



Australian Government  
Australian Transport Safety Bureau

# In-flight engine fire involving AVRO 146-RJ100, VH-NJI

Departing Perth Airport, Western Australia | 29 April 2014



Investigation

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

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# Safety summary

## What happened

On 29 April 2014 an AVRO 146-RJ100 aircraft, registered VH-NJI and operated by Cobham Aviation Services Australia (Cobham), was on a charter flight to Barrow Island Airport from Perth Airport, Western Australia. The aircraft sustained a mechanical failure of the No. 2 engine shortly after take-off that resulted in an in-flight fuel-fed engine fire.

The flight crew extinguished the engine fire by shutting down the No. 2 engine and activating the fire suppression system. The aircraft was flown back to Perth Airport, having sustained significant damage to the No. 2 engine and cowling. There were no injuries.

### VH-NJI in-flight fire damage



Source: Jason Grimm

## What the ATSB found

The Honeywell International Inc (Honeywell) LF507-1F (LF507) engine has four combustion liner locating pin welded bosses (welded boss) in the combustor turbine module (CTM) combustor housing (housing). The ATSB found that the welded boss located at the 2 o'clock position had cracked and fractured adjacent to the weld as a result of fatigue. The boss separated from the housing, allowing high-pressure combusting fuel to escape radially through the CTM housing, burning through the engine cowling.

The ATSB also found that localised grinding of the inner and outer surfaces of the CTM housing, adjacent to the welded boss, had reduced its wall thickness from 0.050 to 0.035 inches. The reduced wall thickness increased local stresses and hence the likelihood of crack formation. The crack accelerated at an unpredictable rate until penetrating the full thickness of the housing. It is likely that the grinding was associated with a weld repair conducted during a CTM heavy maintenance visit. The grinding repair was not an acceptable repair to Honeywell for returning the component to the original design strength.

Finally, the ATSB found that the normal scheduled visual inspection of the housing, which was designed to find cracks before they developed into a fracture, was ineffective in this case. This was because the reduced wall thickness invalidated the original crack growth rate predictions.

## What's been done as a result

In response to this occurrence Cobham proactively inspected all of their LF507 engines, focusing on the welded bosses. Of those engines, one spare engine had grinding at one of the welded bosses, similar to the occurrence engine, and was withdrawn from the availability pool. Although no cracking was found at the combustion liner location pin welded bosses, Cobham did find seven cracks at the location of the ignition bosses that had not been previously identified. These cracks were managed in accordance with the Honeywell maintenance manual.

Honeywell also instigated several actions in response to this occurrence. These included amendment of the LF507 engine maintenance and overhaul manuals to address crack limits and weld repair specifications, and the issue of a Service Bulletin to alert operators of possible welded boss cracking.

## Safety message

This occurrence highlights the importance of repairing aircraft components in accordance with the manufacturer's specifications and ensuring that the repair meets the design intent of the manufacturer.

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# The occurrence

On 29 April 2014 an AVRO 146-RJ100 aircraft, registered VH-NJI and operated by Cobham Aviation Services Australia (Cobham), departed Perth Airport on a charter flight to Barrow Island Airport, Western Australia. Shortly after take-off, at about 1045 Western Standard Time<sup>1</sup> as the aircraft climbed through about 400 ft, the flight crew were alerted to an emergency situation by the cabin crew. During this inter-crew communication the flight crew could hear passengers shouting in the cabin. About the same time, the flight deck master warning panel light illuminated and the No. 2 engine thrust lever fire warning and fire handle illuminated, and the associated warning bell sounded. The flight crew reported that, prior to the fire warning, engine operations were normal.

The flight crew shut down the No. 2 engine, activated the fire suppression system for that engine and declared a PAN<sup>2</sup> requesting immediate return to Perth Airport. Full emergency procedures for Perth Airport were activated and the aircraft landed at 1055.

Technical inspection of the aircraft after landing found that the No. 2 engine sustained an in-flight fuel-fed engine fire that significantly damaged the engine and its cowling (Figure 1).

**Figure 1: Right side of the No.2 engine showing the fire damage to the combustor housing and liner (looking forward)**



Source: Cobham, modified by the ATSB

<sup>1</sup> Western Standard Time (WST) was Coordinated Universal Time + 8 hours.

<sup>2</sup> An internationally-recognised radio call announcing an urgency condition that concerns the safety of an aircraft or its occupants but where the flight crew does not require immediate assistance.



