Document 1

From: s.47F(1)
To:
Cc:
Subject: New investigation 201807226 - 9V-OJE B787 - Engine Failure - Perth WA - 11 Oct 2018 [DLM=For-Official-Use-Only]
Date: Friday, October 12, 2018 9:55:14 AM

For Official Use Only

Good Morning,

New investigation: **201807226** - 9V-OJE B787 - Engine Failure - Perth WA - 11 Oct 2018

Regards,

s.47F(1)
Australian Transport Safety Bureau

62 Northbourne Avenue
Canberra ACT 2601

P s.47F(1) | E s.47F(1)

Australia's national transport safety investigator
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Document 2

Australian Government
Australian Transport Safety Bureau

Transport Safety Investigation Act 2003- Section 32

Request for Interview and/or Relevant Material

Form: **F32-1**

ATSB Investigation No. AO-2018-069

The Australian Transport Safety Bureau is conducting an investigation into the following transport safety matter.

Engine failure involving Boeing 787 , 9V-OJE, Perth WA, 11 October 2018

To Name: s.38(1)(b)(i)

Organisation: s.38(1)(b)(i)

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s.38(1)(b)(i)

Evidence Required by: s.38(1)(b)(i)

Section 47 of the TSI Act provides that self-incrimination is not an excuse for not complying with this request. Information relating to section 32 and section 47 of the TSI Act is provided overleaf.

Thank you for your cooperation.

Signature of ~~Chief Commissioner~~ /Delegate

s.38(1)(b)(i)

Name of ~~Chief Commissioner~~ /Delegate : s.38(1)(b)(i)

Date 12/10/2018

Phone: s.38(1)(b)(i)

The following is a plain legal language summary of the relevant sections of the *Transport Safety Investigation Act 2003*. Please see the ATSB website **www.atsb.gov.au** for the complete text of the TSI Act.

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Transport Safety Investigation Act 2003- Section 62

Australian Government
Australian Transport Safety Bureau

Authorisation to access restricted information

Form: **F62-1**

ATSB Investigation No. AO-2018-069

The Australian Transport Safety Bureau is conducting an investigation into the following transport safety matter.

Engine failure involving Boeing 787, 9V-OJE, Perth WA, 11 October 2018

Authorisation under Transport Safety Investigation Act 2003 – Section 62

Section 62 of the Act allows the ATSB to authorise a non-staff member to have access to information that is classified as 'restricted information' while requiring the non-staff member to adhere to confidentiality requirements of the Act.

Description of restricted information which access is being given to:

s.38(1)(b)(i)

The person or persons listed below have been authorised to access the identified restricted information. Through being authorised access to the information under section 62, the identified person or persons within the Organisation are subject to the confidentiality requirements of subsection 60(3) of the *Transport Safety Investigation Act 2003* (information relating to section 60 of the TSI Act is provided overleaf). The signed persons acknowledge and accept these obligations.

Name of authorised person	Signature of authorised person	Date	Phone
s.38(1)(b)(i)			

Please return a signed copy of this form to the person at the ATSB listed below

PO Box 967
Civic Square ACT 2608 Australia

Signature of ATSB/Delegate
s.38(1)(b)(i)

Name of ATSB/Delegate:
s.38(1)(b)(i)

Date
10/15/2018

Delegate Phone:
s.38(1)(b)(i)

Delegate Fax:

Delegate Email:
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Confidentiality - Subsection 60(3)

Where access to restricted information is received under section 62 of the Act it is an offence for the recipient to make a record of or disclose 'restricted information'. The penalty is imprisonment.
Exceptions are mainly for the purpose of carrying out functions under the Act.

[*Note*: 'restricted information' is information collected in the course of an investigation under the Act. It may include statements, medical information, personal information, vehicle movements, and other evidence.]

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Australian Government
Australian Transport Safety Bureau

Uncommanded engine shutdown involving Boeing 787-9, 9V-OJE

46 km north of Perth Airport, Western Australia, 11 October 2018

ATSB Transport Safety Report
Aviation Occurrence Investigation (Short)
AO-2018-069
Final – 1 December 2020

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

Publishing information

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Addendum

Page	Change	Date

Safety summary

What happened

On 11 October 2018, a Boeing 787-9, 9V-OJE, operated by Scoot Tigerair (Scoot), departed Singapore on a scheduled flight to Perth, Western Australia. During descent, the flight crew noticed that the right engine was slow to respond to commands, and its performance continued to decline throughout the descent. While passing through 9,000 ft, severe thrust asymmetry developed, and the engine shut down shortly afterwards. The crew followed appropriate procedures, and due to the proximity of the airport, elected not to attempt a restart. The aircraft landed safely with emergency services in attendance. There were no injuries sustained and no aircraft damage as a result of the incident.

What the ATSB found

The ATSB determined that following a series of engine status and alert messages, 9V-OJE experienced an uncommanded engine shutdown while on descent into Perth, before landing safely using the operational engine.

Based on a review of the flight data and an examination of engine components by Rolls-Royce, the engine shutdown was due to debris from worn journal bearings in the engine's secondary high-pressure fuel pump blocking an inlet filter for the fuel metering valve servo assembly. This prevented the valve from delivering sufficient fuel to the engine.

Rolls-Royce also determined that, between late 2018 and early 2019, the operator's fleet of 787 aircraft had been particularly susceptible to low-life wear in the journal bearings of the secondary high-pressure fuel pump. It identified a number of potential factors that led to the component wear but, due to the number of variables, a single/dominant reason could not be established.

What has been done as a result

Rolls-Royce updated its Fault Isolation Manual to instruct all operators to remove the fuel pump and hydro-mechanical unit in the event of a maintenance message regarding the fuel metering valve not being in the commanded position. Rolls-Royce is also monitoring maintenance messages and investigating the possibility of using flight data to detect fuel pump journal wear before its effects on valve operation become apparent.

Safety message

This occurrence highlights the importance of flight crew being familiar with emergency procedures, so that the appropriate corrective action can be taken quickly and effectively. In this case, the flight crew worked effectively to assess the situation, and took appropriate action to minimise risk in accordance with the operator's flight crew operations manual.

This occurrence also shows that positively identifying the factors contributing to technical failures can be difficult and time consuming. However, manufacturers and operators can implement interim risk mitigation measures, as was the case here.

The investigation

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 investigation was conducted in order to produce a short investigation report, and allow for greater industry awareness of findings that affect safety and potential learning opportunities.

The occurrence

On 11 October 2018, at about 1421 Western Standard Time,[1] a Boeing 787-9, 9V-OJE, operated by Scoot Tigerair (Scoot), departed Changi Airport, Singapore. The aircraft was on a scheduled passenger flight to Perth, Western Australia, with 11 crew members and 356 passengers on board.

Approximately 2 hours into the flight, the crew received two status messages indicating abnormalities within the right engine. Three hours later, during descent, the aircraft was passing through FL 250[2] when the crew noticed that the right engine was slow to respond to commanded inputs. Throughout the descent, the right engine performance continued to decline. Passing through 9,000 ft, severe thrust asymmetry developed, and the captain noticed rudder input from the autopilot. Shortly after, at 1853, the crew received the engine-indicating and crew-alerting system (EICAS) message ENG FAIL R, and the right engine shut down.

In response, the flight crew declared a PAN[3] and requested air traffic control clearance to level off at 5,000 feet and be vectored off the approach to allow time for completion of the quick reference handbook (QRH) checklist items. Completion of the QRH checklist required the flight crew to decide whether they should attempt to relight the engine. Due to the proximity of the airport and because the aircraft is capable of landing safely with one engine, the flight crew decided that attempting an engine restart was unnecessary. After the checklist was completed, the flight crew conducted a NITS[4] briefing with the cabin crew.

Subsequently, the flight crew completed the landing performance calculations and advised ATC that they were ready to land. The flight crew also requested that emergency services conduct a visual inspection of the aircraft after landing.

At 1909, the aircraft landed safely at Perth Airport and emergency services carried out a visual inspection. The aircraft was cleared to taxi to the parking bay and disembark passengers normally via the aerobridge.

There were no injuries sustained and no damage to the aircraft as a result of the occurrence.

Context

Subsequent maintenance

Following the occurrence, an engineering team carried out a detailed inspection of the aircraft to address the in-flight shutdown and status/EICAS warning messages observed by the crew. The technical examination resulted in replacement of the right engine hydro-mechanical unit (HMU) and a high-power engine run was then successfully performed.

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1 Western Standard Time (WST): Coordinated Universal Time (UTC) + 8 hours.

2 Flight level: at altitudes above 10,000 ft in Australia, an aircraft's height above mean sea level is referred to as a flight level (FL). FL 250 equates to 25,000 ft.

3 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.

4 NITS – Acronym encompassing the nature of the emergency, the intentions of the flight crew, the time available before landing, and the need for a special instructions brief.

On 12 October 2018, a non-revenue flight (no passengers or cargo) was conducted to return the aircraft to Singapore for further maintenance, during which time the electronic engine controller (EEC) was replaced. The aircraft then returned to revenue service.

On 15 October 2018, the aircraft was on a flight from Sydney to Singapore when several maintenance messages indicating similar issues to the occurrence flight were generated, but there was no noticeable effect on engine performance. Following the flight, additional components were replaced, including the:

- HMU (further replacement)
- fuel pump
- high- and low-pressure fuel filters
- left and right variable stator vane actuator.

The aircraft was then declared serviceable and returned to service with no further recurrence of the maintenance messages.

Engine fuel system

The Trent 1000 fuel system includes a three-stage pump that supplies fuel from the aircraft to the engine. Fuel runs through a low pressure (LP) pump followed by two high pressure (HP) pumps, identified as primary and secondary, running in parallel. The primary HP pump operates under all conditions, while the larger secondary HP pump increases fuel flow to the engine at periods of high demand, such as take-off.

The HP pumps supply fuel to the HMU, which controls fuel flow to the engine using its fuel metering valve (FMV) as follows:

- Fuel enters the FMV servo assembly within the HMU through an inlet filter.
- To change the flow rate of fuel supplied to the engine, the EEC sends electrical signals to the FMV servo assembly.
- The signals control the position of a valve, which changes the fuel pressures within the servo assembly.
- These servo pressures determine the position of the FMV, which ultimately controls the flow rate of fuel to the burners.

Rolls-Royce investigation

Following the occurrence and subsequent non-revenue flight to Singapore, the engine manufacturer, Rolls-Royce, conducted an investigation into the occurrence. This included reviewing flight data from both flights, examining engine components from 9V-OJE, and based on its findings, assessing the Trent 1000 fleet more widely.

Review of flight data

Approximately 2 hours into the flight, during cruise, the right engine's EEC generated the following message:

> Hydro-Mechanical Unit (Right Engine) fuel metering valve (FMV) torque motor current is too low or too high.

This message indicated that the current required to adjust the fuel flow via the FMV was outside the expected range. Eleven minutes later, another message indicated that the current had exceeded an allowable limit:

> Hydro-Mechanical Unit (Right Engine) fuel metering valve (FMV) torque motor current is failed too low or too high.

During descent, approximately 3 hours later, two more messages were generated:

> Hydro-Mechanical Unit (Right Engine) fuel metering valve (FMV) is not in commanded position.

Right Engine is failed below idle with fuel switch on.

Rolls-Royce determined that the first message was evidence the FMV was taking longer than it should have to reach the position specified by the EEC. It was found that the second message was generated after the EEC had commanded a deceleration. The FMV moved below the idle position as requested, but once deceleration had occurred, it did not move back to the directed idle position. The right engine then ran at sub-idle speed for a short time before shutting down. Data for the entire occurrence flight indicated that the torque motor current required to control the FMV position increased throughout the flight up until the in-flight shutdown.

Rolls-Royce also identified that the maintenance messages generated during the flight to Singapore on 15 October 2018 indicated that control of the new FMV was still requiring a higher than expected torque motor current. However, the engine continued to operate normally, and the flight was completed without incident.

