the appropriate full maintenance checks can be completed.

2. Conduct of the inquiry

- 2.1. The engine failure occurred at about 1515 on Wednesday 20 June 2012. The Transport Accident Investigation Commission (Commission) was notified by the Civil Aviation Authority (CAA) later that evening. After making preliminary enquiries the Commission opened an inquiry on 21 June 2012 under section 13(1) of the Transport Accident Investigation Commission Act 1990, and appointed an investigator in charge.
- 2.2. On Thursday 21 June 2012 the investigator in charge, assisted by a second investigator who had engineering experience, travelled to Auckland to inspect the aeroplane and engine. During the next two days the investigation team interviewed the following Air New Zealand (operator) personnel:
- the captain of the flight from Wellington to Auckland
 - the engineers who met the aeroplane on arrival in Auckland
 - the engineering management and safety personnel involved.
- 2.3. During the following week the investigators interviewed:
- the engineer who carried out the bird strike inspection at Wellington
 - the operator's line maintenance manager at Wellington
 - Wellington air traffic control staff working in the control tower, including the controller on duty at the time of the incident
 - Wellington International Airport Limited (Wellington airport) personnel concerned with bird management on the aerodrome.
- 2.4. The Commission's investigators also obtained a number of records and documents, including:
- CAA bird strike and near-miss data for New Zealand aerodromes
 - aerodrome bird strike data and management procedures for the major aerodromes around the country
 - aeroplane flight data recorder information.
- 2.5. On 9 July 2012 the French Bureau d'Enquêtes et d'Analyses (BEA), the United Kingdom Air Accident Investigations Branch (AAIB) and the United States National Transportation Safety Board (NTSB), as the states of manufacture of the aeroplane or engine, were informed of the incident and invited to participate. BEA and AAIB appointed non-travelling Accredited Representatives in accordance with Annex 13 to the International Civil Aviation Organization's Convention on International Civil Aviation. NTSB elected not to appoint an Accredited Representative, and instead nominated a contact person to co-ordinate any requests for support.
- 2.6. The Commission notified the engine manufacturer, International Aero Engines (IAE),⁵ of the incident. The Commission accepted an offer of assistance from IAE, which then appointed Rolls-Royce Air Safety Investigation as the initial point for communications. IAE later also nominated a Pratt & Whitney representative to assist the investigation. The Commission also notified the aeroplane manufacturer, Airbus, of the incident.
- 2.7. The engine was sent to the Christchurch Engine Centre for examination under the supervision of the Commission. A full teardown⁶ of the engine was performed and components sent to Rolls-Royce for further detailed inspection. Induction and teardown reports were obtained from the engine centre. On 16 October 2012 IAE (Rolls-Royce) provided a technical services

⁵ A joint consortium of Pratt & Whitney, Rolls-Royce plc, Japanese Aero Engine Corporation and MTU Aero Engines. Fiat Avio was also initially a partner but withdrew from the consortium early in the engine's development. It remained as a supplier.

⁶ A teardown is the disassembly and inspection of an engine.

report covering the specialist examination of the removed components and an overview of the rotor blade fractures on the engine. The report also included engine reliability data and a bird strike risk assessment.

- 2.8. On 19 June 2013 IAE provided a copy of its final technical services report on the examination of the engine. On 21 June 2013 the Commission provided a list of questions to IAE for further comment.⁷ On 15 November 2013 Pratt & Whitney provided a response to those questions.
- 2.9. On 15 January 2015 the Commission sought comment from BEA, on behalf of Airbus and the European Aviation Safety Agency (EASA), the airworthiness authority for the Airbus A320. A response was received on 27 January 2015 and as a result NTSB was asked to comment as the representative for the state of manufacture of the engine. On 26 February 2015 a teleconference was held involving representatives of NTSB, IAE (Pratt & Whitney) and the Commission.
- 2.10. On 26 March 2015 the Commission approved a draft version of this report for circulation to interested persons for comment. Submissions were received from the operator and crew, and considered in preparing the final report.
- 2.11. On 28 May 2015 the Commission approved the publication of the report.

⁷ Because of a changed commercial arrangement, Rolls-Royce forwarded the questions to Pratt & Whitney for response.

3. Factual information

3.1. Narrative

- 3.1.1. On the morning of Wednesday 20 June 2012, an Airbus A320-232 aeroplane, registration ZK-OJQ, was on a scheduled flight from Auckland to Wellington. The flight was uneventful until the aeroplane was landing at Wellington, when a bird struck the right engine. The crew was unaware of the bird strike and the pilot flying selected reverse thrust as normal. Shortly afterwards a strong odour characteristic of bird ingestion was evident in the cockpit and cabin of the aeroplane.
- 3.1.2. The crew reported the bird strike to the tower controller and line maintenance personnel when they arrived at the gate.⁸ An engineer met the aeroplane at the gate and spoke with the pilots. They agreed that the odour was consistent with a bird having been ingested into an engine. The maintenance engineer made an initial inspection of the engine and confirmed that the bird had entered the core of the right engine. The aeroplane was removed from service for a bird strike inspection in accordance with the Airbus aircraft maintenance manual (the maintenance manual). See Appendix 1 for a full description of the inspection procedure.
- 3.1.3. The three engineers who inspected the engine collected the bird remains from around the engine and sent them to the University of Auckland for a deoxyribonucleic acid (DNA) analysis, which confirmed that the remains were that of a male black-backed gull.
- 3.1.4. The lead engineer completed all the tasks outlined in the maintenance manual procedure for when an engine has suffered a bird strike. In addition to the checklist items he inspected the first stage rotor blades of the low-pressure compressor (LPC) stage 1.5⁹ with a mirror and torch. He said his experience had shown the need to check this specific area of the low-pressure compressor for damage after a core ingestion. No damage was detected during the inspection.
- 3.1.5. The engineer then performed a low-power engine ground run¹⁰ while the aeroplane was still positioned at the gate. With the doors closed the right engine was run at idle power for eight or nine minutes to check the engine and to try to clear the odour from inside the aeroplane. The engineer had other people walk through the aeroplane to determine if the odour was clearing, and after confirming it had cleared sufficiently he shut the engine down. He recalled that the N1 and N2 rotors of the right engine had shown no signs of increased vibrations during the engine run.¹¹
- 3.1.6. The maintenance manual bird strike inspection checklist for a suspected core ingestion directed that the engineer perform a borescope inspection of the engine's low-pressure compressor stages 1.5 and 2.5, and high-pressure compressor (HPC) stages 3 and 6. Because the bird strike had affected one engine only, the maintenance manual provided a continued operating allowance of "less than 10 flight hours or 2 flight cycles,¹² which occurs first" before the borescope inspection needed to be completed. The engineer consulted the operator's maintenance operations control (MOC) then released the aeroplane to service using the continued operating allowance. He also raised a maintenance task card for the borescope inspection to be performed when the aeroplane arrived in Auckland.
- 3.1.7. A replacement flight crew arrived later on the same day to fly the aeroplane to Auckland. The engineer briefed the captain about the bird strike and the captain was agreeable to flying the aeroplane as long as the engineer and MOC were satisfied that the requirements had been

⁸ The parking gate adjacent to the terminal.

⁹ The various stages of the engine's compressor sections are numbered from the front of the engine starting with the fan blades as LPC 1 followed by LPC 1.5, through to the high-pressure section.

¹⁰ Idle, or close to idle, power only.

¹¹ Vibration detection equipment can help to identify engine damage.

¹² A cycle is one take-off and one landing.

met and the aeroplane was cleared for the flight. The engineer told the captain that he had performed the required maintenance tasks and that MOC had been involved with his decision to return the aeroplane to service.