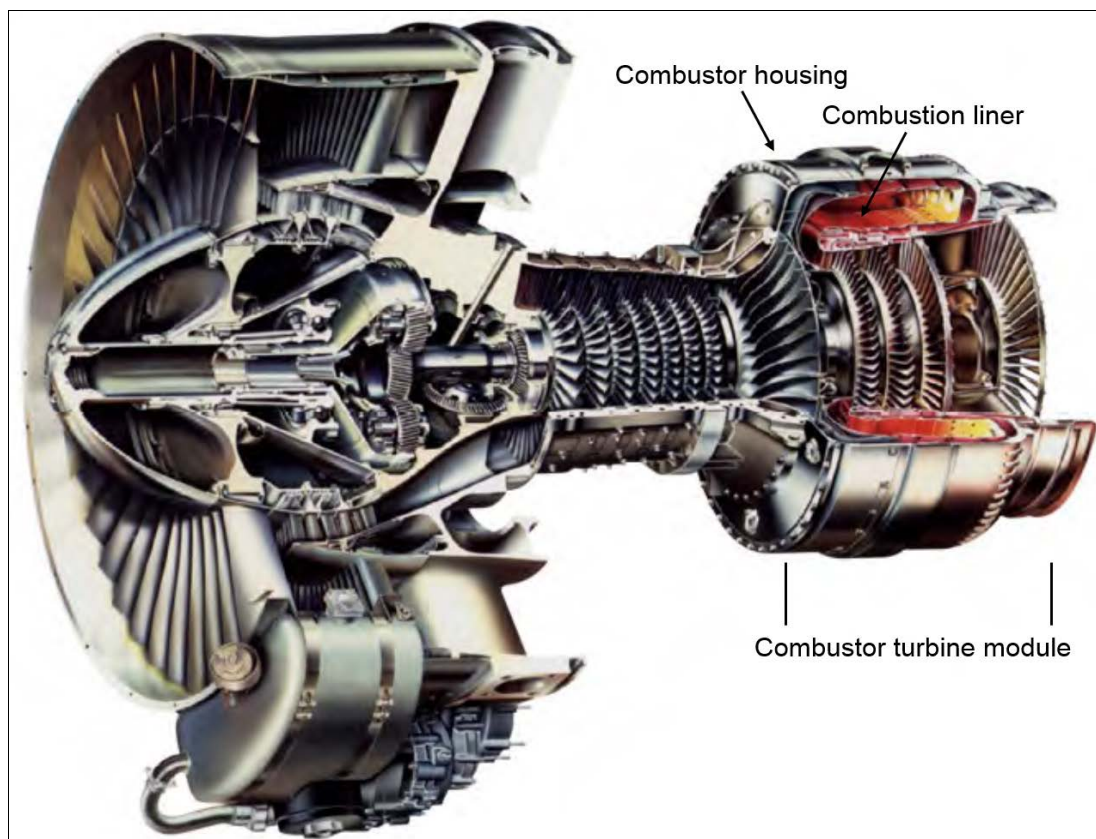
# Context

## Engine information

The aircraft was powered by four Honeywell International Inc (Honeywell) LF507-1F (LF507) dual-spool, high-bypass turbofan engines. For maintenance and serviceability, the LF507 engine is divided into four modules: the fan assembly, gas producer, combustor turbine and accessory gearbox. This occurrence related to the combustor section of the combustor turbine module (CTM) (Figure 2).

The CTM consists of the combustor and the low-pressure turbine that are retained within the combustor housing (housing). The housing has four welded bosses located at the two, four, eight and ten o'clock positions (looking forward from the rear of the engine). A spigot pin is screwed into each welded boss to locate and retain the combustion liner. During normal operation, the fuel/air mixture is ignited in the combustion liner and supplies energy to the low-pressure turbine.

**Figure 2: Left-side cut-out view of an exemplar LF507 engine showing the locations of the combustor housing, combustion liner and combustor turbine module**