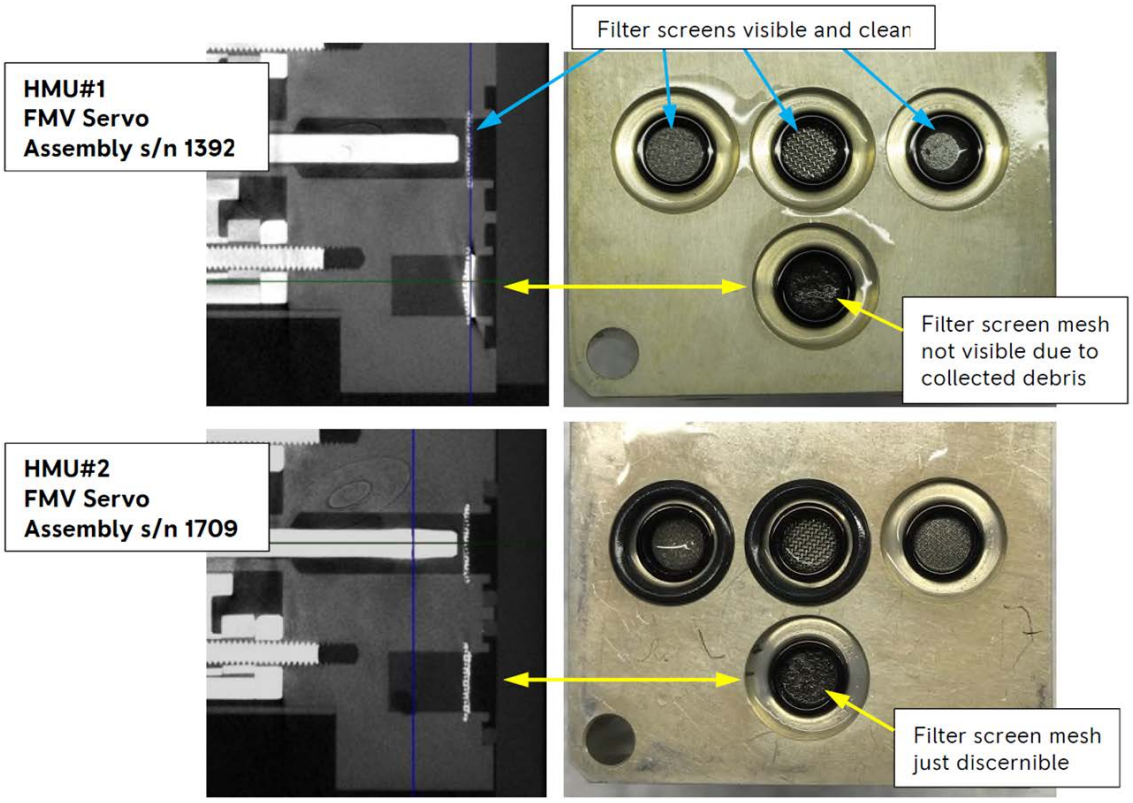
Component examination

Rolls-Royce examined the HMU from the occurrence flight (HMU 1) as well as the one from the subsequent flight (HMU 2). In both units, a build-up of metallic debris was found in various locations, although more debris was found in HMU 1. The inlet filter to the FMV servo assembly was at least partially blocked with debris in both units.

Rolls-Royce concluded that the in-flight shutdown of 9V-OJE's right engine was the result of the blocked inlet filter on the FMV servo assembly. The blockage restricted the EEC's ability to control the FMV, and ultimately, the flow of fuel to the engine.

The FMV servo assemblies from each HMU were scanned using CT imaging. The resulting x-ray cross sections are shown with photographs of each servo assembly in Figure 1.

Figure 1: Blocked inlet filters on both FMV servo assemblies

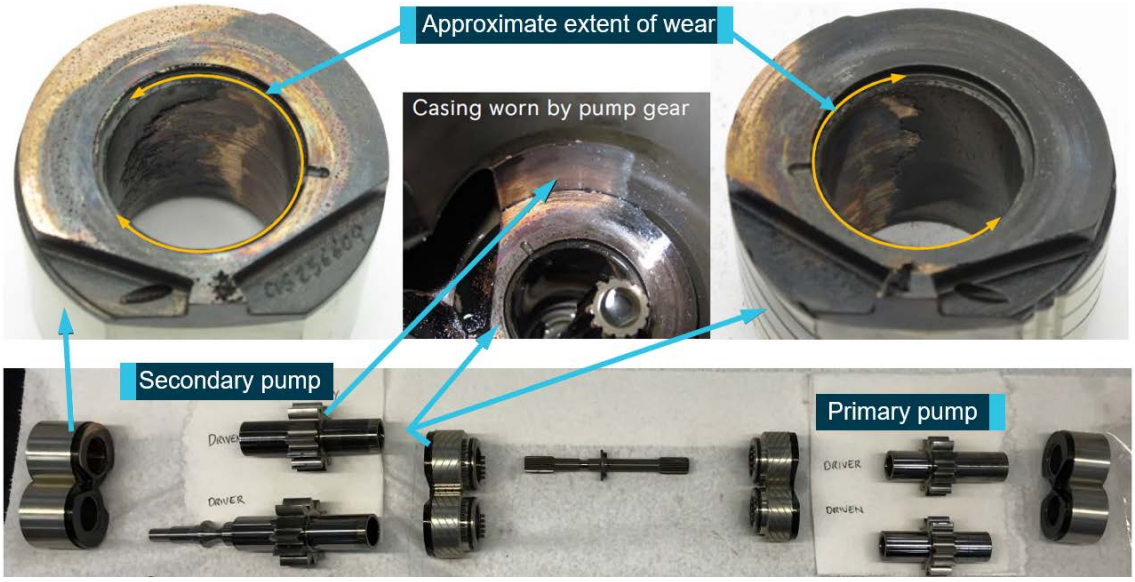


The build-up of metallic debris was greater on HMU #1. Some deformation can also be observed in the #1 inlet filter x-ray image. Rolls-Royce determined that this was likely due to the high-pressure differential caused by the blockage.
Source: Rolls-Royce

Analysis of the metallic debris revealed that it consisted of material from the fuel pump bearings and the casing. All three stages of the pump (the LP pump, and the two HP pumps) were disassembled and examined by Rolls-Royce in the presence of the United Kingdom Air Accidents Investigation Branch.

The examination found that the debris originated from the secondary HP pump. The bearings for the secondary HP pump driven gear were heavily worn, with evidence of scoring and missing material (Figure 2). Rolls-Royce found that the casing for the driven gear had more wear than would be expected during normal operation, likely due to shaft movement resulting from the damaged journal bearings. No damage was found on other bearings within the secondary HP pump or the other two fuel pumps.

Figure 2: Worn journal bearings and casing for the secondary HP pump driven gear



Source: Rolls-Royce

Rolls-Royce reviewed the manufacturing records for the secondary HP pump, but found that it was typical of the fleet. No abnormalities had been noted, and the pump dimensions were within the accepted tolerances. The material composition of the fuel pump components was checked and found to be similar to the rest of the population. The fuel pump and HMU from the left engine were removed and inspected as a precaution, but there was no evidence of journal wear or debris build-up.

Trent 1000 fleet inspection

On 1 November 2018, another Scoot Boeing 787 generated maintenance messages related to the HMU during start-up, prior to a flight. The engine was inspected, and some wear was also found on the secondary HP pump journal bearings.

To search for similar HMU maintenance messages, Rolls-Royce examined all maintenance data across the fleet of Trent 1000 Package B and Package C engines and continued to monitor ongoing flights. Six other events were found where messages were generated due to fuel pump debris blocking the FMV servo assembly inlet filter. Five of these events were from aircraft operated by Scoot, while one was from a different operator.

Of the events found in the Scoot fleet, the age of the pumps varied between 5,201 and 12,686 hours. The recommended life of the pumps was 22,000 hours. Based on the number of occurrences compared with the greater Trent 1000 fleet, Rolls-Royce determined that the secondary HP pump journal bearings on Scoot aircraft were particularly susceptible to low life journal wear.

In an effort to determine what was increasing wear susceptibility in the Scoot fleet's bearings, Rolls-Royce identified a number of potential factors, including the following:

- Pump manufacture and build: The worn pumps found on Scoot aircraft had been manufactured over a number of years from 2015 to 2017. As such, it was determined that a batch or build issue was unlikely to be a common factor.
- Fuel quality: Analysis of fuel samples from Singapore Changi Airport found no anomalies within the 12 months prior to the occurrence involving 9V-OJE. There were also no reports of fuel pump bearing wear from other Trent 1000 operators that used the same airport.
- Operations: Rolls-Royce noted that Scoot generally flew shorter routes than most other Trent 1000 operators, but there were comparable operations with no evidence of fuel pump journal wear. Within the Scoot fleet, aircraft flew to multiple destinations, and there were no specific city pairs associated with the engines with worn bearings.
- Maintenance: Scoot shared its maintenance facilities with another operator that also used Trent 1000 engines. There was no evidence of fuel pump bearing wear from this operator.

Based on its investigation, Rolls-Royce concluded the following:

> It is likely that a combination of factors have led to Scoot bearings being particularly susceptible to significant low life wear, but analysis of data to date has not identified any significant differences between worn and unworn bearings, both within the Scoot fleet and the wider Trent 1000 Pack B & C fleets.

It was further noted that the majority of Scoot events occurred between late 2018 and early 2019. With the exception of the occurrence flight, none resulted in an in-flight shutdown.

The Rolls-Royce investigation also considered factors in addition to those listed above but, due to the number of variables, was unable to identify which might have been dominant with respect to the pump bearing wear. However, it identified and implemented interim measures (mainly related to engine data monitoring) to address the risk from low life wear of bearings.

Safety analysis

While on descent into Perth, the right engine of 9V-OJE shut down. After completing the necessary checklists, the flight crew landed the aircraft safely on one engine. There were no injuries sustained as a result.

The engine manufacturer, Rolls-Royce, concluded that the engine shutdown was the result of a blocked inlet filter on the fuel metering valve (FMV) servo assembly. This blockage restricted the electronic engine controller's (EEC) ability to adjust fuel pressures within the servo. As a result, the EEC had limited control over the FMV position, and consequently the amount of fuel flowing to the burners. When the EEC commanded the FMV to increase fuel flow from sub-idle to idle levels, it did not respond in time, and the engine shut down. The blockage was due to debris from worn journal bearings in the secondary HP fuel pump driven gear.

Rolls-Royce's examination of flight data and maintenance records from its Trent 1000 engines identified that Scoot's fleet of 787 aircraft had been particularly susceptible to low life wear in their secondary HP pump journal bearings over a period of several months. The Rolls-Royce investigation identified various potential factors that might have contributed to low life journal wear, including the fleet's operation, maintenance, fuel quality, or pump design and construction. However, it found no evidence that any factors were significantly different to the wider Trent 1000 fleet. Additionally, due to the number of variables associated with operations, maintenance, design and manufacture, it was not possible to determine the relative effect of these factors (and possibly others) when combined.

Findings

ATSB investigation report findings focus on safety factors (that is, events and conditions that increase risk). Safety factors include 'contributing factors' and 'other factors that increased risk' (that is, factors that did not meet the definition of a contributing factor for this occurrence but were still considered important to include in the report for the purpose of increasing awareness and enhancing safety). In addition 'other findings' may be included to provide important information about topics other than safety factors.

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

From the evidence available, the following findings are made with respect to the uncommanded engine shutdown involving Boeing 787-9, 9V-OJE, on 11 October 2018 near Perth Airport.

Contributing factors

- Following a series of status and alert messages related to the aircraft's right engine, the engine shut down during descent. The flight crew followed the appropriate procedures and landed the aircraft safely using the operational engine.
- The engine shutdown was the result of insufficient fuel delivery due to low pressure in the fuel metering valve servo assembly, as debris from worn fuel pump bearings had blocked its inlet filter.
- The engine manufacturer, Rolls-Royce, identified that between late 2018 and early 2019 the operator's fleet of 787 aircraft were particularly susceptible to low life wear in the journal bearings of the secondary high-pressure fuel pump.

Other finding

- Rolls-Royce identified a number of potential factors that led to the component wear but, due to the number of variables, a single/dominant reason could not be established.

Safety actions

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.

Safety action by Rolls-Royce

As part of its investigation into the engine failure, Rolls-Royce instructed Scoot to remove the engine's fuel pump in the event of debris being found in the ports during removal of a hydro-mechanical unit. In February 2020, the Fault Isolation Manual was updated to instruct all operators to remove the fuel pump and hydro-mechanical unit in the event of a maintenance message regarding the fuel metering valve not being in the commanded position.

Rolls-Royce is investigating the possibility of detecting potential fuel pump bearing journal wear by using flight data (particularly the fuel metering valve torque motor current) to detect partial filter blockage before maintenance messages are generated. It is also continuing to monitor maintenance messages and the condition of unserviceable fuel pumps 'to ensure that the risk of an in-flight shutdown caused by fuel pump bearing wear is maintained at an acceptable rate'.

