



**Australian Government**

**Australian Transport Safety Bureau**

# Engine shut down involving Boeing 787, VH-VKK

370 km north of Guam, 6 August 2016

**ATSB Transport Safety Report**  
Aviation Occurrence Investigation  
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**Addendum**

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# Engine shut down involving Boeing 787, VH-VKK

## What happened

On the evening of 6 August 2016, Jetstar Airways flight JQ12, a Boeing 787 aircraft, registered VH-VKK, departed from Tokyo, Japan on a scheduled passenger transport flight to the Gold Coast, Queensland. On board the aircraft were two flight crew, nine cabin crew and 309 passengers.

The aircraft was pushed back from the gate at Narita Airport, Tokyo, at 1133 UTC.<sup>1</sup> About two hours into the flight, the flight crew received an engine indication and crew alerting system (EICAS) message ELEC GEN DRIVE R2, which indicated a fault with the number 2 generator in the right engine. The flight crew performed the checklist actions for that fault, which included disconnecting the number 2 generator drive from the engine driven accessory gearbox (AGB) and starting the auxiliary power unit to supplement the aircraft electrical power with the auxiliary power unit driven generators.

About 30 minutes later, cruising at FL 400,<sup>2</sup> the secondary engine instruments appeared<sup>3</sup> on the flight crews' multi-function displays and the flight crew detected there was a low oil quantity indication for the right engine. While the flight crew investigated the engine indications, another EICAS message annunciated, ENG OIL PRESS R, which indicated low oil pressure in the right engine. The flight crew performed the checklist actions for low oil pressure in the right engine. The right engine auto-throttle was switched off and the right engine thrust lever retarded to idle. The low oil pressure EICAS message momentarily cleared before it returned again, and the flight crew shut down the right engine in accordance with the checklist procedures.

The captain identified Guam Airport as the nearest suitable airport, about 370 km to the south of their position. They made a PAN<sup>4</sup> call to Guam air traffic control, who provided them with a clearance to manoeuvre as required for a landing at Guam Airport. The flight crew sent a message using the aircraft communications addressing and reporting system to their operations control that they were diverting the aircraft to Guam. They descended the aircraft to FL 220 due to single engine performance limitations and diverted around some weather as they tracked towards Guam Airport. The captain reported that they made an uneventful one engine landing on runway 24 at about 1520 UTC.

After the aircraft vacated the runway, the captain held the aircraft on the taxiway to allow the airport emergency services to inspect the engine before they taxied the aircraft to the arrival gate. The aircraft was shut down at the arrival gate without further incident.

## Maintenance findings

When the engine cowls were opened for the initial inspection there was a large quantity of oil found throughout the engine and a considerable amount of metallic debris found within the engine oil system. A data download of the engine was performed and the results were sent to GE Aviation, the engine manufacturer, for review. GE Aviation provided options for returning the aircraft to service, of which Jetstar determined an engine change was the most expeditious.

<sup>1</sup> Coordinated Universal Time (abbreviated UTC) is the time zone used for civil aviation. Local time zones around the world can be expressed as positive or negative offsets from UTC.

<sup>2</sup> 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 400 equates to 40,000 ft.

<sup>3</sup> The secondary engine instruments are only displayed when an abnormal condition is detected.

<sup>4</sup> 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.

### **Engine manufacturer findings**

GE Aviation found there was no history or shift in oil system parameters except for the chip count<sup>5</sup> on this flight. Chips are detected and recorded by the engine debris monitoring system (DMS), within the engine oil system.