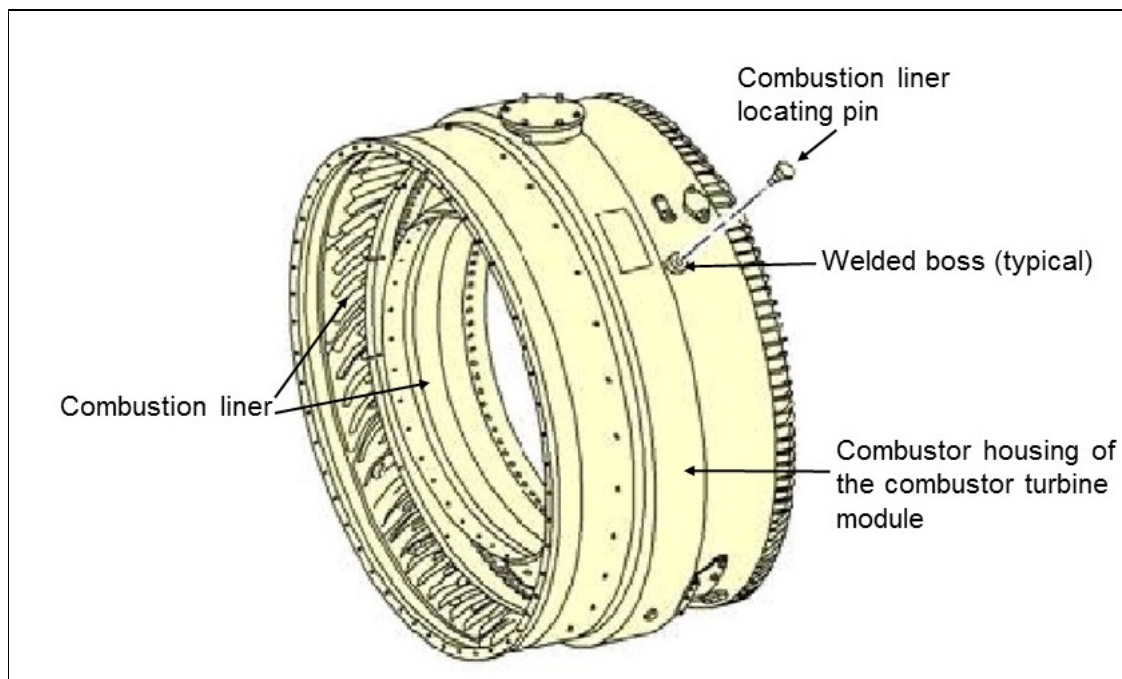
Source: Honeywell, modified by the ATSB

VH-NJI (NJI) was introduced into Australian service in 2012 with engine serial number LF07405, CTM serial number 93K004 and the occurrence combustor housing (serial number 363) fitted. The engine and these components were subsequently operated in the No. 2 engine position on NJI until the occurrence in April 2014. In the intervening period, the combustor housing accumulated 1,319 engine cycles in service since its last heavy maintenance inspection.

## Engine examination

Examination of the engine found that the combustion liner welded boss (welded boss) at the two o'clock position had fractured and separated from the housing (Figure 3).

**Figure 3: Exemplar LF507 engine showing the combustor housing and combustion liner highlighting a typical welded boss and combustion liner locating pin**



Source: Honeywell, modified by the ATSB

A portion of the combustion liner, a separate component that normally contains the combusting fuel/air mixture gases, fractured adjacent to the 2 o'clock welded boss and sustained significant fire damage (Figure 4). The breached combustor housing and combustion liner created a radial escape path for the high-pressure combusting fuel, which quickly burnt through the engine cowling support structure and engine cowling in that location.

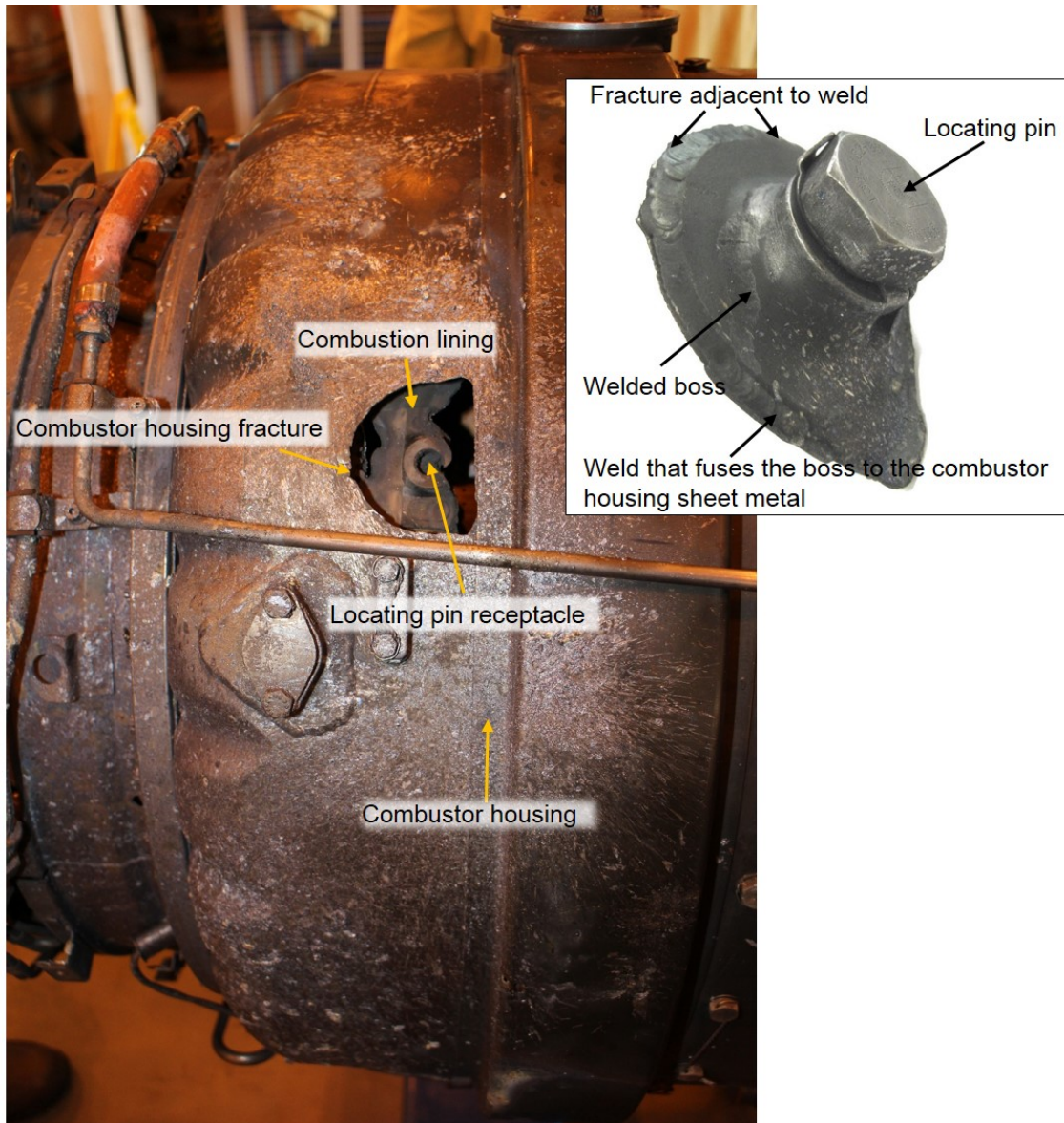
A review of the Engine Condition Trend Monitoring<sup>3</sup> data for the engine was conducted by the ATSB and Cobham Aviation Services (Australia) (Cobham) several days after the occurrence. The review confirmed that there were no air leakage indications or parameter shifts prior to the occurrence that may have alerted maintenance staff of a pending defect or failure.