Sources and submissions

Sources of information

The sources of information during the investigation included:

- the aircraft captain
- Scoot Tigerair

- Rolls-Royce

Submissions

Under section 26 of the *Transport Safety Investigation Act 2003*, the ATSB may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. That section allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the following directly involved parties:

- the aircraft captain
- the aircraft first officer
- Scoot Tigerair
- Rolls-Royce
- The Boeing Company
- the Civil Aviation Safety Authority
- the Transport Safety Investigation Bureau of Singapore
- the United States National Transportation Safety Board
- the Air Accidents Investigation Branch (United Kingdom)

Submissions were received from:

- Rolls-Royce
- the United States National Transportation Safety Board
- the Air Accidents Investigation Branch (United Kingdom)

The submissions were reviewed and, where considered appropriate, the text of the report was amended accordingly.

General details

Occurrence details

Date and time:	11 October 2018 – 1853 WST	
Occurrence category:	Incident	
Primary occurrence type:	Engine failure or malfunction	
Location:	46 km north of Perth Airport, Western Australia	
	Latitude: 31° 31.37' S	Longitude: 115° 58.02' E

Aircraft details

Manufacturer and model:	The Boeing Company 787-9	
Registration:	9V-OJE	
Operator:	Scoot Tigerair	
Serial number:	37116 LN:316	
Type of operation:	Air Transport High Capacity - Passenger	
Activity:	Commercial air transport – Scheduled – International	
Departure:	Singapore	
Destination:	Perth, Western Australia	
Persons on board:	Crew – 11	Passengers – 356
Injuries:	Crew – Nil	Passengers – Nil

s.47F(1)

From: s.47F(1)
Sent: Friday, 20 November 2020 1:27 PM
To: s.47F(1)
Cc:
Subject: RE: For your approval: draft dips/advance emails for release of AO-2018-069 [SEC=OFFICIAL]

Categories: Red Category

Hi s.47F(1)

That list is complete and correct – I just CCed s.47F(1) who's the manager for this one.

Cheers,
s.47F(1)

From: s.47F(1)
Sent: Friday, 20 November 2020 13:20
To: s.47F(1)
Subject: For your approval: draft dips/advance emails for release of AO-2018-069 [SEC=OFFICIAL]

OFFICIAL

s.47F(1)

For your approval, below are the advance release emails and contacts for AO-2018-069

Please check to ensure all contacts are as expected and advise of any changes or additions required.

PDF of the report attached for reference.

Regards

Thanks

s.47F(1)

DIPS and Party with an Involvement (PWI) and Interested Party (IPs) distribution lists – WILL receive a PDF of the report
Please check all contacts listed are as expected, as collected from SIIMS.

s.47F(1)	Directly Involved Party	s.47F(1)
	Directly Involved Party	
	Directly Involved Party	
	Directly Involved Party	
	Directly Involved Party	
	Directly Involved Party	

s.47F(1)

Directly Involved Party
Directly Involved Party
Directly Involved Party

s.47F(1)

Email title: Advance release of ATSB investigation report (AO-2018-069): Uncommanded engine shutdown involving Boeing 787-9, 9V-OJE, 46 km north of Perth Airport, Western Australia, 11 October 2018

Dear Directly Involved Party

Attached for your information is a copy of the following ATSB Transport Safety Report:

Report number:	AO-2018-069
Report type:	Final
Report title:	Uncommanded engine shutdown involving Boeing 787-9, 9V-OJE
Location:	46 km north of Perth Airport, Western Australia
Date of occurrence:	11 October 2018
Investigation level:	Short
Public release:	1 December 2020 at 10:30 am AEDT

I am providing you with an advance copy of the report under the provisions of Section 26(1) of the *Transport Safety Investigation Act 2003*. Under Section 26, the report may only be copied and disclosed prior to its public release for the purpose of taking safety action. Disclosure of this document in any other circumstance prior to its public release date may constitute a criminal offence.

If new evidence becomes available that impacts upon the factual accuracy of the report, the ATSB may make changes before its public release. In a small number of instances, editorial or other changes may also be made. If the changes are substantive, we will provide an amended copy of the relevant document before its public release. The final version of the report will be released in accordance with subsection 25(1) of the Act.

On 1 July 2017, the ATSB updated its policy of identifying organisations in its transport safety investigations. For more information visit the ATSB website.

Should you need to contact the ATSB about the contents of this report prior to its public release, do not reply to this email, as this address is not monitored. Instead, please contact me using the details below.

Yours sincerely,

s.47F(1)

ATSB

Australian Transport Safety Bureau
Level 2, 62 Northbourne Avenue
Canberra ACT 2601

s.47F(1)

www.atsb.gov.au
@atsbgovau

Australia's national transport safety investigator

Ministerial/departmental distribution Deputy Prime Minister's Office
- WILL receive a PDF of the report

To: example DPMO Aviation <DPMOAviation@atsb.gov.au> (note there are emails groups for each transport mode get from outlook address book)

CC: example ATSB - Reports_Aviation <ATSB-Reports_Aviation@atsb.gov.au> (note there are emails groups for each transport mode get from outlook address book)

Email title: Advance release of ATSB investigation report (AO-2018-069): Uncommanded engine shutdown involving Boeing 787-9, 9V-OJE, 46 km north of Perth Airport, Western Australia, 11 October 2018

Good morning,

The ATSB is releasing investigation report: AO-2018-069 - Uncommanded engine shutdown involving Boeing 787-9, 9V-OJE

The report will become a public document on 1 December 2020 at 10:30 am AEDT.

Brief details of the investigation are as follows:

Sensitivity	Release of the report may attract media interest. As part of the ATSB's media management for this report release, we will conduct media interviews on request, respond to enquiries, and use our social media platforms and website to promote the safety messages in the report.
What	On 11 October 2018, a Boeing 787-9, 9V-OJE, operated by Scoot Tigerair (Scoot), departed Singapore on a scheduled flight to Perth, Western Australia. During descent, the flight crew noticed that the right engine was slow to respond to commands, and its performance continued to decline throughout the descent. While passing through 9,000 ft, severe thrust asymmetry developed, and the engine shut down shortly afterwards. The crew followed appropriate procedures, and due to the proximity of the airport, elected not to attempt a restart. The aircraft landed safely with emergency services in attendance. There were no injuries sustained and no aircraft damage as a result of the incident.
Safety message	This occurrence highlights the importance of flight crew being familiar with emergency procedures, so that the appropriate corrective action can be taken quickly and effectively. In this case, the flight crew worked effectively to assess the situation, and took appropriate action to minimise risk in accordance with the operator's flight crew operations manual. This occurrence also shows that positively identifying the factors contributing to technical failures can be difficult and time consuming. However, manufacturers and operators can implement interim risk mitigation measures, as was the case here.
When	11 October 2018
Where	46 km north of Perth Airport, Western Australia
Injuries	NIL

I am providing you with an advance copy of the report and any associated Safety Advisory Notices (SANs) under the provisions of Section 26(1) of the *Transport Safety Investigation Act 2003*. Under Section 26, the report or SANs may only be copied and disclosed prior to their public release for the purpose of taking safety action. Disclosure of these documents in any other circumstance prior to their public release date may constitute a criminal offence.

If new evidence becomes available that impacts upon the investigation findings or the factual accuracy of the report or SAN, the ATSB may make changes to these documents before their public release. In a small number of instances, editorial or other changes may also be made. If the changes are substantive, we will provide an amended copy of the relevant document/s before their public release. The final report (and SAN/s) will be released in accordance with subsection 25(1) of the Act.

Should you need to contact the ATSB about the contents of this report prior to its public release, do not reply to this email, as this address is not monitored. Instead, please contact me using the details below.

Yours sincerely,

s.47F(1)

ATSB

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Level 2, 62 Northbourne Avenue
Canberra ACT 2601

s.47F(1)

www.atsb.gov.au
@atsbgovau

Australia's national transport safety investigator

From: s.47F(1)
Bcc:

Subject: DATE CORRECTION - Release for DIP comment - Draft ATSB Transport Safety Investigation Report AO-2018-069 [SEC=OFFICIAL:Sensitive, ACCESS=Legislative-Secrecy, NOTE=Transport Safety Investigation ACT 2003]
Date: Tuesday, 27 October 2020 16:44:00

OFFICIAL:Sensitive
Legislative secrecy

Dear Directly Involved Party

One small correction regarding feedback on the report AO 2018 069: Please provide comments by **10 November 2020.**

Apologies for the mix up.

Kind regards,

s.47F(1)
Transport Safety Investigator

ATSB

Australian Transport Safety Bureau
Level 1, 62 Northbourne Avenue
Canberra ACT 2601
s.47F(1)

www.atsb.gov.au
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Australia's national transport safety investigator

From: draftcomments
Sent: Tuesday, 27 October 2020 16:35
Subject: Release for DIP comment Draft ATSB Transport Safety Investigation Report AO 2018-069 [SEC=OFFICIAL:Sensitive, ACCESS=Legislative Secrecy, NOTE=Transport Safety Investigation ACT 2003]

OFFICIAL:Sensitive
Legislative secrecy

Dear Directly Involved Party,

Subject: **Release of *Draft* transport safety investigation report**
Attached is a copy of the following report:

Report Number: AO-2018 069
Report Type: Draft

Aircraft/Train/Vessel: Boeing 787-9
Registration: 9V-OJE
Location: 46 km north of Perth Airport, Western Australia
Date of occurrence: 11 October 2018

The ATSB's policy is to seek comment on the factual content of its transport safety reports from organisations and/or individuals who were directly involved in those occurrences, (or immediately after the occurrences), or who may be affected by the findings.

The draft report has been provided to you under Section 26 of the *Transport Safety Investigation Act 2003* to enable checking of the accuracy of the content and to ensure natural justice. Under Section 26, the report may only be copied and disclosed prior to its public release for the purpose of taking safety action or providing comment to the ATSB. Disclosure of this report in any other circumstance prior to its public release date constitutes a criminal offence.

Should you wish to comment on the factual accuracy of the attached report, including providing advice on safety action taken or proposed by you/your organisation to address safety issues identified, your comments should be provided to the ATSB (draftcomments@atsb.gov.au) by **10 December 2020**. If your comment seeks to have the ATSB report amended, factual information in support of such a request must be included with your response.

To assist in finalising this report, we request that you confirm receipt of the draft by return email to draftcomments@atsb.gov.au.

Kind regards,

s.47F(1)
Transport Safety Investigator

ATSB

Australian Transport Safety Bureau
Level 1, 62 Northbourne Avenue
Canberra ACT 2601
s.47F(1)

www.atsb.gov.au
@atsbgovau
Australia's national transport safety investigator

From: draftcomments
Bcc: s.47F(1)

Subject: Release for DIP comment - Draft ATSB Transport Safety Investigation Report AO-2018-069 [SEC=OFFICIAL:Sensitive, ACCESS=Legislative-Secrecy, NOTE=Transport Safety Investigation ACT 2003]
Date: Tuesday, 27 October 2020 16:34:00
Attachments: AO-2018-069 Draft.pdf

OFFICIAL:Sensitive
Legislative secrecy

Dear Directly Involved Party,

Subject: **Release of *Draft* transport safety investigation report**
Attached is a copy of the following report:

Report Number:	AO-2018-069
Report Type:	Draft
Aircraft/Train/Vessel:	Boeing 787-9
Registration:	9V-OJE
Location:	46 km north of Perth Airport, Western Australia
Date of occurrence:	11 October 2018

The ATSB's policy is to seek comment on the factual content of its transport safety reports from organisations and/or individuals who were directly involved in those occurrences, (or immediately after the occurrences), or who may be affected by the findings.

The draft report has been provided to you under Section 26 of the *Transport Safety Investigation Act 2003* to enable checking of the accuracy of the content and to ensure natural justice. Under Section 26, the report may only be copied and disclosed prior to its public release for the purpose of taking safety action or providing comment to the ATSB. Disclosure of this report in any other circumstance prior to its public release date constitutes a criminal offence.

Should you wish to comment on the factual accuracy of the attached report, including providing advice on safety action taken or proposed by you/your organisation to address safety issues identified, your comments should be provided to the ATSB (draftcomments@atsb.gov.au) by **10 December 2020**. If your comment seeks to have the ATSB report amended, factual information in support of such a request must be included with your response.

To assist in finalising this report, we request that you confirm receipt of the draft by return email to draftcomments@atsb.gov.au.