- 3.1.8. The engineer told the captain that even though he had run the engine to clear the smell, there could still be a smell in the aeroplane when they left Wellington. The engineer asked the captain if it was possible to give the engine a good run-up before take-off to check that the engine performance parameters were normal.
- 3.1.9. At about 1430 the passengers boarded for the flight to Auckland. The captain told the passengers that there could be a smell during the initial stages of the flight. When the aeroplane reached the runway threshold the captain held it on the brakes and increased power to check the engine parameters as the engineer had requested.¹³ All appeared to be normal, so he released the brakes and commenced the take-off. As soon as the aeroplane became airborne there was a strong smell as expected. The captain said the smell improved slightly as the flight continued.
- 3.1.10. The flight from Wellington to Auckland took about 35 minutes and included a few minutes only in the cruise. Soon after levelling at cruise altitude the first officer quickly completed the trip number record and exhaust gas temperature (EGT) divergence monitoring form. The form was not required to be completed on such a short flight, as normally the aeroplane needed to be in a sustained cruise configuration to allow the engine readings to stabilise. However, he thought he could quickly note down the information. He recorded on the paperwork the EGT readings for both engines, which showed a 19 degrees Celsius (°C) split between the two engines, with the right engine being hotter. The aeroplane entered the descent immediately afterwards.
- 3.1.11. At about 1515 the aeroplane was between 1,500 feet and 1,000 feet on the approach to Auckland with the runway in sight when the right engine compressor stalled,¹⁴ with loud banging noises. The odour of burnt bird increased on the flight deck and in the cabin. The captain moved the right engine thrust lever back to idle power and the banging noises stopped. He elected not to spend time trying to find a thrust lever position where the stall ceased, as the runway was clear but a heavy rain shower was approaching the far end. He advanced the left-engine thrust lever and instructed the first officer to select the auto brakes to medium. The landing checklist was completed and a Pan-Pan call¹⁵ made to the tower requesting that the rescue fire service meet the aeroplane once it had landed. The first officer spoke briefly with the inflight service manager, who advised that flames had been seen coming from the tail pipe of the engine and that the cabin was secure for landing.
- 3.1.12. After the aeroplane touched down the captain moved both thrust levers into reverse, with both engines responding as expected. As the aeroplane slowed he moved the thrust levers back to idle and manoeuvred the aeroplane on to the taxiway to the side of the runway. The aeroplane was brought to a halt and the right engine shut down. The rescue fire service met the aeroplane and confirmed that there was no fire or obvious danger. The aeroplane was taxied to the gate using the left engine. During this time the captain made several announcements to the passengers.
- 3.1.13. Once on the gate the captain shut down the left engine and, after making a final announcement, disembarked the passengers. The flight and cabin crews held a debrief a short time later. There was no brace position instruction given to the passengers as the cabin crew said they knew the engine stall had ceased and could hear the left engine still operating normally, and the aeroplane appeared to be stable on the approach.

¹³ The power setting used was not recorded, but was probably towards 50% of take-off thrust.

¹⁴ A compressor stall is the disruption of normal airflow through the compressor section of an engine resulting from a stall of the aerofoils. The event may vary from a minor power loss that occurs too quickly to be seen on engine instruments, to a complete breakdown of airflow through the compressor (surge) requiring a reduction of fuel flow to the engine.

¹⁵ A Pan-Pan call is a radio call indicating a state of urgency where assistance may be required.

- 3.1.14. The aeroplane was met on the gate by a line maintenance engineer from the operator. The engineer completed an initial inspection and said that there was a very strong smell of bird at the rear of the engine, which seemed to confirm the likelihood of a recent bird strike.
- 3.1.15. The engineer walked around the outside of the engine and found no evidence of a bird strike at the front of the engine or anywhere else on the outside of the engine, but he did find two small pieces of bird feather on one of the fan exit guide vanes inside the engine fan case. The pieces were sent to the University of Auckland for DNA analysis, which identified them as from a male black-backed gull.
- 3.1.16. The aeroplane was taken to the operator's engineering hangar in Auckland and a borescope inspection was performed on the engine. The inspection revealed that one third-stage high-pressure-compressor blade was missing. The missing blade had caused substantial damage to the core of the engine. The engine was removed from the aeroplane and sent to an approved overhaul and repair facility for further assessment and repair.

3.2. **Engine damage**

- 3.2.1. Four of the acoustic panels behind the fan blades were damaged, of which two were beyond repair. A small amount of damage was evident on the fan blades and annulus fillers, which showed that the bird had been ingested into the centre of the engine and the bulk of the bird had gone down the core.
- 3.2.2. The low-pressure compressor stage 1.5 rotor blades sustained tip curl to nine of the blades. The tip curl was caused by the stage 1.5 blades contacting the front case of the low-pressure compressor during the bird strike or possibly during the engine stall in Auckland. Four of the blades were damaged beyond repair and had to be replaced.
- 3.2.3. The high-pressure-compressor stator section had bird debris on all of the variable inlet guide vanes and there was a significant amount of damage to the stages 4-6 rotor path segments. All the variable inlet guide vanes, variable stator vanes and subsequent fixed stator vane stages were damaged beyond repair and had to be replaced. The stage 8 rotor path case was replaced due to the amount of foreign object damage.
- 3.2.4. One third-stage compressor blade was found fractured and the adjacent blades had soft body impact damage typical of a bird strike. A piece of the fractured blade that was found in the 3-8 rotor drum showed signs of soft impact damage to the leading edge. Extensive hard body impact damage caused by the released blade was evident on all stages downstream of stage 3.



Figure 1
Fractured third-stage blade and an example of clapper shingling

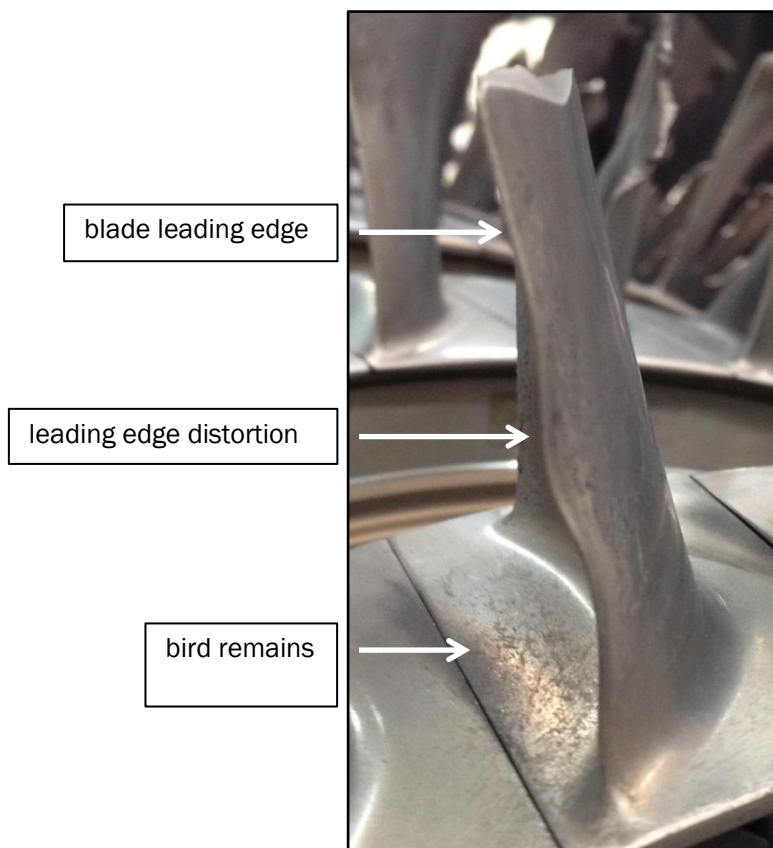


Figure 2
Fractured third-stage blade showing soft body impact damage to the leading edge