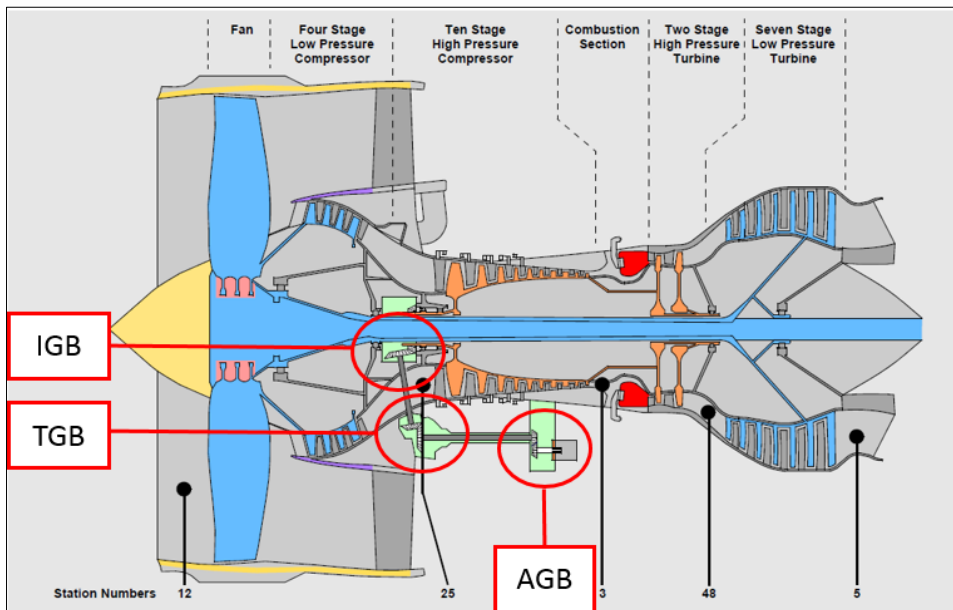
On the incident flight, the right engine oil system started to detect chips from about one hour into the flight. The chip count reached seven when the crew were alerted to disconnect the number 2 generator. At 1415 a status message was generated for ENG OIL DMS R, which indicated the chip count for the right engine had reached eight.

Between 1415 and 1419 the chip count reached 11, there was a rapid loss of engine oil, a momentary spike in vibration from the engine number 1 bearing, and the EICAS message to the flight crew reporting low engine oil pressure. The engine was shut down and the aircraft landed about 52 minutes later.

### **Engine driven gearboxes**

Engine rotation is transmitted to an inlet gearbox (IGB) with a radial driveshaft, which connects to a transfer gearbox (TGB). The TGB transmits the engine speed to the AGB via a horizontal driveshaft (Figure 1). The AGB drives the accessories necessary for engine operation and other aircraft services, such as the generators for the aircraft electrical system. The engine oil system provides lubrication, cooling and removes debris from the gearboxes.