Kind regards,

s.47F(1)
Transport Safety Investigator

ATSB

Australian Transport Safety Bureau
Level 1, 62 Northbourne Avenue

Canberra ACT 2601
s.47F(1)

www.atsb.gov.au
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Australia's national transport safety investigator

Australian Government
Australian Transport Safety Bureau

Uncommanded engine shutdown involving Boeing 787-9, 9V-OJE

46 km north of Perth Airport, Western Australia, 11 October 2018

ATSB Transport Safety Report
Aviation Occurrence Investigation (Short)
AO-2018-069
Final – 1 December 2020

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

Publishing information

Published by: Australian Transport Safety Bureau
Postal address: PO Box 967, Civic Square ACT 2608
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Accident and incident notification: 1800 011 034 (24 hours)
Email: atsbinfo@atsb.gov.au
Website: www.atsb.gov.au

Addendum

Page	Change	Date

Safety summary

What happened

On 11 October 2018, a Boeing 787-9, 9V-OJE, operated by Scoot Tigerair (Scoot), departed Singapore on a scheduled flight to Perth, Western Australia. During descent, the flight crew noticed that the right engine was slow to respond to commands, and its performance continued to decline throughout the descent. While passing through 9,000 ft, severe thrust asymmetry developed, and the engine shut down shortly afterwards. The crew followed appropriate procedures, and due to the proximity of the airport, elected not to attempt a restart. The aircraft landed safely with emergency services in attendance. There were no injuries sustained and no aircraft damage as a result of the incident.

What the ATSB found

The ATSB determined that following a series of engine status and alert messages, 9V-OJE experienced an uncommanded engine shutdown while on descent into Perth, before landing safely using the operational engine.

Based on a review of the flight data and an examination of engine components by Rolls-Royce, the engine shutdown was due to debris from worn journal bearings in the engine's secondary high-pressure fuel pump blocking an inlet filter for the fuel metering valve servo assembly. This prevented the valve from delivering sufficient fuel to the engine.

Rolls-Royce also determined that, between late 2018 and early 2019, the operator's fleet of 787 aircraft had been particularly susceptible to low-life wear in the journal bearings of the secondary high-pressure fuel pump. It identified a number of potential factors that led to the component wear but, due to the number of variables, a single/dominant reason could not be established.

What has been done as a result

Rolls-Royce updated its Fault Isolation Manual to instruct all operators to remove the fuel pump and hydro-mechanical unit in the event of a maintenance message regarding the fuel metering valve not being in the commanded position. Rolls-Royce is also monitoring maintenance messages and investigating the possibility of using flight data to detect fuel pump journal wear before its effects on valve operation become apparent.

Safety message

This occurrence highlights the importance of flight crew being familiar with emergency procedures, so that the appropriate corrective action can be taken quickly and effectively. In this case, the flight crew worked effectively to assess the situation, and took appropriate action to minimise risk in accordance with the operator's flight crew operations manual.

This occurrence also shows that positively identifying the factors contributing to technical failures can be difficult and time consuming. However, manufacturers and operators can implement interim risk mitigation measures, as was the case here.

The investigation

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 investigation was conducted in order to produce a short investigation report, and allow for greater industry awareness of findings that affect safety and potential learning opportunities.

The occurrence

On 11 October 2018, at about 1421 Western Standard Time,[1] a Boeing 787-9, 9V-OJE, operated by Scoot Tigerair (Scoot), departed Changi Airport, Singapore. The aircraft was on a scheduled passenger flight to Perth, Western Australia, with 11 crew members and 356 passengers on board.

Approximately 2 hours into the flight, the crew received two status messages indicating abnormalities within the right engine. Three hours later, during descent, the aircraft was passing through FL 250[2] when the crew noticed that the right engine was slow to respond to commanded inputs. Throughout the descent, the right engine performance continued to decline. Passing through 9,000 ft, severe thrust asymmetry developed, and the captain noticed rudder input from the autopilot. Shortly after, at 1853, the crew received the engine-indicating and crew-alerting system (EICAS) message ENG FAIL R, and the right engine shut down.

In response, the flight crew declared a PAN[3] and requested air traffic control clearance to level off at 5,000 feet and be vectored off the approach to allow time for completion of the quick reference handbook (QRH) checklist items. Completion of the QRH checklist required the flight crew to decide whether they should attempt to relight the engine. Due to the proximity of the airport and because the aircraft is capable of landing safely with one engine, the flight crew decided that attempting an engine restart was unnecessary. After the checklist was completed, the flight crew conducted a NITS[4] briefing with the cabin crew.

Subsequently, the flight crew completed the landing performance calculations and advised ATC that they were ready to land. The flight crew also requested that emergency services conduct a visual inspection of the aircraft after landing.

At 1909, the aircraft landed safely at Perth Airport and emergency services carried out a visual inspection. The aircraft was cleared to taxi to the parking bay and disembark passengers normally via the aerobridge.

There were no injuries sustained and no damage to the aircraft as a result of the occurrence.

Context

Subsequent maintenance

Following the occurrence, an engineering team carried out a detailed inspection of the aircraft to address the in-flight shutdown and status/EICAS warning messages observed by the crew. The technical examination resulted in replacement of the right engine hydro-mechanical unit (HMU) and a high-power engine run was then successfully performed.

---

1 Western Standard Time (WST): Coordinated Universal Time (UTC) + 8 hours.

2 Flight level: at altitudes above 10,000 ft in Australia, an aircraft's height above mean sea level is referred to as a flight level (FL). FL 250 equates to 25,000 ft.

3 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.

4 NITS – Acronym encompassing the nature of the emergency, the intentions of the flight crew, the time available before landing, and the need for a special instructions brief.

On 12 October 2018, a non-revenue flight (no passengers or cargo) was conducted to return the aircraft to Singapore for further maintenance, during which time the electronic engine controller (EEC) was replaced. The aircraft then returned to revenue service.

On 15 October 2018, the aircraft was on a flight from Sydney to Singapore when several maintenance messages indicating similar issues to the occurrence flight were generated, but there was no noticeable effect on engine performance. Following the flight, additional components were replaced, including the:

- HMU (further replacement)
- fuel pump
- high- and low-pressure fuel filters
- left and right variable stator vane actuator.

The aircraft was then declared serviceable and returned to service with no further recurrence of the maintenance messages.

Engine fuel system

The Trent 1000 fuel system includes a three-stage pump that supplies fuel from the aircraft to the engine. Fuel runs through a low pressure (LP) pump followed by two high pressure (HP) pumps, identified as primary and secondary, running in parallel. The primary HP pump operates under all conditions, while the larger secondary HP pump increases fuel flow to the engine at periods of high demand, such as take-off.

The HP pumps supply fuel to the HMU, which controls fuel flow to the engine using its fuel metering valve (FMV) as follows:

- Fuel enters the FMV servo assembly within the HMU through an inlet filter.
- To change the flow rate of fuel supplied to the engine, the EEC sends electrical signals to the FMV servo assembly.
- The signals control the position of a valve, which changes the fuel pressures within the servo assembly.
- These servo pressures determine the position of the FMV, which ultimately controls the flow rate of fuel to the burners.

Rolls-Royce investigation

Following the occurrence and subsequent non-revenue flight to Singapore, the engine manufacturer, Rolls-Royce, conducted an investigation into the occurrence. This included reviewing flight data from both flights, examining engine components from 9V-OJE, and based on its findings, assessing the Trent 1000 fleet more widely.

Review of flight data

Approximately 2 hours into the flight, during cruise, the right engine's EEC generated the following message:

> Hydro-Mechanical Unit (Right Engine) fuel metering valve (FMV) torque motor current is too low or too high.

This message indicated that the current required to adjust the fuel flow via the FMV was outside the expected range. Eleven minutes later, another message indicated that the current had exceeded an allowable limit:

> Hydro-Mechanical Unit (Right Engine) fuel metering valve (FMV) torque motor current is failed too low or too high.

During descent, approximately 3 hours later, two more messages were generated:

> Hydro-Mechanical Unit (Right Engine) fuel metering valve (FMV) is not in commanded position.

Right Engine is failed below idle with fuel switch on.

Rolls-Royce determined that the first message was evidence the FMV was taking longer than it should have to reach the position specified by the EEC. It was found that the second message was generated after the EEC had commanded a deceleration. The FMV moved below the idle position as requested, but once deceleration had occurred, it did not move back to the directed idle position. The right engine then ran at sub-idle speed for a short time before shutting down. Data for the entire occurrence flight indicated that the torque motor current required to control the FMV position increased throughout the flight up until the in-flight shutdown.

Rolls-Royce also identified that the maintenance messages generated during the flight to Singapore on 15 October 2018 indicated that control of the new FMV was still requiring a higher than expected torque motor current. However, the engine continued to operate normally, and the flight was completed without incident.

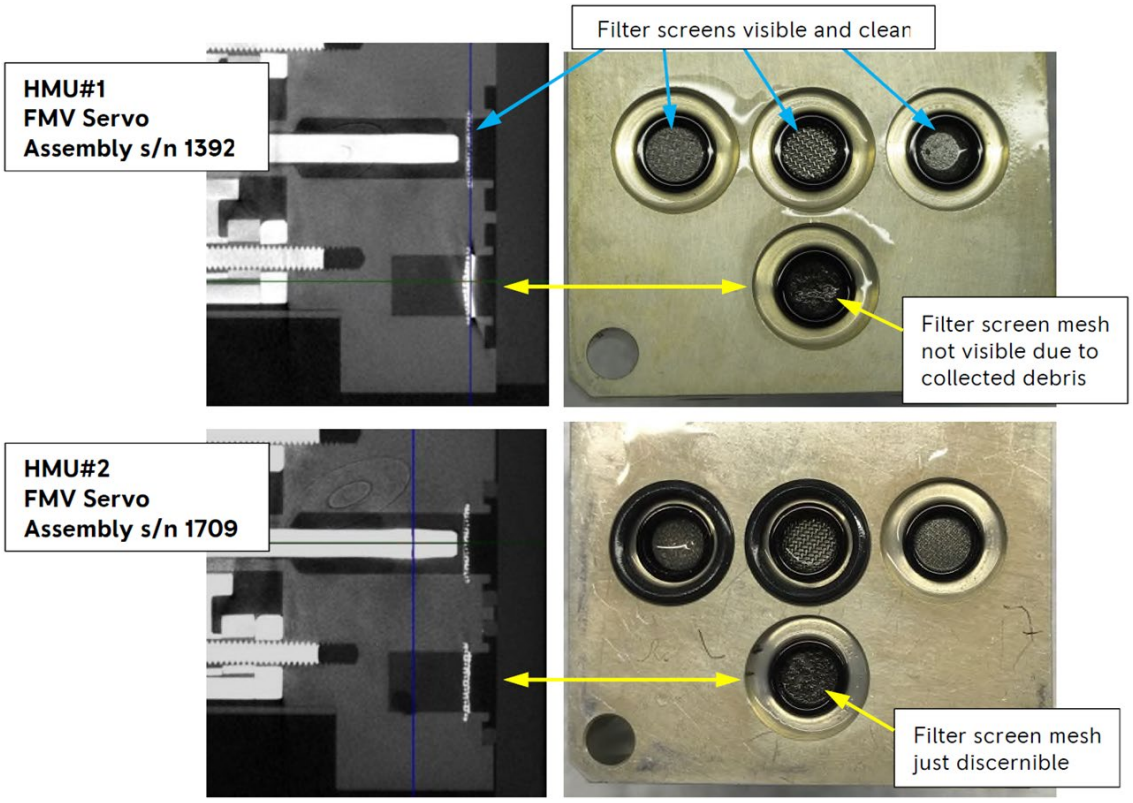
Component examination

Rolls-Royce examined the HMU from the occurrence flight (HMU 1) as well as the one from the subsequent flight (HMU 2). In both units, a build-up of metallic debris was found in various locations, although more debris was found in HMU 1. The inlet filter to the FMV servo assembly was at least partially blocked with debris in both units.

Rolls-Royce concluded that the in-flight shutdown of 9V-OJE's right engine was the result of the blocked inlet filter on the FMV servo assembly. The blockage restricted the EEC's ability to control the FMV, and ultimately, the flow of fuel to the engine.

The FMV servo assemblies from each HMU were scanned using CT imaging. The resulting x-ray cross sections are shown with photographs of each servo assembly in Figure 1.