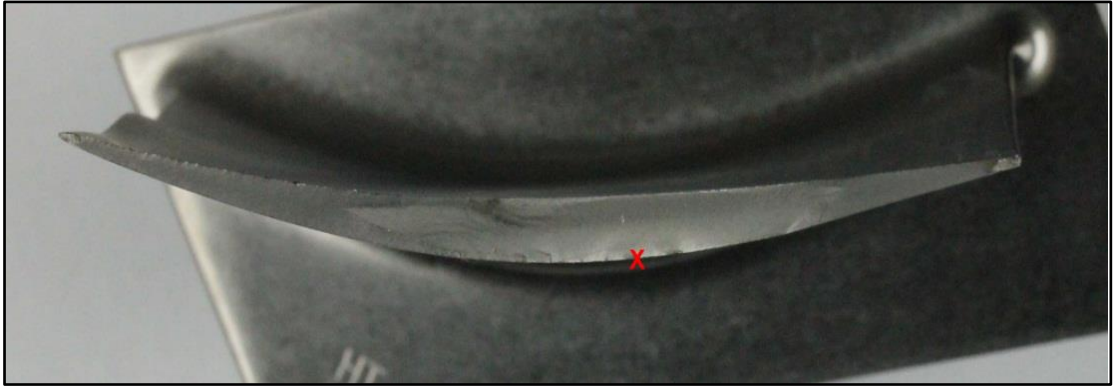


Figure 3
Crack initiation x

- 3.2.5. All 31 of the third-stage high-pressure-compressor blades and the fractured piece of blade were removed and sent to an approved laboratory for further analysis. The fractured blade displayed high-cycle-fatigue crack growth (propagation) followed by aerofoil liberation. High-cycle-fatigue crack growth is caused by stresses placed on the blade during in-service vibrations. The crack originated from the mid chord on the suction side (convex) of the blade about 43 millimetres above the platform and 23 millimetres from the blade leading edge.
- 3.2.6. The diffuser section of the engine had damage to the exit stator case vanes caused by objects passing through the engine. The exit stator case was scrapped and 11 fuel nozzles out of the 20 were scrapped due to impact damage to the inner heat shields. All the liner segments were scrapped in the combustion section due to the large amount of impact damage and metal deposits found on the surface of the liners. The number 4 bearing compartment and stage 1 nozzle guide vanes had heavy maintenance action performed due to the amount of metal debris and metal deposits found in these areas.
- 3.2.7. A significant amount of metal deposits and debris found in the high-pressure turbine module. Eleven number 1 turbine wheel blades were scrapped due to the metal deposits on the external surfaces of the blades. The entire stage 2 nozzle guide vanes and stage 2 blades were repaired due to the metal deposits found on the surface of the parts.
- 3.2.8. Metal deposits were found throughout the engine, with the exception of the exhaust, with associated damage rearward of the third-stage high-pressure turbine.

3.3. Aeroplane and engine information

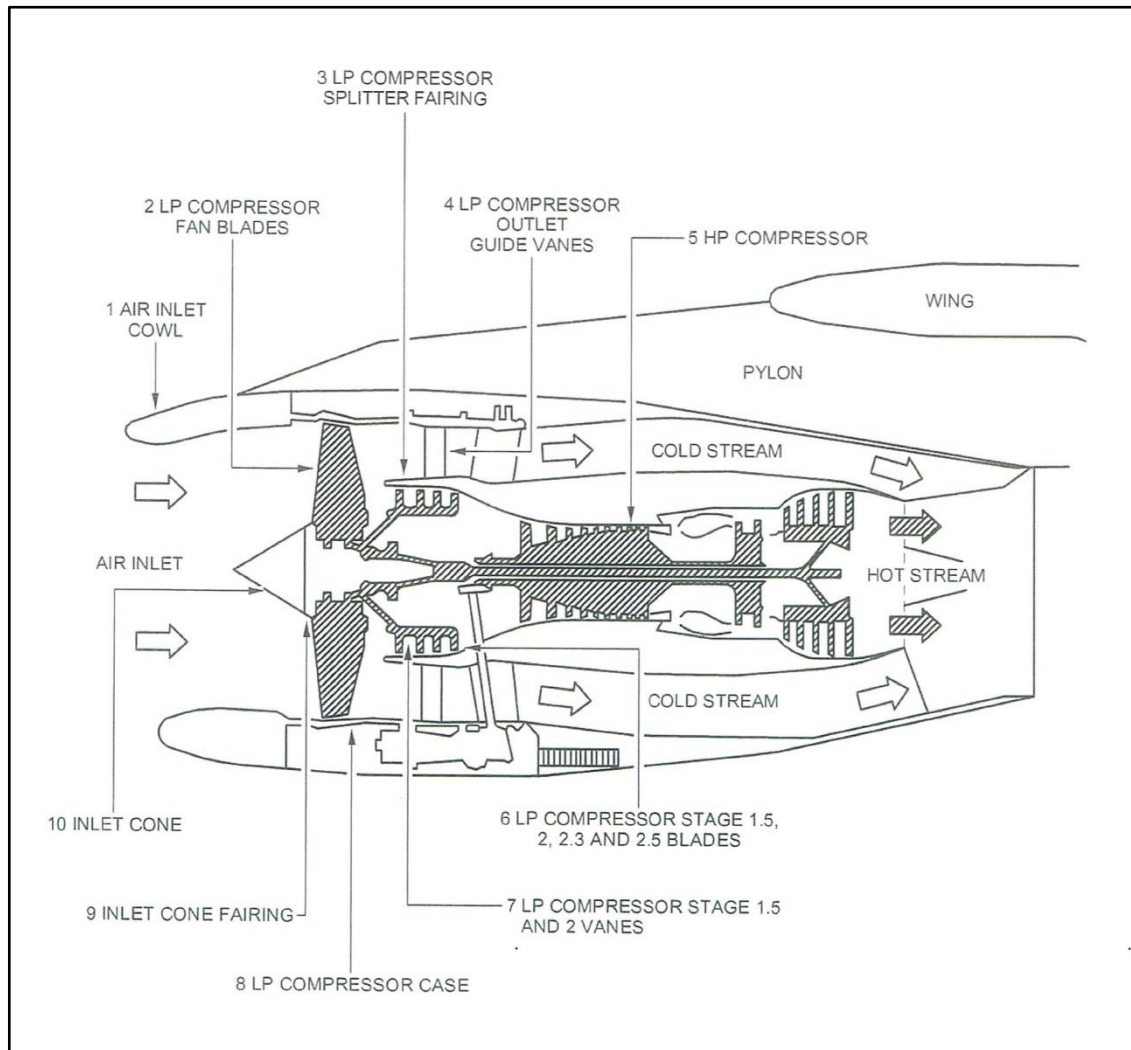


Figure 4
Mechanical arrangement of the V2500 gas turbine engine

Source: Aircraft maintenance manual

3.3.1. The Airbus A320 aeroplane was a narrow-body aircraft of conventional design, with a significant amount of the structure made from lightweight composite material. The aircraft included a full digital fly-by-wire flight control system and a full glass cockpit. The flight deck was equipped with an electronic flight instrument system (EFIS) and had an electronic centralised aircraft monitor (ECAM) system that provided the flight crew with information about the status of all the systems on board the aircraft.

3.3.2. The operator's A320 fleet was fitted with IAE V2527-A5¹⁶ engines, which were rated at 27,000 pounds of take-off thrust. The incident engine, serial number V15721, was an IAE V2527-A5 "select one" engine, which meant that it incorporated the latest performance improvements supported by an aftermarket agreement. At the time of the incident it had acquired a total of 3,337 cycles and 3,164.77 hours since new.

¹⁶ The "V" in the IAE engine number was representative of the five original shareholders in IAE. In October 2011 Rolls-Royce sold its share to Pratt & Whitney's parent company, United Technologies, but remained a major supplier. As the manufacturer of the compressor section of the engine, Rolls-Royce was best placed to initially assist the Commission's inquiry.