The engine was removed from the aircraft and dispatched to an engine overhaul facility in the United Kingdom (UK) for technical examination. This disassembly and inspection was carried out under the supervision of the UK Air Accidents Investigation Branch, with assistance from Honeywell. Components that were relevant to the investigation, including the combustor housing, combustion liner and the four combustion liner locating pins, were dispatched to the United States (US) for detailed examination.

Detailed examination of the housing, combustion liner and the four locating pins was conducted by Honeywell under the supervision of the US National Transportation Safety Board. The fractured welded boss, which was subsequently found in the engine cowling and recovered by Cobham, was initially examined by the ATSB before also being sent to Honeywell in the US for further detailed examination.

<sup>3</sup> Engine Condition Trend Monitoring: A process in which changes in certain engine performance parameters are analysed to identify engine performance deterioration and malfunction of engine components and accessories.

**Figure 4: No. 2 engine showing the combustor housing, combustion liner (seen internal to the combustor housing) and insert image showing the locating pin secured in the fractured welded boss**



Source: ATSB

## Results of the detailed component examination in the US

The detailed examination in the US identified an area of the combustion liner that had thermal damage and was fractured adjacent to the two o'clock welded boss position. That damage was consistent with the effect of temperature and pressure variations between the combustor housing and the combustion liner once the welded boss fractured from the housing (Figure 4).

Honeywell conducted a detailed metallurgical examination of the combustor housing and the recovered welded boss. It was determined that the sheet metal of the combustor housing fractured as a result of fatigue cracking adjacent to the boss weld line (Figure 5). In addition, weld repairs were identified on cross-sectional samples taken through the joints surrounding the recovered welded boss.

Honeywell advised that the fatigue fracture was consistent with low cycle fatigue and did not appear to be associated with the weld repairs.