Figure 1: Blocked inlet filters on both FMV servo assemblies

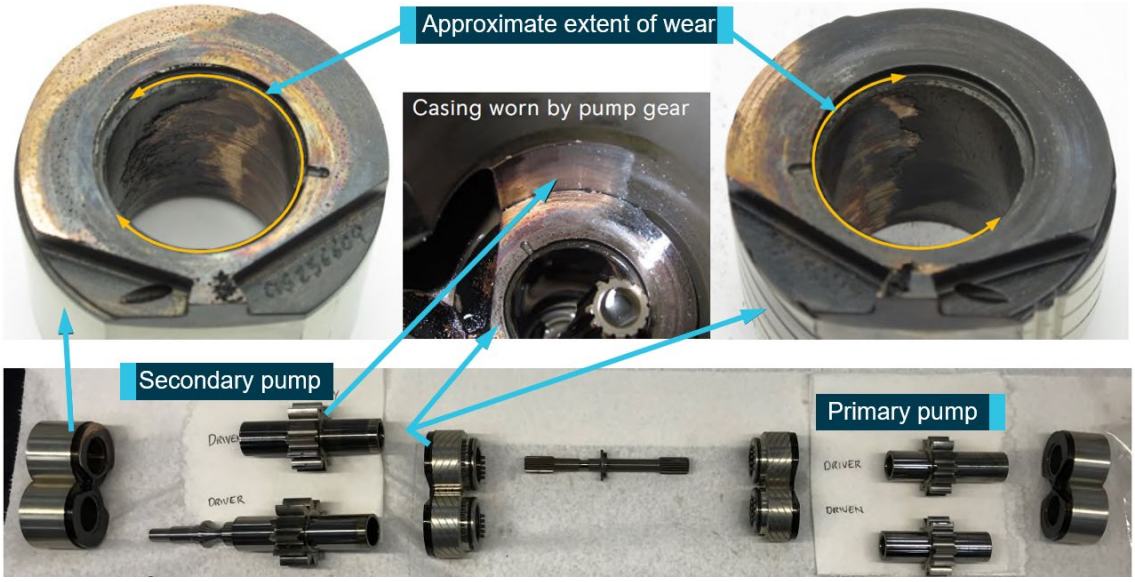


The build-up of metallic debris was greater on HMU #1. Some deformation can also be observed in the #1 inlet filter x-ray image. Rolls-Royce determined that this was likely due to the high-pressure differential caused by the blockage.
Source: Rolls-Royce

Analysis of the metallic debris revealed that it consisted of material from the fuel pump bearings and the casing. All three stages of the pump (the LP pump, and the two HP pumps) were disassembled and examined by Rolls-Royce in the presence of the United Kingdom Air Accidents Investigation Branch.

The examination found that the debris originated from the secondary HP pump. The bearings for the secondary HP pump driven gear were heavily worn, with evidence of scoring and missing material (Figure 2). Rolls-Royce found that the casing for the driven gear had more wear than would be expected during normal operation, likely due to shaft movement resulting from the damaged journal bearings. No damage was found on other bearings within the secondary HP pump or the other two fuel pumps.

Figure 2: Worn journal bearings and casing for the secondary HP pump driven gear



Source: Rolls-Royce

Rolls-Royce reviewed the manufacturing records for the secondary HP pump, but found that it was typical of the fleet. No abnormalities had been noted, and the pump dimensions were within the accepted tolerances. The material composition of the fuel pump components was checked and found to be similar to the rest of the population. The fuel pump and HMU from the left engine were removed and inspected as a precaution, but there was no evidence of journal wear or debris build-up.

Trent 1000 fleet inspection

On 1 November 2018, another Scoot Boeing 787 generated maintenance messages related to the HMU during start-up, prior to a flight. The engine was inspected, and some wear was also found on the secondary HP pump journal bearings.

To search for similar HMU maintenance messages, Rolls-Royce examined all maintenance data across the fleet of Trent 1000 Package B and Package C engines and continued to monitor ongoing flights. Six other events were found where messages were generated due to fuel pump debris blocking the FMV servo assembly inlet filter. Five of these events were from aircraft operated by Scoot, while one was from a different operator.

Of the events found in the Scoot fleet, the age of the pumps varied between 5,201 and 12,686 hours. The recommended life of the pumps was 22,000 hours. Based on the number of occurrences compared with the greater Trent 1000 fleet, Rolls-Royce determined that the secondary HP pump journal bearings on Scoot aircraft were particularly susceptible to low life journal wear.

In an effort to determine what was increasing wear susceptibility in the Scoot fleet's bearings, Rolls-Royce identified a number of potential factors, including the following:

- Pump manufacture and build: The worn pumps found on Scoot aircraft had been manufactured over a number of years from 2015 to 2017. As such, it was determined that a batch or build issue was unlikely to be a common factor.
- Fuel quality: Analysis of fuel samples from Singapore Changi Airport found no anomalies within the 12 months prior to the occurrence involving 9V-OJE. There were also no reports of fuel pump bearing wear from other Trent 1000 operators that used the same airport.
- Operations: Rolls-Royce noted that Scoot generally flew shorter routes than most other Trent 1000 operators, but there were comparable operations with no evidence of fuel pump journal wear. Within the Scoot fleet, aircraft flew to multiple destinations, and there were no specific city pairs associated with the engines with worn bearings.
- Maintenance: Scoot shared its maintenance facilities with another operator that also used Trent 1000 engines. There was no evidence of fuel pump bearing wear from this operator.

Based on its investigation, Rolls-Royce concluded the following:

> It is likely that a combination of factors have led to Scoot bearings being particularly susceptible to significant low life wear, but analysis of data to date has not identified any significant differences between worn and unworn bearings, both within the Scoot fleet and the wider Trent 1000 Pack B & C fleets.

It was further noted that the majority of Scoot events occurred between late 2018 and early 2019. With the exception of the occurrence flight, none resulted in an in-flight shutdown.

The Rolls-Royce investigation also considered factors in addition to those listed above but, due to the number of variables, was unable to identify which might have been dominant with respect to the pump bearing wear. However, it identified and implemented interim measures (mainly related to engine data monitoring) to address the risk from low life wear of bearings.

Safety analysis

While on descent into Perth, the right engine of 9V-OJE shut down. After completing the necessary checklists, the flight crew landed the aircraft safely on one engine. There were no injuries sustained as a result.

The engine manufacturer, Rolls-Royce, concluded that the engine shutdown was the result of a blocked inlet filter on the fuel metering valve (FMV) servo assembly. This blockage restricted the electronic engine controller's (EEC) ability to adjust fuel pressures within the servo. As a result, the EEC had limited control over the FMV position, and consequently the amount of fuel flowing to the burners. When the EEC commanded the FMV to increase fuel flow from sub-idle to idle levels, it did not respond in time, and the engine shut down. The blockage was due to debris from worn journal bearings in the secondary HP fuel pump driven gear.

Rolls-Royce's examination of flight data and maintenance records from its Trent 1000 engines identified that Scoot's fleet of 787 aircraft had been particularly susceptible to low life wear in their secondary HP pump journal bearings over a period of several months. The Rolls-Royce investigation identified various potential factors that might have contributed to low life journal wear, including the fleet's operation, maintenance, fuel quality, or pump design and construction. However, it found no evidence that any factors were significantly different to the wider Trent 1000 fleet. Additionally, due to the number of variables associated with operations, maintenance, design and manufacture, it was not possible to determine the relative effect of these factors (and possibly others) when combined.

Findings

ATSB investigation report findings focus on safety factors (that is, events and conditions that increase risk). Safety factors include 'contributing factors' and 'other factors that increased risk' (that is, factors that did not meet the definition of a contributing factor for this occurrence but were still considered important to include in the report for the purpose of increasing awareness and enhancing safety). In addition 'other findings' may be included to provide important information about topics other than safety factors.

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

From the evidence available, the following findings are made with respect to the uncommanded engine shutdown involving Boeing 787-9, 9V-OJE, on 11 October 2018 near Perth Airport.

Contributing factors

- Following a series of status and alert messages related to the aircraft's right engine, the engine shut down during descent. The flight crew followed the appropriate procedures and landed the aircraft safely using the operational engine.
- The engine shutdown was the result of insufficient fuel delivery due to low pressure in the fuel metering valve servo assembly, as debris from worn fuel pump bearings had blocked its inlet filter.
- The engine manufacturer, Rolls-Royce, identified that between late 2018 and early 2019 the operator's fleet of 787 aircraft were particularly susceptible to low life wear in the journal bearings of the secondary high-pressure fuel pump.

Other finding

- Rolls-Royce identified a number of potential factors that led to the component wear but, due to the number of variables, a single/dominant reason could not be established.

Safety actions

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.

Safety action by Rolls-Royce

As part of its investigation into the engine failure, Rolls-Royce instructed Scoot to remove the engine's fuel pump in the event of debris being found in the ports during removal of a hydro-mechanical unit. In February 2020, the Fault Isolation Manual was updated to instruct all operators to remove the fuel pump and hydro-mechanical unit in the event of a maintenance message regarding the fuel metering valve not being in the commanded position.

Rolls-Royce is investigating the possibility of detecting potential fuel pump bearing journal wear by using flight data (particularly the fuel metering valve torque motor current) to detect partial filter blockage before maintenance messages are generated. It is also continuing to monitor maintenance messages and the condition of unserviceable fuel pumps 'to ensure that the risk of an in-flight shutdown caused by fuel pump bearing wear is maintained at an acceptable rate'.

Sources and submissions

Sources of information

The sources of information during the investigation included:

- the aircraft captain
- Scoot Tigerair

- Rolls-Royce

Submissions

Under section 26 of the *Transport Safety Investigation Act 2003*, the ATSB may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. That section allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the following directly involved parties:

- the aircraft captain
- the aircraft first officer
- Scoot Tigerair
- Rolls-Royce
- The Boeing Company
- the Civil Aviation Safety Authority
- the Transport Safety Investigation Bureau of Singapore
- the United States National Transportation Safety Board
- the Air Accidents Investigation Branch (United Kingdom)

Submissions were received from:

- Rolls-Royce
- the United States National Transportation Safety Board
- the Air Accidents Investigation Branch (United Kingdom)

The submissions were reviewed and, where considered appropriate, the text of the report was amended accordingly.

General details

Occurrence details

Date and time:	11 October 2018 – 1853 WST	
Occurrence category:	Incident	
Primary occurrence type:	Engine failure or malfunction	
Location:	46 km north of Perth Airport, Western Australia	
	Latitude: 31° 31.37' S	Longitude: 115° 58.02' E

Aircraft details

Manufacturer and model:	The Boeing Company 787-9	
Registration:	9V-OJE	
Operator:	Scoot Tigerair	
Serial number:	37116 LN:316	
Type of operation:	Air Transport High Capacity - Passenger	
Activity:	Commercial air transport – Scheduled – International	
Departure:	Singapore	
Destination:	Perth, Western Australia	
Persons on board:	Crew – 11	Passengers – 356
Injuries:	Crew – Nil	Passengers – Nil

Australian Government
Australian Transport Safety Bureau

Document 16

Aviation Notification Form

Notification Officer: s.47F(1) **Phone:** 1800 011 034

All orange fields are Mandatory unless information is not available from Reporter

Reporters Name:	s.47F(1)	**Role:**	s.47F(1)	**Employer**	rservices Austra
Report date:	11/10/2018	**Report time:**	2217	**Phone:**	s.47F(1)

Registration:	9V-OJE	**Flight No:**	s.47F(1)	**Aircraft Type:**	787 (eg. Boeing 737, Cessna 210)
Occurrence type:	engine out landing (eg. Loss of separation, wheels up landing)			**Operation Type:**	rpt (eg.charter pax, mustering, private)
Occurrence Date:	11/10/2018	**Occurrence Time:**	1109	○ Local ◉ UTC	
Occurrence location:	Perth airport			**State:**	WA
Latitude/Longitude:					(Important for accidents away from aerodromes)
Aircraft Operator:					

Injuries	Fatal	Serious	Minor	Nil
Crew				
Passengers				
Ground				

Damage description:

Description of occurrence and Additional Information: (Press ALT + ENTER for a new paragraph)

s.47F(1) 9V-OJE a 787 landing Perth with starboard engine out at 1109 UTC. The engine was lost about 10 to 15 NM final, PAN PAN declared at 1057, relight attempted then engine shut down prior to landing. 371 POB and no dangerous cargo

Flt Recs Quarantined: ○ Yes ○ No **ELT Disabled** ○ Yes ○ No **Guard:** ○ Yes ○ No

Passed on:	Date	Time	Name		Date	Time	Name
COR:				**WebSMS:**			
Other:				**Other:**			