- 3.3.3. The engine operating parameters such as EGT, vibrations and fuel flow were monitored electronically in the cockpit and fed into the Aircraft Communication Addressing and Reporting System (ACARS) in order for regular automatic engine condition monitoring (ECM) reports to be transmitted. The reports allowed maintenance and planning personnel to see live engine data while the aeroplane was flying. The system was also designed to send alerts should there be a sudden change in performance or a limit exceeded. The reports aided in condition monitoring activities and planning for scheduled and unscheduled maintenance.
- 3.3.4. ACARS also allowed a direct exchange of data between aeroplane and airline ground computers. The aeroplane-to-ground messages, commonly called the downlink, included information relative to operations, maintenance and performance. The ground-to-aeroplane messages, commonly referred to as the uplink, typically included operational information such as weather and aerodrome conditions. The automatic downlink of reports was adapted to suit individual operators' reporting needs.
- 3.3.5. The operator's A320 aeroplanes produced a take-off and cruise report for each flight as part of the aircraft condition monitoring and reporting systems. The reports were sent to the aircraft communications server on the ground. The aircraft communications server was programmed to redirect the reports and messages in the form of emails to different email addresses. The engine condition monitoring programme also received the engine reports from the aircraft communications server while the aeroplane was flying.
- 3.3.6. The engine condition monitoring data for the Wellington to Auckland flight on 20 June identified that the normal take-off report was not generated when the aeroplane departed Wellington. The reporting programme language worked on flight phases. Because of the low-power ground run performed at Wellington, the EGT reading did not pass a minimum figure, so the ACMS trigger logic that controlled the generation of the take-off report was inhibited for one flight. The aeroplane did, however, generate a cruise report that contained three alerts indicating that there was a change in EGT, fuel flow and N2 vibrations on the right engine (the bird strike engine).
- 3.3.7. The cruise report that contained the alerts was sent from the aeroplane to MOC during the flight. However, an incorrect data character in the report resulted in it being sent to a telex-error-holding folder, so the alerts did not appear in front of the MOC duty manager during the flight. The alerts were only processed and seen in the evening of the same day when a systems engineer fixed the problem by changing the data character, allowing the report to be processed correctly.
- 3.3.8. A review of the aeroplane's flight data recorder (FDR) revealed that from the beginning of the take-off in Wellington the right engine was operating at nearly 30°C hotter than the left engine, with an increased fuel flow of 3.7% and an increase in the N2 rotor vibrations of 0.6 units. The temperature difference reduced to 19°C during the short cruise and about 7°C in the descent. The aeroplane was 18 months old and trend monitoring data showed that prior to this flight there had been no significant EGT or fuel flow split between the engines.

3.4. **Wildlife information**

- 3.4.1. The DNA analysis of the samples taken at Wellington and Auckland identified both as being from the black-backed gull (*Larus dominicanus*). Both samples were sexed as male and both had identical DNA sequences. The two samples were indistinguishable, but because of testing limitations the laboratory was not able to state conclusively whether the samples were from the same bird or whether there had been two separate bird strikes, both involving male black-backed gulls.
- 3.4.2. Civil Aviation Rule Part 139 (CAA, 2010) for aerodromes required aerodrome operators to develop environmental management programmes to comply with subpart 139.71. The CAA provided guidance material in advisory circular AC139-16 (CAA, 2011a), which helped aerodrome operators to comply with the Rule.
- 3.4.3. Bird management programmes in New Zealand are mainly focused on mitigating the risk of bird strike as it can have significant impacts for aircraft operators, including the loss of revenue, the cost of repairing damaged aircraft and, in extreme cases, the loss of an aircraft. The financial costs can vary depending on the extent of the damage to the aircraft; for example, the cost of repairing damage to the engine core of a Boeing 737 or Airbus A320 can typically be between US\$2 million and US\$4 million.
- 3.4.4. Wildlife hazard management programmes try to reduce the frequency and severity of bird strikes and are normally developed with input from a number of parties, including aircraft operators, air traffic control, land owners around aerodromes, local councils and government organisations.
- 3.4.5. CAA Rule Part 12 (CAA, 2011b) requires the pilot in command of an aircraft to report all bird incidents to the CAA. The pilot normally passes any information concerning a bird strike or near strike to the nearest air traffic controller, who passes on the information to the CAA. Operators also have internal reporting systems that pass on the information to the CAA and for discussion with airport operators.

4. Analysis

4.1. Introduction

- 4.1.1. The engine failure on the approach to land at Auckland was the result of the continued operation of the engine damaged in the earlier bird strike as the aeroplane was landing at Wellington. The possibility of a second bird strike on the same engine was considered highly unlikely for several reasons. Firstly, the engine failure occurred at a height where, according to bird strike data, a strike from a black-backed gull would not normally be expected. Secondly, the DNA collected at Wellington and Auckland corresponded to the same bird species and sex and, as far as testing allowed, the same bird. Finally, and perhaps most importantly, there was clear evidence of a change in engine performance when the aeroplane departed Wellington.
- 4.1.2. The engineer who carried out the inspection at Wellington followed the prescribed procedure for a bird strike. He also performed several additional actions to identify any damage. With no damage found, and after consulting the operator's MOC, he released the aeroplane back into revenue service in accordance with the fly-on allowance. The engine subsequently failed early in the 10-hour allowance.
- 4.1.3. There were several opportunities after the return of the aeroplane to service in Wellington for the performance of the engine to alert either the crew or MOC to a potential problem. However, even if the alerts had been received and acted upon, the resulting action may have simply been to reduce power or continue to monitor the suspect engine, which might not have prevented the failure. Nevertheless, the failure of these established detection systems is a concern and is examined further, along with the fly-on allowance. Bird strikes and the management of this hazard are also examined, as well as the crew's actions in Auckland.

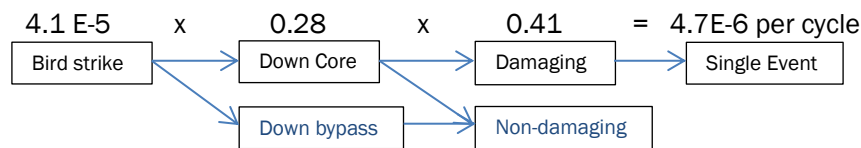
4.2. Engine certification and risk management

- 4.2.1. The bird strike at Wellington occurred at a stage of flight when engine power and fan speed were near their lowest, increasing the likelihood of the bird or parts of it being ingested into the core of the engine. At higher fan speeds, for example during take-off, items are more likely to be thrown outwards and thereby bypass the core, causing little or no damage.
- 4.2.2. The ingestion of the bird into the core of the engine forced the blades out of alignment, causing blade movement during the flight to Auckland. This movement resulted in the clappers¹⁷ shingling¹⁸ and a crack forming and growing under the stresses present. Eventually the crack ruptured and the blade separated, causing the engine surge. It is also possible that because of the disrupted airflow from the then excessive blade movement and shingling, the engine surged, causing the section of blade to rupture and separate. Regardless of the final sequence of events, the initiator was the bird strike and the resulting soft impact damage.
- 4.2.3. After the initial surge at Auckland the engine continued to operate at idle power, and neither the release of the section of compressor blade nor the use of reverse thrust after landing caused any external damage. The containment of damage to inside the engine is a required design feature for which the engine is certified.

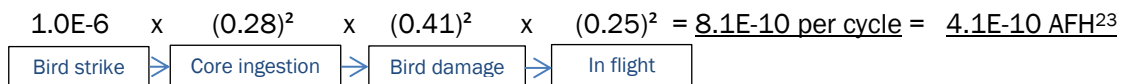
¹⁷ A clapper is a compressor blade mid-span support designed to prevent aerodynamic instability and vibrations.

¹⁸ Shingling is the overlapping movement of the blade clapper platform mating edge with the adjacent blade clapper platform edge.

- 4.2.4. The regulatory continued airworthiness threshold for a **dual-engine** in-flight shutdown per aircraft flying hour for the V2500 engine was 1.0E-9 per flight hour.¹⁹ This meant that for every flight hour there was a 0.000000001 or one-in-a-billion risk of a dual-engine shutdown.
- 4.2.5. The engine manufacturer performed mathematical risk assessments based on the regulator's requirements and developed the aircraft maintenance manual inspection schedules based on the mathematical results. The less-than-10-hours or two-flight-cycles fly-on allowance, under which the engine in this incident was released, was developed in this manner.
- 4.2.6. According to IAE, based on V2500 fleet experience at the time of the occurrence, the **single-engine** bird strike event rate was 4.1E-5 per engine cycle.²⁰ Based on V2500-A5 experience, 28% (535) of the reported bird strikes on engines resulted in core ingestion. Of the 535 core ingestions, 41% (219) caused damage to the engines. The single-engine-event analysis calculation of the probability of an in-flight shutdown due to bird strike was then worked out using the following equation:



- 4.2.7. IAE stated that of the 41% of cases where damage resulted from known core ingestions, 75% (164) of the aeroplanes were not able to take off on their next scheduled flights. In these cases, typically the damage was identified either during the initial inspection or by noting a deterioration in engine performance before the aeroplane could take off.
- 4.2.8. On 55 occasions²¹ or 25% of the damaging events, equivalent to 10.3% of the known core ingestion events,²² the aeroplanes were able to get airborne using the fly-on allowance with undetected damage to the engines (at that time).
- 4.2.9. The current dual-engine bird strike event rate for the V2500 engine was 1.0E-6 per aircraft cycle. Using the known core ingestion and damage rates identified in the above calculation, the possibility of a dual-engine shutdown is calculated below.