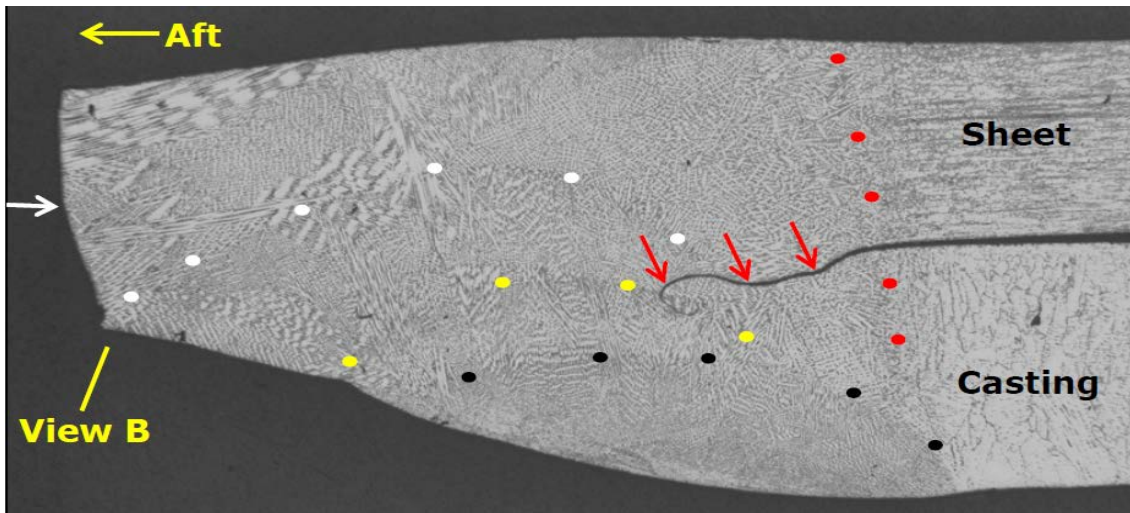


A non-penetrating crack, a crack that did not penetrate through the full thickness of the housing sheet metal, had propagated over a period of about 2,680 load cycles. Each load cycle on the affected components was considered by Honeywell to be associated with pressure variations within the engine. Pressure variations can be caused by engine power level changes, compressor stalls, combustion rumble and temperature variations that lead to expansion and contraction of the housing. Numerous load cycles can occur during normal flight.

Engine maintenance is based on engine hours, cycles<sup>4</sup> or calendar days, depending on the type of component. Engine maintenance is not based on load cycles as each flight can produce a significant variation due to conditions at that time.

The examination of the fractured welded boss identified three separate weld repairs. These were identified on cross-sectional samples taken through the joints surrounding the recovered welded boss (Figure 5). Honeywell concluded that the fatigue cracking was not directly associated with the weld. Hardness measurements taken from the housing sheet metal, boss casting, and weld indicated that heat treatment was performed on the assembly subsequent to weld repair, as specified by Honeywell.

**Figure 5: Metallographic image of a cross section of the fractured welded boss. The red dots likely indicate the original weld. The white, yellow and black dots likely indicate subsequent weld repairs. The red arrows indicate a crack emanating from the forward side of the weld at the housing/casting interface. The white arrow is the fracture surface, where the boss separated from the combustor housing. The fracture initiated at the outside diameter of the welded boss**



Source: Honeywell

Further examination of the combustor housing in the location of the fractured welded boss found that a section of the combustor housing sheet metal had been thinned at the inside and outside surfaces by grinding (Figure 6). This grinding was associated with a weld repair where the boss was weld fused to the sheet metal. Thicknesses of 0.035 inches–0.040 inches were measured at the CTM housing adjacent to the two o'clock welded boss.

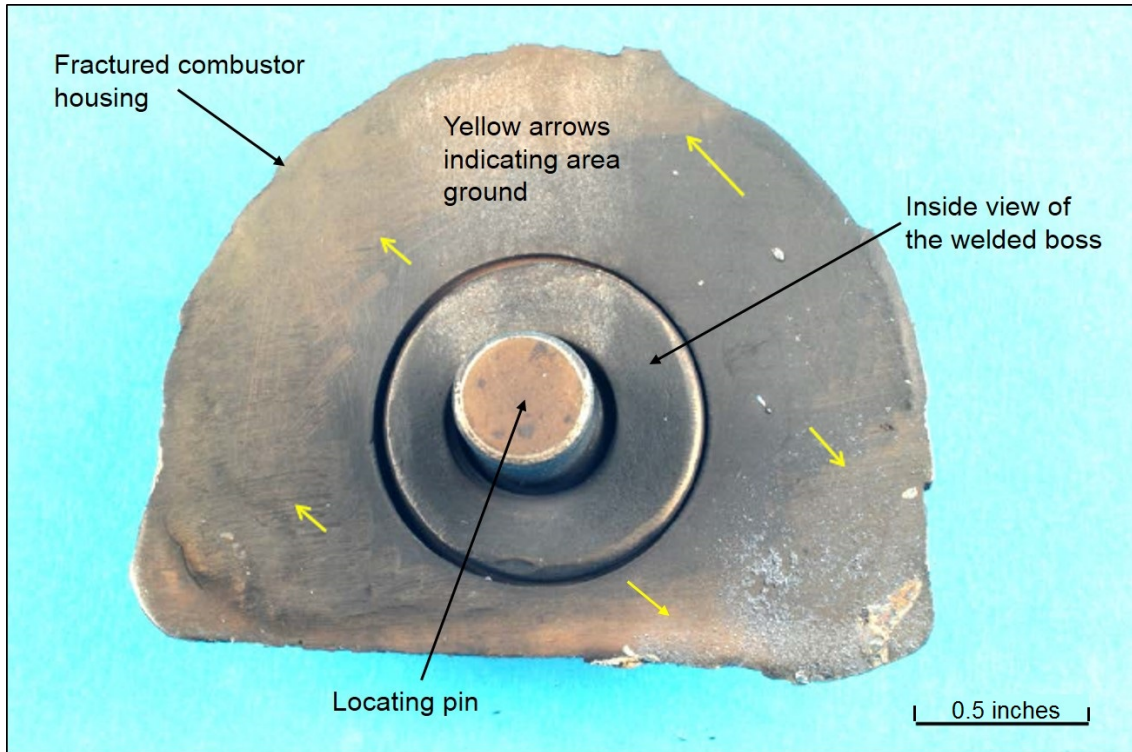
The thickness of the combustor housing sheet metal was specified by Honeywell as nominally 0.049–0.050 inches thick. This indicated that during a repair, about 20–30 per cent of the housing thickness had been removed. In this regard, the combustor housing is a pressure vessel. Honeywell does not approve the removal of material leading to a reduction of housing wall thickness.