Document 17

Notification Source Details	
Status:	Loaded
Reference Number	ATS-0164197
Role Group	ATC
Injury Level	Unknown
Source	CIRRIS
Status Date	14 Oct 2018 00:50:03
Is Confidential	No
Occurrence Date And Time	11 Oct 2018 10:50:00
Reporting Group Branch SDLUnit	Perth TCU
Occurrence Location Group Branch SDLUnit	Perth TCU
Summary	s.47F(1) starboard engine failure
Detailed Description	s.47F(1) called PAN approximately 25nm north YPPH. Starboard engine failure advised and requested vectors at A050 to attempt to re ignite starboard engine. POB 371, NIL dangerous cargo. Full emergency procedures activated by Perth Tower. s.47F(1) was unable to re start the engine and carried out an orbit and proceeded inbound RWY21. s.47F(1) , preceding arrival RWY21 sent around to ensure nil restriction for s.47F(1) s.47F(1) landed RWY21 at 1108 and stopped on the runway. Following an inspection by ARFF the aircraft taxied under own power to the gate.
Primary Occurrence Type	Emergency Operations
Additional Types	
Airspace Category	Class C/CTA
Controlling Authority	Airservices
ATSService Provided	Approach - surveillance
Location Code	YPPH
Bearing	0
Distance	25
Latitude	
Longitude	0000:00:00 East
Principal Aircraft Ground Vehicle Involved	Civil Foreign Registered
ACIDCall Sign	s.47F(1)
Registration	9VOJE
Other Aircraft Ground Vehicle Involved1	
ACIDCallsign1	
Registration1	
Other Aircraft Ground Vehicle Involved2	
ACIDCallsign2	
Registration2	
Civil Foreign Registered Aircraft Details	
ACIDCallsign	s.47F(1)
Registration	9VOJE
Aircraft Operator	TIGERAIR SINGAPORE

Aircraft Type	B789
Flight Rules	I
ADEP	WSSS
ADES	YPPH
Typeof Flight	S
ATIS	
Designator	
Timeof Observation	
Typeof Approach	
Runway Details	
Runway Occurrence	
Runway Surface Condition	
Wind Directionand Speed	
Present Weather	
Visibility	
Cloud	
Temperature	0
QNH	0
Additional Information	
Runway Operating Proceduresin Use	
Emergency Operations IFER	
Aircraft Diversion Required	No
Phase Declared	Full Emergency - Level 3
Reason	Engine Malfunction
View Original Email	

From: s.47F(1)
To: ATSB International Reporting
Subject: FW: IFN: Australia, B-787, 10/11/18
Date: Tuesday, 16 October 2018 5:49:38 AM
Attachments: Accident & Serious Incident Notification.pdf

Good evening,
I will be the nontraveling US Accredited Representative for this event. Let me know if you need any assistance from US manufacturers.
Best regards,
s.47F(1)

From: ROC <cmctr@ntsb.gov>
Sent: Friday, October 12, 2018 12:00 AM
To: s.47F(1)
Subject: IFN: Australia, B-787, 10/11/18

The following text was included in reply to the notifying authority:

Thank you for your notification to the National Transportation Safety Board. The notification has been forwarded to the appropriate duty officer for response.

From: ATSB International Reporting <ATSBInternationalReporting@atsb.gov.au>
Sent: Thursday, October 11, 2018 11:56 PM
To: mailto:notification_to_aaib@mot.gov.sg <notification_to_aaib@mot.gov.sg>; ROC <cmctr@ntsb.gov>; United Kingdom AAIB 24 hour contact <investigations@aaib.gov.uk>; adrep@icao.int
Cc: ATSB International Reporting <ATSBInternationalReporting@atsb.gov.au>; s.47F(1)
s.47F(1)
Subject: INCID 201807226 - 9V-OJE B787-9 - Engine Failure - near Perth WA - 11 Oct 2018 [SEC=UNCLASSIFIED]

Good Day,

Attached is notification of an incident involving a Boeing 787-900 with Rolls Royce Trent 1000 engines. Please forward to the relevant organisations/personnel.

The ATSB is investigating this incident.

Regards,

s.47F(1)
Safety Reporting Officer

Australian Transport Safety Bureau

62 Northbourne Avenue
Canberra ACT 2601

s.47F(1)

Australian Government
Australian Transport Safety Bureau

ICAO Annex 13 Chapter 4
Accident & Serious Incident Notification

ATSB Reference: 201807226 **Category:** Incident
Investigation: Yes - AO-2018-069
Date and Time: Thursday, October 11, 2018 11:09 AM UTC
Location: Perth Aerodrome
State: WA **Country:** Australia
Latitude: -31.9403 **Longitude:** 115.9670
Highest Injury: Nil
Occurrence: Technical - Powerplant / propulsion - Engine failure or malfunction
Site Access: Accessible
Dangerous Goods: Nil

Injury Details:	Crew	Passenger	Ground
Fatal	0	0	0
Serious	0	0	0
Minor	0	0	0
Nil	0	0	-

Nationalitites: N/A
Aircraft Details:
9V-OJE

Aircraft Type: Aeroplane
Serial Number: 37116 LN:316
Manufacturer: Boeing
Model: 787-900
Engine Manufacturer: Rolls Royce
Engine Model: Trent 1000
Operation: Air Transport High Capacity Passenger
Damage Level: Nil
Country of Registration: Singapore
Country of Manufacture: United States
Departed: Singapore
Destination: Perth WA

Summary: During approach, the right engine failed. The investigation is continuing.

From:	ATSB International Reporting
To:	mailto:notification_to_aaib@mot.gov.sg; NTSB USA National Transport Safety Authority; United Kingdom AAIB 24 hour contact; adrep@icao.int
Cc:	ATSB International Reporting; s.47F(1)
Subject:	INCID 201807226 - 9V-OJE B787-9 - Engine Failure - near Perth WA - 11 Oct 2018 [SEC=UNCLASSIFIED]
Date:	Friday, 12 October 2018 2:56:06 PM
Attachments:	Accident & Serious Incident Notification.pdf

Good Day,

Attached is notification of an incident involving a Boeing 787-900 with Rolls Royce Trent 1000 engines. Please forward to the relevant organisations/personnel.

The ATSB is investigating this incident.

Regards,

s.47F(1)
Safety Reporting Officer

Australian Transport Safety Bureau

62 Northbourne Avenue
Canberra ACT 2601

s.47F(1)

Australian Government
Australian Transport Safety Bureau

ICAO Annex 13 Chapter 4
Accident & Serious Incident Notification

ATSB Reference: 201807226 **Category:** Incident
Investigation: Yes - AO-2018-069
Date and Time: Thursday, October 11, 2018 11:09 AM UTC
Location: Perth Aerodrome
State: WA **Country:** Australia
Latitude: -31.9403 **Longitude:** 115.9670
Highest Injury: Nil
Occurrence: Technical - Powerplant / propulsion - Engine failure or malfunction
Site Access: Accessible
Dangerous Goods: Nil

Injury Details:	Crew	Passenger	Ground
Fatal	0	0	0
Serious	0	0	0
Minor	0	0	0
Nil	0	0	-

Nationalitites: N/A
Aircraft Details:
9V-OJE

Aircraft Type: Aeroplane
Serial Number: 37116 LN:316
Manufacturer: Boeing
Model: 787-900
Engine Manufacturer: Rolls Royce
Engine Model: Trent 1000
Operation: Air Transport High Capacity Passenger
Damage Level: Nil
Country of Registration: Singapore
Country of Manufacture: United States
Departed: Singapore
Destination: Perth WA

Summary: During approach, the right engine failed. The investigation is continuing.

From: s.47F(1)
To:
Cc:
Subject: RE: INCID 201807226 - 9V-OJE B787-9 - Engine Failure - near Perth WA - 11 Oct 2018 [SEC=UNCLASSIFIED]
Date: Friday, 12 October 2018 5:31:02 PM
Attachments: image001.png

Message Classification: Restricted

To whom it may concern

Please be advised that TSIB has appointed s.47F(1) as the Accredited Representative to participate in this investigation. Please liaise with him directly once the Investigator-in-Charge from ATSB is appointed. s.47F(1) is copied in this email.

Regards

s.47F(1)

MINISTRY OF TRANSPORT
SINGAPORE

South Finger Pier, Passenger Terminal 2 #0 8-058, Changi Airport P.O. Box 1005
mot.gov.sg | facebook.com/motsg

From: ATSB International Reporting <ATSBInternationalReporting@atsb.gov.au>
Sent: Friday, October 12, 2018 11:56 AM
To: MOT Notification To AAIB (MOT) <notification_to_aaib@mot.gov.sg>; NTSB USA National Transport Safety Authority <roc@ntsb.gov>; United Kingdom AAIB 24 hour contact <investigations@aaib.gov.uk>; adrep@icao.int
Cc: ATSB International Reporting <ATSBInternationalReporting@atsb.gov.au>; s.47F(1)
Subject: INCID 201807226 - 9V-OJE B787-9 - Engine Failure - near Perth WA - 11 Oct 2018 [SEC=UNCLASSIFIED]

Good Day

Attached is notification of an incident involving a Boeing 787-900 with Rolls Royce Trent 1000 engines. Please forward to the relevant organisations/personnel.

The ATSB is investigating this incident.

Regards

s.47F(1)
Safety Reporting Officer

Australian Transport Safety Bureau

62 Northbourne Avenue
Canberra ACT 2601
s.47F(1)

Australia's national transport safety investigator
AVIATION | MARINE | RAIL
Web www.atsb.gov.au
Twitter @ATSBinfo

From:	ATSB International Reporting
To:	United Kingdom AAIB 24 hour contact; NTSB USA National Transport Safety Authority; "adrep@icao.int"; MOT Notification of Air Occurrences (MOT)
Cc:	ATSB International Reporting
Subject:	FINAL 201807226 - Uncommanded engine shutdown involving Boeing 787-9, 9V-OJE, 46 km north of Perth Airport, Western Australia, on 11 October 2018 [SEC=UNOFFICIAL]
Date:	Tuesday, 15 December 2020 3:46:01 PM
Attachments:	FINAL 201807226.pdf Uncommanded engine shutdown involving B...pdf

Good day,

Please see final report for ATSB 201807226.

Kind regards,

s.47F(1)

ATSB

Australian Transport Safety Bureau
Level 1, 62 Northbourne Avenue
Canberra ACT 2601
s.47F(1)

@atsbgovau
Australia's national transport safety investigator

Australian Government
Australian Transport Safety Bureau

ICAO ADREP Occurrence Report - 201807226

State Reporting	Reporting Organisation	State File Number	Date Created	Report Status
Australia	Australia (ATSB)	201807226	15 December 2020	Data

Headline	Occurrence Class	Occurrence Category
INCIDENT 201807226 Engine failure involving Boeing 787 , 9V-OJE, Perth WA, 11 October 2018	Incident	SCF-PP: Powerplant failure or malfunction

Local Date Time	UTC Date Time	State/Area Of Occurrence	Location	Latitude	Longitude
11 October 2018 6:53 PM WST	11 October 2018 10:53 AM UTC	Australia	Perth Aerodrome, 000° T 46Km	-31.5228	115.9670

Narrative

On 11 October 2018, a Boeing 787-9, 9V-OJE, operated by Scoot Tigerair (Scoot), departed Singapore on a scheduled flight to Perth, Western Australia. During descent, the flight crew noticed that the right engine was slow to respond to commands, and its performance continued to decline throughout the descent. While passing through 9,000 ft, severe thrust asymmetry developed, and the engine shut down shortly afterwards. The crew followed appropriate procedures, and due to the proximity of the airport, elected not to attempt a restart. The aircraft landed safely with emergency services in attendance. There were no injuries sustained and no aircraft damage as a result of the incident.

Injury Totals

	Crew	Passenger	Other
Fatal	0	0	0
Serious	0	0	0
Minor	0	0	0
Nil	11	356	-

Occurrence Types

Technical - Powerplant / propulsion - Engine failure or malfunction

Findings

Finding Type	Safety Factor	Description
Contributing safety factor	Occurrence event	The engine shutdown was the result of insufficient fuel delivery due to low pressure in the fuel metering valve servo assembly, as debris from worn fuel pump bearings had blocked its inlet filter.
Contributing safety factor	Risk control - Technical failure management - Manufacture	The engine manufacturer, Rolls-Royce, identified that between late 2018 and early 2019 the operator's fleet of 787 aircraft were particularly susceptible to low life wear in the journal bearings of the secondary high pressure fuel pump.
Contributing safety factor	Occurrence event	Following a series of status and alert messages related to the aircraft's right engine, the engine shut down during descent. The flight crew followed the appropriate procedures and landed the aircraft safely using the operational engine.
Other key finding		Rolls Royce identified a number of potential factors that led to the component wear but, due to the number of variables, a single/dominant reason could not be established.