- 4.2.10. According to IAE the data showed that the risk of a dual-engine in-flight shutdown rate of 4.1E-10 AFH was below the regulatory continued airworthiness threshold of 1.0E-9 per aircraft flying hour. The manufacturer said that the assessment supported the use of the aircraft maintenance manual fly-on allowance of less than 10 hours' flying or two flight cycles when only one engine was subject to bird strike.
- 4.2.11. However, what is not known is when in the 10-hour or two-flight-cycle tolerance period the borescope inspections were completed on any of the engines with high-pressure-compressor damage. For example, did any of the aeroplanes released under the fly-on allowance use the full fly-on allowance? Or were all the borescope inspections completed within one or two hours? The average length of a flight was about two hours and the maximum was about five hours.

¹⁹ This is the worst case scenario, as the A320 is capable of operating on a single engine for any phase of normal flight.

²⁰ 5686 V2500 engines that have flown more than 65 million cycles in 122.3 million hours.

²¹ Of the 219 damage events, the damage was detected on 165 occasions, leaving 55 undetected.

²² Fifty-five out of a total 535 core ingestion events.

²³ AFH – aircraft flight hour.

- 4.2.12. The risk analysis calculations provided by the manufacturer were based on an aeroplane with two good engines. When ZK-OJQ took off from Wellington with 172 persons on board, it had already suffered a bird strike that required further inspection for damage. Because there was clear evidence of a core ingestion of the bird, based on historical data there was theoretically a 41% probability of some damage being present.²⁴
- 4.2.13. The manufacturer advised that this occurrence was the first recorded event of a blade release within the aircraft maintenance manual fly-on allowance. The manufacturer also reported that until the incident on 20 June 2012 there had been no in-flight shutdowns on any of the 55 preceding flights operating under the fly-on allowance. While this may give confidence in the robustness of the engine to withstand the core ingestion of a medium-sized bird, the engine surge on approach to Auckland occurred within 45 minutes of the aeroplane departing Wellington – well inside the 10-hour limit. The engine run at Wellington was a low-power run of short duration only and was not considered part of the fly-on allowance.
- 4.2.14. The IAE technical services report on the incident contained the following recommendation:
- EFI/0945/002: It is recommended that IAE review the fly-on time limit in the AMM [aircraft maintenance manual] inspection (task 72-00-00-200-010A), to determine whether or not it remains an appropriate timescale that will mitigate future in-service blade release occurrences resulting from similar core ingestion events.
- 4.2.15. The manufacturer later advised that after reviewing the information available, no change to the fly-on allowance was proposed “as the IFSD [in-flight shutdown] risk across the fleet has sufficient margin to the prescribed, Regulatory threshold for Continued Airworthiness”.²⁵ The manufacturer had surveyed three major operators of the V2500 engine²⁶ to gauge their actions following bird strike. The three operators advised that they followed the manufacturer’s maintenance manual and would use the allowance if required.
- 4.2.16. The Commission, through BEA, sought comment from Airbus and EASA as the airworthiness authority for the Airbus A320. BEA advised that Airbus was in agreement with IAE’s risk analysis. The fly-on allowance remained valid, with the risk of either a dual engine failure or a single engine failure following the satisfactory completion of the bird strike inspection procedure sufficiently low as not to require amending.
- 4.2.17. EASA advised that an aircraft maintenance manual formed part of “the Instructions for Continued Airworthiness” that a manufacturer must provide to operators. Only its airworthiness limitations section had to be approved by EASA and fly-on allowances were usually not part of this. The fly-on allowance contained in the aircraft maintenance manual was therefore the responsibility of Airbus.
- 4.2.18. EASA’s certification specifications for engines specified no single turbine engine shutdown rate, which was defined as a “Minor Engine Effect” (EASA, 2010).²⁷ EASA contended that the fleet-wide safety objective for the V2500 engine had been achieved, and both BEA and EASA were only concerned if both engines had been subjected to bird strike and core ingestion.
- 4.2.19. An IAE Pratt & Whitney technical services representative confirmed that after being questioned by the Commission and again reviewing engine reliability data, no changes to the fly-on allowance were planned. The representative explained that while there was a 41% possibility of damage following a core ingestion, a core ingestion was most likely to occur at low engine speed on approach to land. These ingestions typically resulted in minor tip curl of the blades, which did not pose an immediate danger to the aircraft. The aeroplane involved in

²⁴ The 41% probability was determined as a result of the review undertaken by the engine manufacturer post this occurrence.

²⁵ Email dated 15 November 2013.

²⁶ United Airlines – 302 engines, US Airways – 256 engines and British Airways – 174 engines.

²⁷ EASA Certification Specifications for Engines, Subpart D – Turbine Engines; Design and Construction, CS-E 510 Safety Analysis.

this incident was the only example of severe damage and blade failure when operating under the fly-on allowance.

- 4.2.20. However, IAE did acknowledge that the wording in the maintenance manual relating to the fly-on allowance could be confusing. The intention was to limit the allowance to less than 10 hours' flying and fewer than two cycles; in other words a maximum of 9.9 hours' flying and one cycle only. IAE is going to put out information to all operators clarifying what the fly-on allowance is.
- 4.2.21. This analysis of the risk following a single-engine bird strike event involving the IAE engine included a review of that risk assessment by the various regulators and aeroplane and engine manufacturers. The argument supported the hypothesis that a single-engine bird strike on this type of aeroplane fitted with this type of engine was highly unlikely to result in an unacceptable risk to flight safety. Accordingly the Commission has no recommendation to make on that matter.

Findings

1. It is highly likely that this contained engine failure was the result of a single bird strike event on the previous flight when the aeroplane was landing at Wellington Aerodrome, when a black-backed gull was ingested into the engine core.
2. The maintenance actions taken by the operator following the bird strike exceeded the engine manufacturer's requirements.
3. Releasing the aeroplane to service under the "fly-on allowance" would have been highly unlikely to result in an unacceptable risk to flight safety.

4.3. Departure report and inflight monitoring

Safety issue: The non-transmission, non-receipt or mismanagement of engine condition reports, especially those containing significant deviations from normal, can deprive flight crew and maintenance personnel of the opportunity to identify a potential problem early.

- 4.3.1. The departure report was not sent because of an unusual combination of programming logic and the low-power ground run. The cruise report was sent to a holding tray because of an incorrect character in the text. Conceivably, if one or both reports had been correctly sent, maintenance operations control (MOC) may have recognised the sudden split in EGT readings for the two engines and attributed it to the earlier bird strike. The operator has since remedied this programming logic error.
- 4.3.2. In this case the most likely action would have been for MOC to contact the crew, alerting them to the EGT split and instructing them to continue to monitor the engine. However, in other circumstances the consequence of MOC not receiving the departure report could have been more significant. Recorded aeroplane data showed that there was little change in the EGT split during the climb, so the crew would have had no warning of an impending failure.
- 4.3.3. The EGT divergence monitoring form was not required to be completed on such a short flight because the aeroplane was not in the cruise long enough for the engine temperatures to stabilise. In this case the aeroplane was in the cruise for about two minutes only. There was no reason to shut down the engine at this time. No alerts had been generated and no limits exceeded. The engine still performed satisfactorily, albeit in a reduced capacity, for the remainder of the flight. The crew's priority was the descent and landing.
- 4.3.4. The request by the engineer for the flight crew to check engine performance before take-off was a positive action that focused the crew's attention on detecting any obvious abnormality, at least for the take-off phase of flight. The departure and cruise reports, and monitoring form, may have singularly or collectively alerted the crew to a potential problem during the flight.