<sup>4</sup> One engine cycle is the complete sequence of an engine start, followed by continued operation and ends with shutdown of the engine.

Removal of material, as in this case, created an area of increased local stress.

The other three welded bosses also exhibited hand finishing, indicating that material removal took place in those locations.

**Figure 6: Image of the inner side of the fractured combustor housing and the locating pin protruding through the welded boss. Areas that have been ground are identified by yellow arrows**



Source: Honeywell, modified by the ATSB

## Repair of ignition or liner welded bosses

During normal engine operation, expansion and contraction of the combustor housing can contribute to the welds at the bosses fatiguing and cracking. Such cracking is predictable and can be monitored during scheduled maintenance.

Honeywell published a system of maintenance where cracks, under a specific criteria, could be monitored during normal operation or repaired during heavy maintenance. Repairs depended on the length of the crack and the measured growth rate. The repair consisted of grinding the cracked boss weld, chemically cleaning the component and then re-welding the area.

In respect of the repair to the No. 2 engine in NJI, the grinding of the combustor housing sheet metal significantly reduced the housing thickness. Such grinding was not part of the Honeywell-approved repair and crack repairs that extended into the sheet metal housing were not approved. Cracks extending into the combustor housing necessitated replacement of the housing.

The repair to the combustor housing of the No. 2 engine in NJI was an unapproved repair.

## Blending of minor blemishes, scratches and nicks

Honeywell advised that the polishing and blending of minor blemishes, scratches and nicks was permitted. However, the use of power tools, or the reduction of housing thickness, was not permitted under the approved repair scheme.

In respect of blend repairs, the Honeywell maintenance manual, section 70-25-01, p.1 of 31 March 2006 stipulated:

- (1) Blend repair such defects as follows:
  - (a) Repair using small diesinker type file and india or carborundum stone. Use crocus cloth (05-07, 70-80-01) or rubberised abrasive block (ST-20-ALO-88X, 06-09, 70-80-01) for final polishing.
  - (b) Blend all repairs and finish smoothly. Lines, scratches, or sharp edges that might cause concentration of stress are not permitted.

At the time of the occurrence, Honeywell had not published any combustor housing wall thickness limits in respect of the amount of material that could be removed during blending. Maintenance personnel performing blending repairs, in the absence of manufacturer's limitations, were required to make their own judgement as to the amount of material that could be removed.

The reduction in housing wall thickness in the No. 2 engine in NJI was most likely a product of a non-standard weld repair, as opposed to a blend of a blemish, nick or scratch. In any case, the housing at the welded boss had been ground, removing 20–30 per cent of the material thickness.

## Engine maintenance schedule

LF507 engine modules can be separated and moved between engines. Engines are often swapped from engine position, aircraft-to-aircraft or to spare. Numerous components on a turbine engine have operational limits measured in hours, cycles and/or calendar days. Modules are frequently removed earlier than the manufacturer stipulates, often as a result of:

- foreign object damage
- to accommodate other required maintenance
- preventive maintenance that may be deemed more economical to perform at that time.

Prior to the occurrence, the CTM was removed from and reinstalled in a number of engines on six separate occasions, including the No. 2 engine in NJI. This included for:

- 6,000-cycle Hot Section Inspections
- non-scheduled shop visit maintenance and modifications that necessitated significant disassembly, maintenance and detailed inspections.

That maintenance activity took place in 1999, 2001, 2005, 2006, 2008, and 2009.

Heavy maintenance was completed on the CTM in 2005 by a European workshop. With assistance from Honeywell, archived records for that shop visit were recovered and examined. The records, dated January 2005, showed that the previously-installed CTM housing, serial number 395, was removed and replaced with the occurrence housing. In the absence of additional data, it is likely that this housing was an exchanged item.

The serviceability of the CTM housing is based on its condition meeting Honeywell's service limitations. It does not have a critical life limit based on hours, cycles or calendar days. Therefore the housing's hours, cycles and/or calendar days were not tracked, nor were they required to be. The release certificate for the occurrence CTM housing when fitted in 2005 stated that the housing was:

Inspected and repaired in accordance with the LF507-1F engine manual section 72-41-03, repairs SP R401, 08, 09, 10, 12 (repair 12 repaired in accordance with the ALF502R engine manual 72-41-04).