**Figure 1: Engine driven gearboxes**



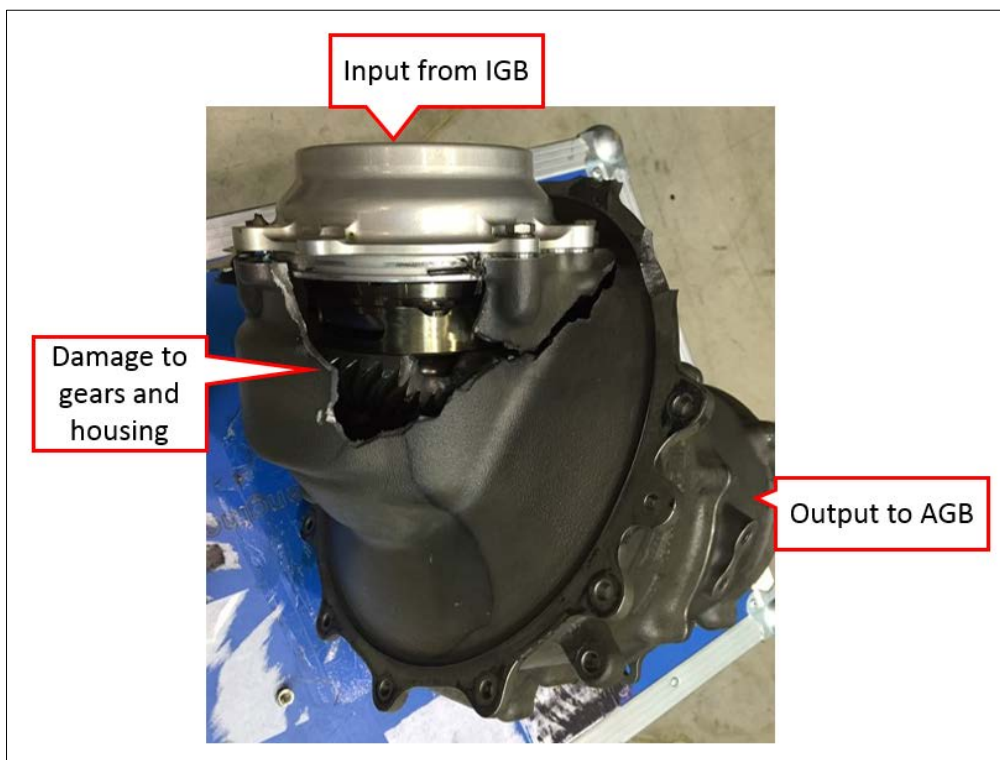
Source: Boeing, annotated by ATSB

### **Transfer gearbox damage**

On inspection, the TGB housing was found to be fractured (Figure 2). The TGB oil screen was found with metallic debris and the engine oil DMS sensor was found with metallic debris (Figure 3). The manufacturer’s inspection of the TGB failure indicated it was consistent with a known failure mode of the TGB described in their service bulletin (SB) 72-0298.

<sup>5</sup> Chip count refers to metallic debris detected within the engine oil system, which may be a leading indicator of machinery failure. Chip count indicates the number of metal chips detected by the debris monitoring system.

**Figure 2: Transfer gearbox damage**



Source: Jetstar Airways

**Figure 3: DMS sensor and TGB oil screen metallic debris**



Source: Jetstar Airways

**GE Aviation service bulletin 72-0298**

GE Aviation SB 72-0298 revision 0, dated 31 March 2016, is applicable to all GENx-1B engines, which were the engines fitted to VH-VKK at the time of the incident. The SB introduces a new transfer gearbox (TGB) configuration. According to the SB:

Pre-modified TGBs have a radial bevel gear with potential resonance modes (see *Resonance*) in the engine operating range. Excitation of resonance modes may lead to a gear fracture, which can result in engine oil loss and an in-flight shut down. The SB modification introduces a new damper ring groove to the radial bevel gear and a damper ring to mitigate the excitation of the resonance modes.

GE Aviation recommended the compliance periods for the SB in Table 1 below, which are based upon the number of cycles since new (CSN) for the TGB as of 31 March 2016.

**Table 1: SB 72-0298 compliance**

Cycles Since New (CSN) as of 31 March 2016	Compliance period from 31 March 2016
TGB less than 300 CSN	12 months
TGB between 300 and 1,000 CSN	10 months
TGB greater than 1,000 CSN	8 months

**Jetstar management of service bulletin 72-0298**

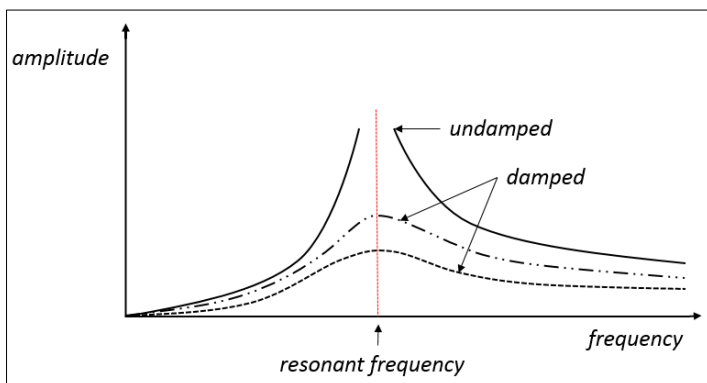
The SB related modifications for the Jetstar 787 fleet was managed with a risk profile developed by GE Aviation. The risk profile had four levels of risk for TGB failures, which depended on a number of engine operating factors in addition to the TGB CSN. Jetstar responded to the SB terminating action by immediately sourcing additional post-modification units from the manufacturer and prioritised the TGB modification in accordance with the order of highest to lowest TGB risk until the incident flight. The incident engine TGB was identified as the lowest risk (based on lowest CSN, limited in-service operational data and GE Aviation recommendations) for the Jetstar fleet at the time of the incident.