- 4.3.5. The aeroplane was flying under a special fly-on allowance with the consequential added risk of a single-engine issue developing during the flight to Auckland. The operator might want to consider a more proactive approach in future by actively monitoring aeroplanes (either directly by MOC or through increased monitoring by the pilots) during flight rather than relying on automated reports.
- 4.3.6. Borescope equipment was not available at Wellington. Had the inspecting engineer found damage when following the checklist, a team and equipment would have needed to be flown in from either Auckland or Christchurch. The operator advised that it would be its continued preference to follow this procedure and not have to locate equipment at Wellington and provide initial and ongoing training for a number of staff there. Wellington was one of many airports into which it operated that did not have such equipment.
- 4.3.7. Given the low risk of an engine actually failing in flight in the manner it did on this occasion, and the even lower risk of having a double engine failure following a single-engine bird strike event, the operator's preference is unlikely to create an unacceptable risk to flight safety.

Findings

- 4. Indications that the right-hand engine was not performing well were not detected by the Maintenance Operation Control due to programming logic errors in the automated engine condition report system. However, even if they had been it is unlikely that any subsequent action would have prevented the engine compressor stall event on landing at Auckland.

4.4. Wildlife management

- 4.4.1. The regular analysis of bird strike data by the CAA, aircraft operators and aerodrome operators is critical in determining whether a hazard management programme is working. The regular monitoring of the data allows the interested parties to look closely at bird strike trends and determine if they are increasing, declining or static. It provides a benchmark for airport operators to ensure that their wildlife hazard management programmes are effective and allows them to make changes accordingly.
- 4.4.2. A review of bird strike data held by the CAA showed that at the time of this incident Wellington was considered a "low risk" at 2.5 bird strikes per 10,000 aircraft movements.²⁸ "Low risk" was considered to be fewer than five strikes per 10,000 movements, "medium" five to fewer than 10, and "high" 10 or more. Of the seven main international aerodromes in New Zealand, Wellington ranked second behind Hamilton (2.1) and ahead of Palmerston North (2.8), Auckland (3.1), Christchurch (3.6), Queenstown (3.6) and Dunedin (5.3).
- 4.4.3. The data also showed that the rate of bird strikes in Wellington had been trending upward.²⁹ Similar trends had been observed at Auckland, Christchurch and Dunedin. The Queenstown rate was constant, while Hamilton and Palmerston North were trending downwards. The combination of risk category and trend determined any CAA action to ensure that an aerodrome was actively minimising the risk. At the time of releasing this report the risk was still assessed as low.
- 4.4.4. An examination of the bird hazard management plan for Wellington showed that a wide range of activities were being undertaken to mitigate the risk of bird strikes. The activities included building modifications (the addition of wires and spikes), grass height variations, bird scarers (shotguns, noise makers, horns and sirens) and culling both on and off the aerodrome. Wellington airport was also about to trial a new type of grass called Avanex™. The grass contains a fungus that affects birds but does not harm them. The grass is currently in use at

²⁸ A movement is a take-off or a landing.

²⁹ The trend analysis allowed for seasonal variations that were common.

Auckland, Christchurch and Hamilton aerodromes, and has proven successful in reducing bird numbers by 87%.

- 4.4.5. Wellington airport undertook annual monitoring of the black-backed gull breeding population near the aerodrome. The most recent report, dated 20 January 2012, showed a steady increase in the number of nests since about 2006.
- 4.4.6. In November 2011 Wellington airport commissioned an ecological survey of the aerodrome and surrounds out to 13 kilometres. The study's report, dated 31 January 2012, noted that a wet winter had created boggy areas on the aerodrome that were attractive to plovers and gulls, and that an increase in recreational fishing activity around the nearby shoreline had resulted in bait and bycatch attracting gulls. Feeding of birds was also a problem. Wellington airport in conjunction with Wellington City Council was running an education program to try to dissuade the public from feeding the birds or leaving food behind.

Findings

- 5. Wellington International Airport is providing an effective bird management programme that is keeping the risk of bird strikes as low as reasonably practicable.

4.5. Crew actions

- 4.5.1. Regardless of how well a crew manages a situation, there will often be useful lessons for other pilots and operators to consider.
- 4.5.2. The crew's initial actions on becoming aware of a problem with the right engine on approach to Auckland were in accordance with the quick reference handbook checklist. The captain promptly retarded the right thrust lever to idle, which stopped the engine surging. The runway was clear but a rain shower was approaching the far end of the aerodrome. The captain's decision to prioritise landing the aeroplane rather than trying to analyse the problem was appropriate in the circumstances, where he had one fully functional engine (the left engine) and was still able to use the second engine (the right engine) if necessary. In the short time available the captain briefed the use of medium braking after landing and made an urgency call to alert air traffic control and rescue services.
- 4.5.3. The use of reverse thrust on both engines after landing was an instinctive response, done many hundreds of times before. While understandable, a quick reminder by either pilot before or after landing may have helped to prompt the captain not to use reverse thrust on the right engine. There was ample runway available to avoid hard braking or reverse thrust.
- 4.5.4. The cabin was prepared for landing when the engine surge occurred. The cabin crew's decision to not contact the flight crew at this critical time allowed them to concentrate on flying the aeroplane. The safest course of action might have been for the cabin crew to instruct passengers to adopt a brace position, even though they were confident that at least one engine was working and the aeroplane was under control. This could, however, have resulted in an unco-ordinated warning to passengers that may have generated confusion and possibly panic.

5. Findings

- 5.1. It is highly likely that this contained engine failure was the result of a single bird strike event on the previous flight when the aeroplane was landing at Wellington Aerodrome, when a black-backed gull was ingested into the engine core.
- 5.2. The maintenance actions taken by the operator following the bird strike exceeded the engine manufacturer's requirements.
- 5.3. Releasing the aeroplane to service under the "fly-on allowance" would have been highly unlikely to result in an unacceptable risk to flight safety.
- 5.4. Indications that the right-hand engine was not performing well were not detected by the Maintenance Operation Control due to programming logic errors in the automated engine condition report system. However, even if they had been it is unlikely that any subsequent action would have prevented the engine compressor stall event on landing at Auckland.
- 5.5. Wellington International Airport is providing an effective bird management programme that is keeping the risk of bird strikes as low as reasonably practicable.

6. Key lessons

- 6.1. Although the safety of the aeroplane and the persons on board was not unduly compromised by releasing the aeroplane to service knowing that a bird had been ingested into the core of one engine, operators will need to balance the cost of having inspection services available at key aerodromes into which they fly with the cost of an engine failure of this scale.
- 6.2. Even if the minimum mandatory checks are made to an engine that has suffered a bird strike down the core, if the aeroplane is released to service before the required full inspection has been undertaken, the pilots and ground engineering services should maintain increased vigilance of engine performance until the appropriate full maintenance checks can be completed.

7. Safety actions

7.1. General

7.1.1. These are listed below.

7.1.2. The Commission classifies safety actions by two types:

- (a) safety actions taken by the regulator or an operator to address safety issues identified by the Commission during an inquiry that would otherwise result in the Commission issuing a recommendation
- (b) safety actions taken by the regulator or an operator to address other safety issues that would not normally result in the Commission issuing a recommendation.

7.2. Safety actions addressing safety issues identified during an inquiry

7.2.1. IAE, the engine manufacturer, reviewed the bird strike and engine reliability data for the V2500 engine and was satisfied with the airworthiness status of the engine and that no changes to the manuals or procedures were required. Nevertheless, operators were to be reminded of the intention of the fly-on allowance of less than 10 hours' flying or fewer than two cycles.

7.2.2. The operator amended its maintenance manual to further limit the fly-on allowance by changing the maximum number of cycles permitted from two to one before a borescope inspection was required. The 10-hour limit was retained.

7.2.3. The operator reviewed the programming logic and informed MOC staff to ensure that a departure report is generated after the completion of any low-power ground run. Similarly the content of the cruise report has been reviewed to help ensure that the messages are sent to the right addresses. Further, the handling procedures for any holding tray messages have been reviewed.

7.2.4. The operator incorporated the lessons learnt from the actions of the crew in its ongoing crew training cycle.

8. Recommendations

8.1. General

- 8.1.1. The Commission may issue, or give notice of, recommendations to any person or organisation that it considers the most appropriate to address the identified safety issues, depending on whether these safety issues are applicable to a single operator only or to the wider transport sector.
- 8.1.2. In this case, the Commission makes no recommendations, as the actions taken by the operator and manufacturer have addressed any potential safety issue.