According to Honeywell, repair 12 has a different application depending on the model of engine being repaired. In respect of Honeywell engines an:

- ALF502 engine repair 12 is a diagnostic plate weld repair
- LF507 engine repair 12 is a repair of cracks in the weld of the ignitor boss or a repair of cracks in the weld of the liner retention welded boss.

In this occurrence, the CTM housing was fitted to an LF507 engine and, according to the release to service document, was repaired in accordance with the ALF502 engine manual. According to Honeywell, at that time the ALF502 engine manual was the appropriate document with which to repair that model housing.

The hours, cycles, or previous work conducted on the occurrence CTM housing could not be established prior to its installation in 2005. The European maintenance organisation that conducted the heavy maintenance on the CTM in 2006, 2008 and 2009 was no longer operating. Records recovered from that period showed that visual inspections were conducted on the CTM housing during that maintenance with no repairs to the housing recorded. The last heavy maintenance inspection and disassembly of the CTM was in 2009, about 3,438 engine cycles prior to the occurrence.

In addition to the scheduled heavy maintenance inspections of the engine modules, the aircraft maintenance system called for an 'on-wing' general visual inspection of the engine(s), including the CTM combustor housing, every 500 flight cycles or 6 months. The intent of that inspection was to identify abnormalities associated with the engine's exterior surfaces. The inspection allocated 2 hours to inspect the front, centre and rear sections of engine Nos. 1, 2, 3 and 4. This included the housing, fittings, plumbing and associated accessories without removal of components.

Honeywell defined a visual inspection as:

An examination of an interior or exterior area, installation or assembly to detect obvious damage, failure or irregularity. This level of inspection is made from within touching distance unless otherwise specified. A mirror may be necessary to enhance visual access to all exposed surfaces in the inspection area. This level of inspection is made under normally available lighting conditions such as daylight, hanger lighting, flashlight or droplight and may require removal or opening of access panels or doors. Stands, ladders or platforms may be required to gain proximity to the area being checked.

No special or detailed inspections were stipulated by Honeywell or the Civil Aviation Safety Authority for the combustor housing when on-wing. No cracks in the combustor housing were recorded by Cobham as a result of its two on-wing inspections of the engine during its service with Cobham. However, non-penetrating cracks that do not show gas leakage, fretting or discolouration are difficult to identify using visual inspection techniques.

Commonly-used documents such as US Federal Aviation Administration Advisory Circular AC43.13 described the equipment and techniques that, when used, may detect cracks when performing non-destructive testing through visual inspection. According to AC43.13, the key to performing a visual inspection is to direct a suitable torch beam, at a 5°–45° angle to the inspection surface, and direct the beam towards the face. Cracks are identified as a shadow or reflected light beam. Use of a 10 times magnifying glass can confirm the existence of a suspected crack. If this is assessed as inadequate, use of other non-destructive testing techniques, such as penetrant or eddy current inspection, can be performed to verify cracks.

## Previous similar occurrences

A search of historic records by Honeywell did not identify the CTM housing as having a high failure rate. In that respect, one other CTM housing welded boss fracture was recorded, 10 years prior to this occurrence.

A major United Kingdom engine overhaul facility for the LF507 engine reported that about 40 per cent of the LF507 engines presented to their facility for maintenance were cracked at other than CTM housing welded boss locations. Those cracks were reported repaired in accordance with the Honeywell maintenance instructions and did not develop into a fracture.

## Subsequent occurrence

During finalisation of this investigation report, on 10 March 2016 the ATSB was notified that a Swiss Global Air Lines Avro 146-RJ100 aircraft, which was powered by LF507-1F engines, had



sustained a No. 2 engine fire during take-off. The aircraft, registered HB-IYT, was on departure from Zurich Airport, Switzerland when the take-off was rejected due to sparks observed from the engine. The Swiss Transport Safety Investigation Board (STSB) is responsible for investigating this occurrence.

The STSB is responsible for the release of the final investigation report into the occurrence involving HB-IYT. Any enquiries in respect of the ongoing STSB investigation, or release of their investigation report should, in the first instance, be directed to the:

Swiss Transportation Safety Investigation Board  
Aviation division  
Aéropôle 1  
CH-1530 Payerne

Email: [info@sust.admin.ch](mailto:info@sust.admin.ch)

# Safety analysis

## In-flight engine fire

At a high engine power setting during the climb, the welded boss at the two o'clock position of the No. 2 Honeywell International Inc (Honeywell) LF507-1F engine fractured and separated from the combustor turbine module (CTM) combustor housing (housing). This led to the fracture of the combustion lining and allowed high-pressure combusting fuel and gases to escape radially from the engine. The engine cowling was weakened and melted from the resulting in-flight engine fire.