Safety Recommendations

No Safety Recommendations have been issued in relation to this incident

Australian Government
Australian Transport Safety Bureau

ICAO ADREP Occurrence Report - 201807226

The Boeing Company - 787-900, 9V-OJE

Aircraft Identification

Manufacturer / Model	Country Of Registration	Registration Number	Year Of Manufacture	Serial Number
The Boeing Company - 787-900	Singapore	9V-OJE	2015	37116 LN:316

Aircraft Operation

Operator	Operation Type	Operation Sub Type
Scoot Tigerair	Air Transport High Capacity	Passenger

Aircraft Description

Aircraft Type	Engine Type	Number Of Engines	Weight Category	Maximum Take Off Weight	Landing Gear Type
Aeroplane	Turbofan	2	27001-272000 Kg (59525-599650 Lbs)	254011kg	Tricycle - Retractable

Engine Description

Engine Manufacturer	Engine Model
Rolls Royce	Trent 1000

Itinerary

Departed From	Destination	Phase Of Flight
Singapore	Perth WA	Descent

Person at Controls

Pilot Flying
s.47F(1)

Pilot in command

Pilot Licence Category	Pilot Licence Type	Total Hours On All	Total Hours On Type	Total Hours On All Last 90 Days	Total Hours On Type Last 90 Days
s.47F(1)					

Co-pilot

Pilot Licence Category	Pilot Licence Type	Total Hours On All	Total Hours On Type	Total Hours On All Last 90 Days	Total Hours On Type Last 90
s.47F(1)					

9V-OJE Injuries

	Crew	Passengers
Fatal	0	0
Serious	0	0
Minor	0	0
Nil	11	356

Australian Government

Australian Transport Safety Bureau

Uncommanded engine shutdown involving Boeing 787-9, 9V-OJE

46 km north of Perth Airport, Western Australia, on 11 October 2018

ATSB Transport Safety Report
Aviation Occurrence Investigation (Short)
AO-2018-069
Final – 1 December 2020

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

Publishing information

Published by: Australian Transport Safety Bureau
Postal address: PO Box 967, Civic Square ACT 2608
Office: 62 Northbourne Avenue Canberra, ACT 2601
Telephone: 1800 020 616, from overseas +61 2 6257 2463
Accident and incident notification: 1800 011 034 (24 hours)
Email: atsbinfo@atsb.gov.au
Website: www.atsb.gov.au

Addendum

Page	Change	Date

Safety summary

What happened

On 11 October 2018, a Boeing 787-9, 9V-OJE, operated by Scoot Tigerair (Scoot), departed Singapore on a scheduled flight to Perth, Western Australia. During descent, the flight crew noticed that the right engine was slow to respond to commands, and its performance continued to decline throughout the descent. While passing through 9,000 ft, severe thrust asymmetry developed, and the engine shut down shortly afterwards. The crew followed appropriate procedures, and due to the proximity of the airport, elected not to attempt a restart. The aircraft landed safely with emergency services in attendance. There were no injuries sustained and no aircraft damage as a result of the incident.

What the ATSB found

The ATSB determined that following a series of engine status and alert messages, 9V-OJE experienced an uncommanded engine shutdown while on descent into Perth, before landing safely using the operational engine.

Based on a review of the flight data and an examination of engine components by Rolls-Royce, the engine shutdown was due to debris from worn journal bearings in the engine's secondary high-pressure fuel pump blocking an inlet filter for the fuel metering valve servo assembly. This prevented the valve from delivering sufficient fuel to the engine.

Rolls-Royce also determined that, between late 2018 and early 2019, the operator's fleet of 787 aircraft had been particularly susceptible to low-life wear in the journal bearings of the secondary high-pressure fuel pump. It identified a number of potential factors that led to the component wear but, due to the number of variables, a single/dominant reason could not be established.

What has been done as a result

Rolls-Royce updated its Fault Isolation Manual to instruct all operators to remove the fuel pump and hydro-mechanical unit in the event of a maintenance message regarding the fuel metering valve not being in the commanded position. Rolls-Royce is also monitoring maintenance messages and investigating the possibility of using flight data to detect fuel pump journal wear before its effects on valve operation become apparent.

Safety message

This occurrence highlights the importance of flight crew being familiar with emergency procedures, so that the appropriate corrective action can be taken quickly and effectively. In this case, the flight crew worked effectively to assess the situation, and took appropriate action to minimise risk in accordance with the operator's flight crew operations manual.

This occurrence also shows that positively identifying the factors contributing to technical failures can be difficult and time consuming. However, manufacturers and operators can implement interim risk mitigation measures, as was the case here.

The investigation

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 investigation was conducted in order to produce a short investigation report, and allow for greater industry awareness of findings that affect safety and potential learning opportunities.

The occurrence

On 11 October 2018, at about 1421 Western Standard Time,[1] a Boeing 787-9, 9V-OJE, operated by Scoot Tigerair (Scoot), departed Changi Airport, Singapore. The aircraft was on a scheduled passenger flight to Perth, Western Australia, with 11 crew members and 356 passengers on board.

Approximately 2 hours into the flight, the crew received two status messages indicating abnormalities within the right engine. Three hours later, during descent, the aircraft was passing through FL 250[2] when the crew noticed that the right engine was slow to respond to commanded inputs. Throughout the descent, the right engine performance continued to decline. Passing through 9,000 ft, severe thrust asymmetry developed, and the captain noticed rudder input from the autopilot. Shortly after, at 1853, the crew received the engine-indicating and crew-alerting system (EICAS) message ENG FAIL R, and the right engine shut down.

In response, the flight crew declared a PAN[3] and requested air traffic control clearance to level off at 5,000 feet and be vectored off the approach to allow time for completion of the quick reference handbook (QRH) checklist items. Completion of the QRH checklist required the flight crew to decide whether they should attempt to relight the engine. Due to the proximity of the airport and because the aircraft is capable of landing safely with one engine, the flight crew decided that attempting an engine restart was unnecessary. After the checklist was completed, the flight crew conducted a NITS[4] briefing with the cabin crew.

Subsequently, the flight crew completed the landing performance calculations and advised ATC that they were ready to land. The flight crew also requested that emergency services conduct a visual inspection of the aircraft after landing.

At 1909, the aircraft landed safely at Perth Airport and emergency services carried out a visual inspection. The aircraft was cleared to taxi to the parking bay and disembark passengers normally via the aerobridge.

There were no injuries sustained and no damage to the aircraft as a result of the occurrence.

Context

Subsequent maintenance

Following the occurrence, an engineering team carried out a detailed inspection of the aircraft to address the in-flight shutdown and status/EICAS warning messages observed by the crew. The technical examination resulted in replacement of the right engine hydro-mechanical unit (HMU) and a high-power engine run was then successfully performed.

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1 Western Standard Time (WST): Coordinated Universal Time (UTC) + 8 hours.

2 Flight level: at altitudes above 10,000 ft in Australia, an aircraft's height above mean sea level is referred to as a flight level (FL). FL 250 equates to 25,000 ft.

3 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.

4 NITS – Acronym encompassing the nature of the emergency, the intentions of the flight crew, the time available before landing, and the need for a special instructions brief.

On 12 October 2018, a non-revenue flight (no passengers or cargo) was conducted to return the aircraft to Singapore for further maintenance, during which time the electronic engine controller (EEC) was replaced. The aircraft then returned to revenue service.

On 15 October 2018, the aircraft was on a flight from Sydney to Singapore when several maintenance messages indicating similar issues to the occurrence flight were generated, but there was no noticeable effect on engine performance. Following the flight, additional components were replaced, including the:

- HMU (further replacement)
- fuel pump
- high- and low-pressure fuel filters
- left and right variable stator vane actuator.

The aircraft was then declared serviceable and returned to service with no further recurrence of the maintenance messages.

Engine fuel system

The Trent 1000 fuel system includes a three-stage pump that supplies fuel from the aircraft to the engine. Fuel runs through a low pressure (LP) pump followed by two high pressure (HP) pumps, identified as primary and secondary, running in parallel. The primary HP pump operates under all conditions, while the larger secondary HP pump increases fuel flow to the engine at periods of high demand, such as take-off.

The HP pumps supply fuel to the HMU, which controls fuel flow to the engine using its fuel metering valve (FMV) as follows:

- Fuel enters the FMV servo assembly within the HMU through an inlet filter.
- To change the flow rate of fuel supplied to the engine, the EEC sends electrical signals to the FMV servo assembly.
- The signals control the position of a valve, which changes the fuel pressures within the servo assembly.
- These servo pressures determine the position of the FMV, which ultimately controls the flow rate of fuel to the burners.

Rolls-Royce investigation

Following the occurrence and subsequent non-revenue flight to Singapore, the engine manufacturer, Rolls-Royce, conducted an investigation into the occurrence. This included reviewing flight data from both flights, examining engine components from 9V-OJE, and based on its findings, assessing the Trent 1000 fleet more widely.

Review of flight data

Approximately 2 hours into the flight, during cruise, the right engine's EEC generated the following message:

> Hydro-Mechanical Unit (Right Engine) fuel metering valve (FMV) torque motor current is too low or too high.

This message indicated that the current required to adjust the fuel flow via the FMV was outside the expected range. Eleven minutes later, another message indicated that the current had exceeded an allowable limit:

> Hydro-Mechanical Unit (Right Engine) fuel metering valve (FMV) torque motor current is failed too low or too high.

During descent, approximately 3 hours later, two more messages were generated:

> Hydro-Mechanical Unit (Right Engine) fuel metering valve (FMV) is not in commanded position.

Right Engine is failed below idle with fuel switch on.

Rolls-Royce determined that the first message was evidence the FMV was taking longer than it should have to reach the position specified by the EEC. It was found that the second message was generated after the EEC had commanded a deceleration. The FMV moved below the idle position as requested, but once deceleration had occurred, it did not move back to the directed idle position. The right engine then ran at sub-idle speed for a short time before shutting down. Data for the entire occurrence flight indicated that the torque motor current required to control the FMV position increased throughout the flight up until the in-flight shutdown.

Rolls-Royce also identified that the maintenance messages generated during the flight to Singapore on 15 October 2018 indicated that control of the new FMV was still requiring a higher than expected torque motor current. However, the engine continued to operate normally, and the flight was completed without incident.

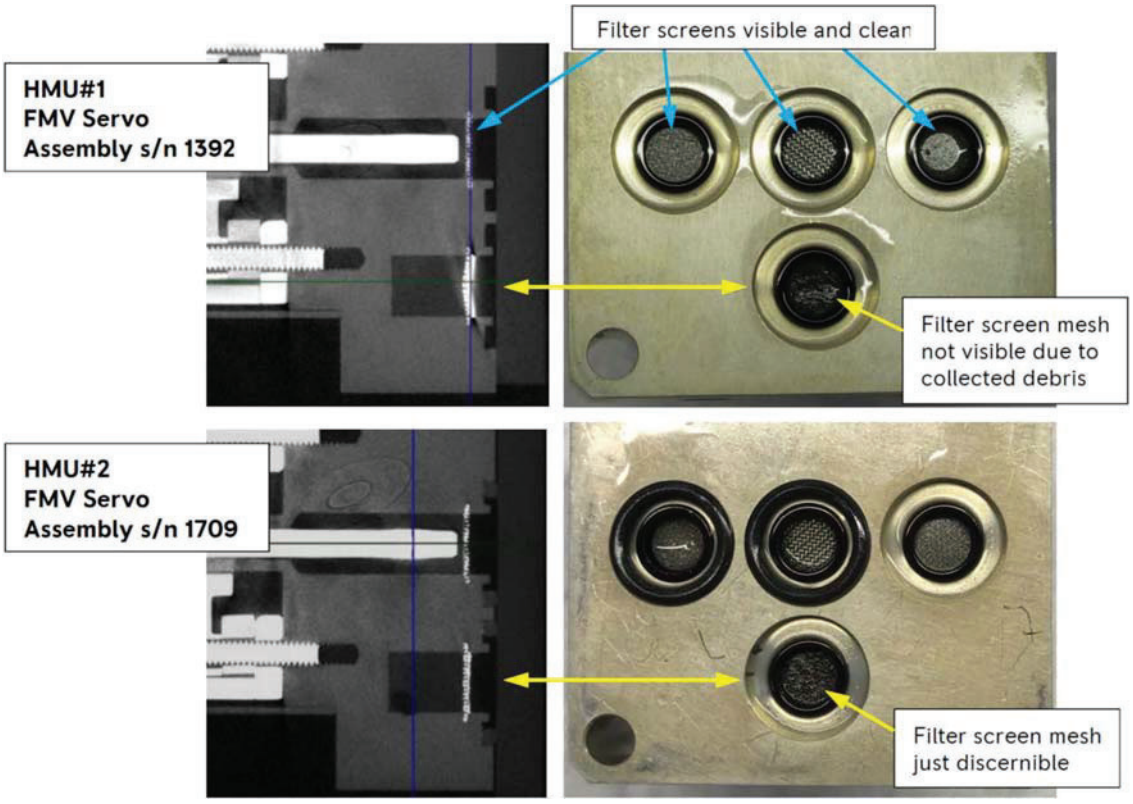
Component examination

Rolls-Royce examined the HMU from the occurrence flight (HMU 1) as well as the one from the subsequent flight (HMU 2). In both units, a build-up of metallic debris was found in various locations, although more debris was found in HMU 1. The inlet filter to the FMV servo assembly was at least partially blocked with debris in both units.