9. Sources

CAA, 2010. Civil Aviation Rule Part 139, Aerodromes – Certification, Operation and Use, effective 25 March 2010.

CAA, 2011a. Civil Aviation Advisory Circular AC139-16, Wildlife Hazard Management at Aerodrome, effective 7 October 2011.

CAA, 2011b. Civil Aviation Rule Part 12, Accidents, Incidents, and Statistics, effective 10 November 2011.

EASA 2010. Certification Specifications for Engines CS-E, Amendment 3, effective 23 December 2010.

Appendix 1: Aircraft maintenance manual procedures



Customer : ANZ Type : A318/A319/A320/A321 Rev. Date : 01.May.2012	Manual: AMM Selected effectivity: ALL
72-00-00-200-010-A - Inspection of the Engine after Bird Strike, Foreign Object or Slush Ingestion	

**** ON A/C ALL**

TASK 72-00-00-200-010-A
Inspection of the Engine after Bird Strike, Foreign Object or Slush Ingestion

WARNING: THERE IS A POSSIBLE HEALTH RISK TO PERSONNEL WHO DO MAINTENANCE TASKS AFTER A BIRD STRIKE. THE SAFETY MEASURES THAT FOLLOW ARE RECOMMENDED:

- USE DISPOSABLE GLOVES.
- USE A DISPOSABLE COVERALL IF THERE IS A RISK OF BODY CONTACT WITH THE BIRD REMAINS.
- DO NOT USE PRESSURIZED AIR OR WATER TO CLEAN THE PARTS WHICH WERE IN CONTACT WITH THE BIRD.
- REMOVE THE BIRD REMAINS AND PUT THEM IN A PLASTIC BAG.
- DO NOT TOUCH YOUR FACE, EYES, NOSE, ETC. WITH YOUR GLOVES.
- REMOVE THE GLOVES AND THE DISPOSABLE COVERALL AND PUT THEM IN THE SAME PLASTIC BAG AS THE REMAINS. SEAL THE BAG.
- DISCARD THE BAG AS YOU DO FOR USUAL GARBAGE.
- CAREFULLY WASH YOUR HANDS WITH SOAP AND WATER.

1. Reason for the Job

This TASK gives the procedure for a general check of the engine after the ingestion of birds, foreign objects or slush.

NOTE: If inspecting the engine following a bird strike, examine the pilots report for evidence of cabin odour. Cabin odour at the same time as a bird strike may indicate a core ingestion

2. Job Set-up Information

A. Fixtures, Tools, Test and Support Equipment

REFERENCE	QTY	DESIGNATION
No specific	AR	ACCESS PLATFORM 1M(3 FT)
No specific	AR	MAT - WORK
No specific	AR	WARNING NOTICE(S)

B. Referenced Information

REFERENCE	DESIGNATION
71-11-11-200-011-A	Visually Examine the Air Intake Cowl - Allowable Damage Data
72-00-00-100-010-A	Clean the Engine Gas Path for Performance Improvement (Water only)
72-00-00-100-010-A-01	Clean the Engine Gas Path for Performance Improvement (Cleaner only)
72-00-00-100-010-A-02	Clean the Engine Gas Path for Performance Improvement (Water only) Repair VRS70 03
72-00-00-200-011-A	TAP Test of LP Compressor Fan Blades
72-00-00-200-016-B	Inspection of the HP Compressor
72-00-00-200-016-B-01	Inspection of the HP Compressor
72-00-00-200-017-B	Inspection of the LP Compressor
72-00-00-200-022-B	Inspection of the LP Compressor Fan Blades and Fan Case Acoustic Linings
72-31-11-100-010-A	Cleaning of the LP Compressor Blades
72-31-11-200-010-B	Inspection of the Low Pressure (LP) Compressor Fan Blades
72-32-60-200-010-A	Inspection of the Screen
72-32-85-200-010-B	Inspection of the Fan Case Assembly
72-32-88-200-010-B	Inspection of the Fan Exit Vane Assembly
72-32-91-200-010-B	Inspection of the LP Compressor Inlet Guide Vane Assembly



Customer : ANZ Type : A318/A319/A320/A321 Rev. Date : 01.May.2012	Manual: AMM Selected effectivity: ALL
72-00-00-200-010-A - Inspection of the Engine after Bird Strike, Foreign Object or Slush Ingestion	

72-38-11-200-010-B	Inspection of the Inlet Cone and the Inlet Cone Fairing
73-22-11-200-010-A	Inspection of the P2/T2 Sensor
Schematic View of Engine SHEET 1	
HP Compressor SHEET 1	
Inspection of the Engine after Bird Strike SHEET 1 Inspection of the Engine after Bird Strike SHEET 2 Inspection of the Engine after Bird Strike SHEET 3 Inspection of the Engine after Bird Strike SHEET 4 Inspection of the Engine after Bird Strike SHEET 5	

3. Job Set-up

Subtask 72-00-00-941-097-A

A. Safety Precautions

- (1) On the center pedestal, on the ENG panel 115VU:
 - (a) Put a WARNING NOTICE(S) to tell persons not to start the engine.
- (2) Make sure that the engine 1(2) shutdown occurred not less than 5 minutes before you do this procedure.
- (3) On the overhead maintenance panel 50VU:
 - (a) Make sure that the ON legend of the ENG/FADEC GND PWR/1(2) pushbutton switch is off.
 - (b) Put a WARNING NOTICE(S) to tell persons not to energize the FADEC 1(2).

Subtask 72-00-00-941-098-A

B. Put the support equipment into position.

- (1) Put the ACCESS PLATFORM 1M(3 FT) into position to give access to the engine for the inspection task.
- (2) Put the MAT - WORK into position in the fan case.

NOTE: Make sure that the red warning pennants can be seen from the external side of the aircraft. Make sure the workmat has sufficient dimensions to give full protection to the lower half of the fan case.

4. Procedure

Subtask 72-00-00-210-094-B

A. Examine the following:

- [\(Ref. Fig. Schematic View of Engine SHEET 1\)](#)
- (1) Examine the air inlet cowl (1) [\(Ref. AMM TASK 71-11-11-200-011\)](#).
 - (2) Examine the P2/T2 probe [\(Ref. AMM TASK 73-22-11-200-010\)](#).
 - (3) Examine the inlet cone (10) [\(Ref. AMM TASK 72-38-11-200-010\)](#).
 - (4) Examine the inlet cone fairing (9) [\(Ref. AMM TASK 72-38-11-200-010\)](#).
 - (a) If there is no damage or the damage is in the limits, continue with step B.
 - (b) If there is damage more than the limits, reject the engine.

Subtask 72-00-00-110-069-A

B. Clean the LP compressor fan blades (2) [\(Ref. AMM TASK 72-31-11-100-010\)](#). [\(Ref. Fig. Schematic View of Engine SHEET 1\)](#)

- (1) Remove sufficient deposits to allow assessment of fan blade damage.