The incident engine TGB had 181 CSN at the time of the incident and therefore the compliance date to complete the SB for this engine was 31 March 2017. The engine modification to comply with the SB for the incident engine was scheduled for 31 December 2016.

**Resonance**

All machinery have a natural frequency of vibration. If a particular abnormality in the machinery generates a forced vibration, which vibrates in-phase and at the same frequency as the natural frequency of vibration, then the energy will magnify. The frequency at which this occurs is known as the resonant frequency (Figure 4). If there is insufficient damping present at the resonant frequency, then the amplitude of the vibrations will increase with each cycle. Excessive movement of components with high energy can cause a catastrophic failure of the machinery.

**Figure 4: Resonant frequency for damped and undamped vibration**



Source: ATSB

**Jetstar Airways extended diversion time operations**

Twin engine turbine aeroplanes are normally restricted to operating on routes where if an engine fails or is shut down in-flight, the aircraft is within 60 minutes flight time, at the cruise speed for one engine inoperative, to a suitable airport. Extended diversion time operations (EDTO), which are approved by CASA for individual operators, permit the Boeing 787 to operate on routes which are further than the 60 minutes flight time in the event of an engine in-flight shut down (IFSD). EDTO approval for an operator is subject to the continuous monitoring of the engine IFSD rate.

For the Jetstar Boeing 787 fleet the EDTO approval at the time of the incident was for up to 180 minutes, which required a target IFSD rate of not greater than 0.02 per 1,000 flight hours. Prior to the incident flight, Jetstar were operating at a rolling 12 month IFSD rate of 0 per 1,000 flight

hours, which increased to 0.0096 post-incident. Jetstar have performed several unscheduled engine changes on their 787 fleet since introduction into service, but no changes prior to the incident flight related to the fault condition identified in SB 72-0298.

## ATSB comment

The ATSB notes that the failure of the TGB and loss of oil is a potential failure mode known to the engine manufacturer and operator. This condition is under risk management through the service bulletin process and the operator was within the compliance period at the time of the incident. Prior to the incident flight, the incident TGB was assessed as being in the lowest risk profile for the operator’s fleet.

## Safety action

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

### **Jetstar Airways**

In light of the incident, Jetstar amended their TGB modification schedule in order to prioritise at least one engine TGB on each aircraft airframe in their fleet at the earliest opportunity (known as deairing or decoupling). The fleet was completely deaired from 26 August 2016. Jetstar completed the modification programme for their fleet in November 2016.

## Safety message

This incident highlights the importance of flight crew complying with checklist actions when dealing with a fault condition. Inflight, the crew did not have knowledge of the extent of the damage to the engine TGB. However, by following their training and checklist procedures, they reduced the risk of a potential escalation of the fault.

## General details

### **Occurrence details**

Date and time:	6 August 2016 – 1400 UTC	
Occurrence category:	Incident	
Primary occurrence type:	Engine failure or malfunction	
Location:	370 km north of Guam, North Pacific Ocean	
	Latitude: 16° 49.72' N	Longitude: 144° 51.60' E

### **Aircraft details**

Manufacturer and model:	The Boeing Company 787-8	
Registration:	VH-VKK	
Operator:	Jetstar Airways PTY Limited	
Serial number:	36237	
Type of operation:	Air Transport High Capacity - Passenger	
Persons on board:	Crew – 11	Passengers – 309
Injuries:	Crew – 0	Passengers – 0
Aircraft damage:	Nil	

## About the ATSB

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

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

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

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

It is not a function of the ATSB to apportion blame or determine liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

## About this report

Decisions regarding whether to conduct an investigation, and the scope of an investigation, are based on many factors, including the level of safety benefit likely to be obtained from an investigation. For this occurrence, a limited-scope, fact-gathering investigation was conducted in order to produce a short summary report, and allow for greater industry awareness of potential safety issues and possible safety actions.