Rolls-Royce concluded that the in-flight shutdown of 9V-OJE's right engine was the result of the blocked inlet filter on the FMV servo assembly. The blockage restricted the EEC's ability to control the FMV, and ultimately, the flow of fuel to the engine.

The FMV servo assemblies from each HMU were scanned using CT imaging. The resulting x-ray cross sections are shown with photographs of each servo assembly in Figure 1.

Figure 1: Blocked inlet filters on both FMV servo assemblies

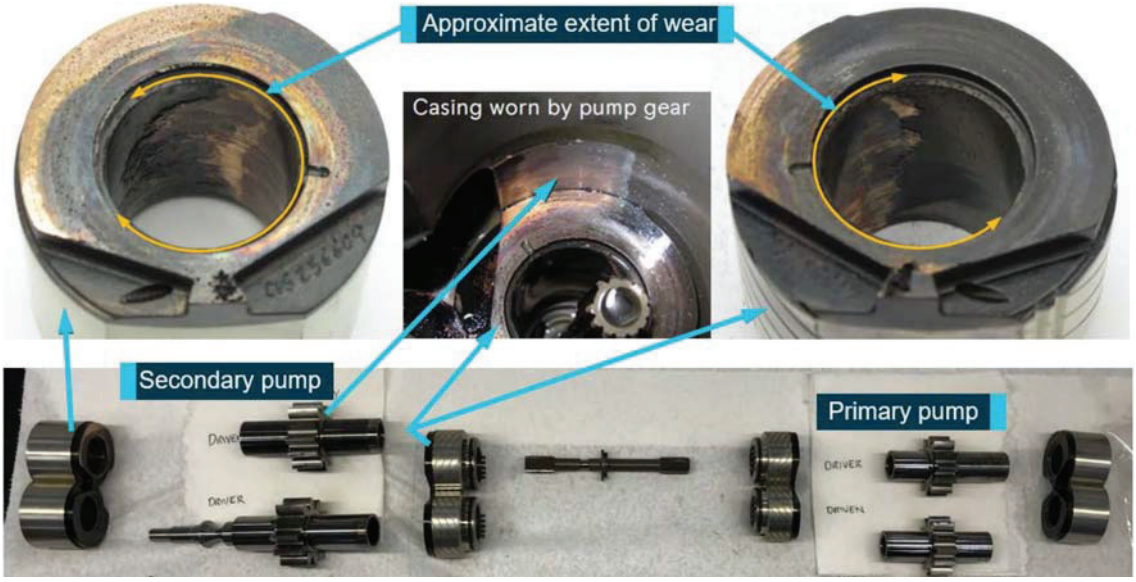


The build-up of metallic debris was greater on HMU #1. Some deformation can also be observed in the #1 inlet filter x-ray image. Rolls-Royce determined that this was likely due to the high-pressure differential caused by the blockage.
Source: Rolls-Royce

Analysis of the metallic debris revealed that it consisted of material from the fuel pump bearings and the casing. All three stages of the pump (the LP pump, and the two HP pumps) were disassembled and examined by Rolls-Royce in the presence of the United Kingdom Air Accidents Investigation Branch.

The examination found that the debris originated from the secondary HP pump. The bearings for the secondary HP pump driven gear were heavily worn, with evidence of scoring and missing material (Figure 2). Rolls-Royce found that the casing for the driven gear had more wear than would be expected during normal operation, likely due to shaft movement resulting from the damaged journal bearings. No damage was found on other bearings within the secondary HP pump or the other two fuel pumps.

Figure 2: Worn journal bearings and casing for the secondary HP pump driven gear



Source: Rolls-Royce

Rolls-Royce reviewed the manufacturing records for the secondary HP pump, but found that it was typical of the fleet. No abnormalities had been noted, and the pump dimensions were within the accepted tolerances. The material composition of the fuel pump components was checked and found to be similar to the rest of the population. The fuel pump and HMU from the left engine were removed and inspected as a precaution, but there was no evidence of journal wear or debris build-up.

Trent 1000 fleet inspection

On 1 November 2018, another Scoot Boeing 787 generated maintenance messages related to the HMU during start-up, prior to a flight. The engine was inspected, and some wear was also found on the secondary HP pump journal bearings.

To search for similar HMU maintenance messages, Rolls-Royce examined all maintenance data across the fleet of Trent 1000 Package B and Package C engines and continued to monitor ongoing flights. Six other events were found where messages were generated due to fuel pump debris blocking the FMV servo assembly inlet filter. Five of these events were from aircraft operated by Scoot, while one was from a different operator.

Of the events found in the Scoot fleet, the age of the pumps varied between 5,201 and 12,686 hours. The recommended life of the pumps was 22,000 hours. Based on the number of occurrences compared with the greater Trent 1000 fleet, Rolls-Royce determined that the secondary HP pump journal bearings on Scoot aircraft were particularly susceptible to low life journal wear.

In an effort to determine what was increasing wear susceptibility in the Scoot fleet's bearings, Rolls-Royce identified a number of potential factors, including the following:

- Pump manufacture and build: The worn pumps found on Scoot aircraft had been manufactured over a number of years from 2015 to 2017. As such, it was determined that a batch or build issue was unlikely to be a common factor.
- Fuel quality: Analysis of fuel samples from Singapore Changi Airport found no anomalies within the 12 months prior to the occurrence involving 9V-OJE. There were also no reports of fuel pump bearing wear from other Trent 1000 operators that used the same airport.
- Operations: Rolls-Royce noted that Scoot generally flew shorter routes than most other Trent 1000 operators, but there were comparable operations with no evidence of fuel pump journal wear. Within the Scoot fleet, aircraft flew to multiple destinations, and there were no specific city pairs associated with the engines with worn bearings.
- Maintenance: Scoot shared its maintenance facilities with another operator that also used Trent 1000 engines. There was no evidence of fuel pump bearing wear from this operator.

Based on its investigation, Rolls-Royce concluded the following:

> It is likely that a combination of factors have led to Scoot bearings being particularly susceptible to significant low life wear, but analysis of data to date has not identified any significant differences between worn and unworn bearings, both within the Scoot fleet and the wider Trent 1000 Pack B & C fleets.

It was further noted that the majority of Scoot events occurred between late 2018 and early 2019. With the exception of the occurrence flight, none resulted in an in-flight shutdown.

The Rolls-Royce investigation also considered factors in addition to those listed above but, due to the number of variables, was unable to identify which might have been dominant with respect to the pump bearing wear. However, it identified and implemented interim measures (mainly related to engine data monitoring) to address the risk from low life wear of bearings.

Safety analysis

While on descent into Perth, the right engine of 9V-OJE shut down. After completing the necessary checklists, the flight crew landed the aircraft safely on one engine. There were no injuries sustained as a result.

The engine manufacturer, Rolls-Royce, concluded that the engine shutdown was the result of a blocked inlet filter on the fuel metering valve (FMV) servo assembly. This blockage restricted the electronic engine controller's (EEC) ability to adjust fuel pressures within the servo. As a result, the EEC had limited control over the FMV position, and consequently the amount of fuel flowing to the burners. When the EEC commanded the FMV to increase fuel flow from sub-idle to idle levels, it did not respond in time, and the engine shut down. The blockage was due to debris from worn journal bearings in the secondary HP fuel pump driven gear.

Rolls-Royce's examination of flight data and maintenance records from its Trent 1000 engines identified that Scoot's fleet of 787 aircraft had been particularly susceptible to low life wear in their secondary HP pump journal bearings over a period of several months. The Rolls-Royce investigation identified various potential factors that might have contributed to low life journal wear, including the fleet's operation, maintenance, fuel quality, or pump design and construction. However, it found no evidence that any factors were significantly different to the wider Trent 1000 fleet. Additionally, due to the number of variables associated with operations, maintenance, design and manufacture, it was not possible to determine the relative effect of these factors (and possibly others) when combined.

Findings

ATSB investigation report findings focus on safety factors (that is, events and conditions that increase risk). Safety factors include 'contributing factors' and 'other factors that increased risk' (that is, factors that did not meet the definition of a contributing factor for this occurrence but were still considered important to include in the report for the purpose of increasing awareness and enhancing safety). In addition 'other findings' may be included to provide important information about topics other than safety factors.

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

From the evidence available, the following findings are made with respect to the uncommanded engine shutdown involving Boeing 787-9, 9V-OJE, on 11 October 2018 near Perth Airport.

Contributing factors

- Following a series of status and alert messages related to the aircraft's right engine, the engine shut down during descent. The flight crew followed the appropriate procedures and landed the aircraft safely using the operational engine.
- The engine shutdown was the result of insufficient fuel delivery due to low pressure in the fuel metering valve servo assembly, as debris from worn fuel pump bearings had blocked its inlet filter.
- The engine manufacturer, Rolls-Royce, identified that between late 2018 and early 2019 the operator's fleet of 787 aircraft were particularly susceptible to low life wear in the journal bearings of the secondary high-pressure fuel pump.

Other finding

- Rolls-Royce identified a number of potential factors that led to the component wear but, due to the number of variables, a single/dominant reason could not be established.

Safety actions

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.

Safety action by Rolls-Royce

As part of its investigation into the engine failure, Rolls-Royce instructed Scoot to remove the engine's fuel pump in the event of debris being found in the ports during removal of a hydro-mechanical unit. In February 2020, the Fault Isolation Manual was updated to instruct all operators to remove the fuel pump and hydro-mechanical unit in the event of a maintenance message regarding the fuel metering valve not being in the commanded position.

Rolls-Royce is investigating the possibility of detecting potential fuel pump bearing journal wear by using flight data (particularly the fuel metering valve torque motor current) to detect partial filter blockage before maintenance messages are generated. It is also continuing to monitor maintenance messages and the condition of unserviceable fuel pumps 'to ensure that the risk of an in-flight shutdown caused by fuel pump bearing wear is maintained at an acceptable rate'.

Sources and submissions

Sources of information

The sources of information during the investigation included:

- the aircraft captain
- Scoot Tigerair

- Rolls-Royce

Submissions

Under section 26 of the *Transport Safety Investigation Act 2003*, the ATSB may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. That section allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the following directly involved parties:

- the aircraft captain
- the aircraft first officer
- Scoot Tigerair
- Rolls-Royce
- The Boeing Company
- the Civil Aviation Safety Authority
- the Transport Safety Investigation Bureau of Singapore
- the United States National Transportation Safety Board
- the Air Accidents Investigation Branch (United Kingdom)

Submissions were received from:

- Rolls-Royce
- the United States National Transportation Safety Board
- the Air Accidents Investigation Branch (United Kingdom)

The submissions were reviewed and, where considered appropriate, the text of the report was amended accordingly.

General details

Occurrence details

Date and time:	11 October 2018 – 1853 WST	
Occurrence category:	Incident	
Primary occurrence type:	Engine failure or malfunction	
Location:	46 km north of Perth Airport, Western Australia	
	Latitude: 31° 31.37' S	Longitude: 115° 58.02' E

Aircraft details

Manufacturer and model:	The Boeing Company 787-9	
Registration:	9V-OJE	
Operator:	Scoot Tigerair	
Serial number:	37116 LN:316	
Type of operation:	Air Transport High Capacity - Passenger	
Activity:	Commercial air transport – Scheduled – International	
Departure:	Singapore	
Destination:	Perth, Western Australia	
Persons on board:	Crew – 11	Passengers – 356
Injuries:	Crew – Nil	Passengers – Nil