Subtask 72-00-00-210-095-B

C. Examine the LP compressor fan blades (2). [\(Ref. Fig. Schematic View of Engine SHEET 1\)](#)



Customer : ANZ Type : A318/A319/A320/A321 Rev. Date : 01.May.2012	Manual: AMM Selected effectivity: ALL
72-00-00-200-010-A - Inspection of the Engine after Bird Strike, Foreign Object or Slush Ingestion	

- (1) Inspection of the LP compressor fan blade (2) aerofoil [\(Ref. AMM TASK 72-31-11-200-010\)](#)
[\(Ref. Fig. HP Compressor SHEET 1\)](#)
- (a) If there is a damage to the fan blades or there is an indication of a large rub on the fan track liner, do a Transient Acoustic Propagation (TAP) test on the full set of fan blades [\(Ref. AMM TASK 72-00-00-200-011\)](#), in less than 10 flight hours or 5 flight cycles, which occurs first.
- NOTE:** If there is an indication of a bird strike but there is no damage to the fan blades, no TAP test inspection is necessary.
- (b) If there is an indication of bird strike, foreign object or slush ingestion in the area A, on more than one engine.
- 1 Examine the LP compressor stages 1.5 and 2.5 [\(Ref. AMM TASK 72-00-00-200-017\)](#) and HP compressor stages 3 and 6 [\(Ref. AMM TASK 72-00-00-200-016\)](#), on one engine before the next flight.
 - If there is an indication of a damage in the HP compressor stages 3 or 6, examine the remaining stages of the HP compressor [\(Ref. AMM TASK 72-00-00-200-016\)](#).
 - If there is a damage more than the limits on LP compressor or HP compressor, reject the engine.
 - If there is no indication of a damage, continue with step C.(1)(b)2.
 - 2 Examine the LP compressor stages 1.5 and 2.5 [\(Ref. AMM TASK 72-00-00-200-017\)](#) and HP compressor stages 3 and 6 [\(Ref. AMM TASK 72-00-00-200-016\)](#), on the remaining engine in less than 10 flight hours or 2 flight cycles, which occurs first.
 - If there is an indication of a damage in the HP compressor stages 3 or 6, examine the remaining stages of the HP compressor [\(Ref. AMM TASK 72-00-00-200-016\)](#).
 - If there is a damage more than the limits on LP compressor or HP compressor, reject the engine.
 - If there is no indication of a damage, continue with step C.(1)(c).
- (c) If there is an indication of bird strike, foreign object or slush ingestion in area A on one engine, examine the LP compressor stages 1.5 and 2.5 [\(Ref. AMM TASK 72-00-00-200-017\)](#) and HP compressor stages 3 and 6 [\(Ref. AMM TASK 72-00-00-200-016\)](#), in less than 10 flight hours or 2 flight cycles, which occurs first.
- 1 If there is an indication of a damage in the HP compressor stages 3 or 6, examine the remaining stages of the HP compressor [\(Ref. AMM TASK 72-00-00-200-016\)](#).
 - 2 If there is a damage more than the limits on LP compressor or HP compressor, reject the engine.
 - 3 If there is no indication of a damage, continue with step C.(1)(d).
- (d) If there is an indication of a damage or bending more than the limits in area B on more than one engine, do as follows:
- 1 Examine the LP compressor stages 1.5 and 2.5 [\(Ref. AMM TASK 72-00-00-200-017\)](#) and HP compressor stages 3 and 6 [\(Ref. AMM TASK 72-00-00-200-016\)](#), on one engine before the next flight.
 - If there is an indication of a damage in the HP compressor stages 3 or 6, examine the remaining stages of the HP compressor [\(Ref. AMM TASK 72-00-00-200-016\)](#).
 - If there is a damage more than the limits on LP compressor or HP compressor, reject the engine.
 - If there is no indication of a damage, continue with step C.(1)(d)2.
 - 2 Examine the LP compressor stages 1.5 and 2.5 [\(Ref. AMM TASK 72-00-00-200-017\)](#) and HP compressor stages 3 and 6 [\(Ref. AMM TASK 72-00-00-200-016\)](#), on the affected engine in less than 10 flight hours or 2 flight cycles, which occurs first.
 - If there is an indication of a damage in the HP compressor stages 3 or 6, examine the remaining stages of the HP compressor [\(Ref. AMM TASK 72-00-00-200-016\)](#).
 - If there is a damage more than the limits on LP compressor or HP compressor, reject the engine.



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- If there is no indication of a damage, continue with step C.(1)(e).
- (e) If there is an indication of a damage or bending more than the limits in area B on one engine, do as follows:
 - 1 Examine the LP compressor stages 1.5 and 2.5 ([Ref. AMM TASK 72-00-00-200-017](#)) and HP compressor stages 3 and 6 ([Ref. AMM TASK 72-00-00-200-016](#)) on the affected engine in less than 10 flight hours or 2 flight cycles, which occurs first.
 - If there is an indication of a damage in the HP compressor stages 3 or 6, examine the remaining stages of the HP compressor ([Ref. AMM TASK 72-00-00-200-016](#)).
 - If there is a damage more than the limits on LP compressor or HP compressor, reject the engine.
 - If there is no indication of a damage, continue with step C.(2).
- (2) Turning of the LP compressor rotor
 - CAUTION: USE A GLOVED HAND AND NOT SHARP-ENDED TOOLS (A METAL BAR FOR EXAMPLE) TO TURN THE LP COMPRESSOR. SHARP-ENDED TOOLS CAN CAUSE DAMAGE TO THE LP COMPRESSOR FAN BLADES.**
 - CAUTION: TURNING THE LP COMPRESSOR ROTOR IN THE CLOCKWISE DIRECTION, WHEN VIEWED FROM THE FRONT OF THE ENGINE, MAY CAUSE THE BRUSH SEALS AND/OR TURBINE BLADE SHROUDS TO BIND, PREVENTING FREE ROTATION OF THE LP COMPRESSOR ROTOR.**
 - (a) Turn the LP compressor (2) in a counterclockwise direction (when viewed from the front) to make sure the LP compressor rotor turns freely and there are no unusual noises.
 - 1 If the LP compressor rotor turns freely and there are no unusual noises, proceed with steps D thru G.
 - 2 If the LP compressor rotor does not turn freely and/or there are unusual noises, allow the engine to cool for a further 30 to 60 minutes and repeat Para 2 (a).
 - If the LP compressor rotor does not turn freely after the cooling period and/or there are unusual noises, reject the engine.

Subtask 72-00-00-210-096-B

- D. Examine the LP compressor fan case assembly (8).
- (1) Examine the attrition linings for rubs, gouges and scores (6) ([Ref. AMM TASK 72-32-85-200-010](#)).
 - (a) If there is no damage or the damage is in the limits, continue with step D.(2).
 - (b) If there is a damage more than the limits, reject the engine.
 - (2) Examine the acoustic linings (4) for debonding, cracks, dents and scores ([Ref. AMM TASK 72-32-85-200-010](#)).
 - (a) If the acoustic panels exhibit impact damage, do a tap test of the panels ([Ref. AMM TASK 72-32-85-200-010](#)).
 - (b) If an acoustic cover sheet is missing, do an inspection ([Ref. AMM TASK 72-00-00-200-022](#)).
 - (c) If there is no damage or the damage is in the limits, continue with step D.(3).
 - (d) If there is a damage more than the limits, reject the engine.

NOTE: C-ducts do not need to be opened, unless it is suspected that panels behind the LP compressor fan blades are damaged.
 - (3) Examine the anti-ice impact panel (5) for damage and scores ([Ref. AMM TASK 72-32-85-200-010](#)).
 - (a) If the anti-ice impact panels exhibit impact damage, do a tap test of the panels ([Ref. AMM TASK 72-32-85-200-010](#)).
 - (b) If an anti-ice impact panel is missing, do an inspection ([Ref. AMM TASK 72-00-00-200-022](#)).



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- (c) If there are no loose or damaged panels, continue with step E.
- (d) If there is a damage more than the limits, reject the engine.

NOTE: C-ducts do not need to be opened, unless it is suspected that panels behind the LP compressor fan blades are damaged.

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E. Examine the Fan Exit Guide Vanes (FEGV's).

- (1) Examine the Fan Exit Vane Assembly vanes ([Ref. AMM TASK 72-32-88-200-010](#)).
 - (a) If there is no damage, or the damage is in the limits, continue with step F.
 - (b) If there is a damage more than the limits, reject the engine.

Subtask 72-00-00-210-134-A

F. Examine the bleed valve outlet screen ([Ref. AMM TASK 72-32-60-200-010](#)).

- (1) If bird strike, foreign object or slush ingestion has been reported inspect the BLEED VALVE OUTLET screen before the next flight.
 - (a) If there is metal debris present in any component, reject the engine.
 - (b) If no metal debris is found, continue with step G.

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G. Examine the LP compressor blades.

([Ref. Fig. Inspection of the Engine after Bird Strike SHEET 1](#)) ([Ref. Fig. Inspection of the Engine after Bird Strike SHEET 2](#)) ([Ref. Fig. Inspection of the Engine after Bird Strike SHEET 3](#))

[Text continues : see text below](#)



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