The engine fire detection and suppression system was effective in alerting the crew to the situation. The crew extinguished the fire using normal operating procedures and returned the aircraft to Perth Airport for landing.

## Non-approved repairs

Metallurgical examination of the fractured welded boss found that it had been weld-repaired on three separate occasions. The only recorded weld repair to the CTM housing was in 2005 although, as the CTM housing was an exchanged unit, its history could not be established. Therefore, either the CTM housing was repaired at or prior to 2005, or the housing was repaired after 2005 and the repair was not recorded. From the evidence available, the ATSB could not determine which was the case. In any event, the housing had been ground adjacent to the welded boss, reducing the housing wall thickness by 20–30 per cent. Grinding of the housing was not in accordance with Honeywell's approved repair scheme, and the non-approved repair was not identified in any of the subsequent heavy maintenance inspections.

The reduction in the housing wall thickness increased the operational stresses at that location. This would have affected the initiation of the fatigue crack and increased its rate of propagation during normal engine operation.

## Limitations in the manufacturer's blending process

The standard practices section of the Honeywell maintenance manual referred to blending as a means of reducing induced metal stress by removing scratches or nicks in the metal. That reference did not limit the amount of material able to be removed during the blending process. According to Honeywell, it was not the intent of the process to remove metal or reduce a combustor housing's wall thickness when blending. In the absence of any limitation, the amount of material that could be removed during the process was open to interpretation by maintenance personnel.

It was possible for the blending process to be applied during a weld repair, where the repairer believed that, despite it not being part of the repair, it was necessary to remove stress raisers. However, this was inconsistent with the grinding evident on the fractured components. That grinding was likely achieved using power tools, as opposed to the Honeywell-defined hand blending process.

## Scheduled maintenance inspections

The rate of cracking around the welded boss was reported to occur in about 40 per cent of the engines introduced into one of the approved engine repair facilities. However, Honeywell was only aware of one other event where the cracking had progressed to catastrophic failure. This indicated that this occurrence, where the fatigue crack developed into a fracture, was very rare. Honeywell considered that, when repaired in accordance with the current repair scheme, the repair specifications were generally adequate. The associated visual inspections were historically effective in detecting cracks around the welded boss prior to catastrophic failure.

The reduction in material thickness and corresponding increase in local stresses may have increased the rate of crack initiation and propagation. The increased cracking rate and resulting stresses meant that a crack might initiate, and the CTM housing ultimately fail, between scheduled inspections. Alternatively, the crack may have existed but remained undetected, or not existed at the previous inspection.

In terms of Cobham Aviation Services Australia's conduct of the most recent 500-hourly on-wing engine inspection, it was reasonable that, if the crack existed at that time, it was not visually-identified as:

- the crack was non-penetrating, meaning that it would probably have only been identifiable when the CTM was fully-disassembled (such as at a scheduled heavy maintenance inspection)
- there were no other, more usual, indications of a crack in the CTM, such as:
  - increases in the engine condition trend monitoring data parameters
  - blacking around any crack edges due to combusted gas leakage or fretting.

In addition to the lack of visual clues, the maintenance personnel were probably not expecting to find a crack. Human attention is guided by two factors:

- expectancy, where an individual will look where they expect to find information
- relevance, where an individual will look to information sources relevant to the important tasks and goals they need to carry out.

The key factor is expectancy. It is well demonstrated that people are more likely to detect targets when expected, and less likely to detect targets that are not expected (Wickens and McCarley, 2008). This occurs even when the targets are salient, potentially important and in an area to which the person is looking (Chabris and Simon, 2010).

# Findings

From the evidence available, the following findings are made with respect to the in-flight engine fire involving AVRO 146-RJ100, registered VH-NJI and operated by Cobham Aviation Services Australia as it departed Perth, Western Australia on 29 April 2014. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

## Contributing factors

- A repair to the two o'clock combustion liner retention boss of the No. 2 engine combustor turbine module housing was not performed in accordance with the manufacturer's repair specification, resulting in a thin-walled housing that increased local stresses in that location.
- As a result of fatigue, the No. 2 engine combustor turbine module housing cracked, then fractured adjacent to the two o'clock combustion liner retention boss weld, propagating at an unpredictable rate as a result of the non-approved repair.
- High-temperature combusting fuel and gases escaped radially from the fracture in the No. 2 engine combustor turbine module housing, leading to an in-flight engine fire.

## Other factors that increased risk

- The Honeywell International Inc documentation for blending did not limit the amount of material that could be removed from the combustor housing.

## Other findings

- The Honeywell International Inc LF507-1F heavy maintenance schedule was adequate to identify and repair cracks in the combustor turbine module housing combustion liner retention boss weld.



# Safety issues and actions

## Additional 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.

### ***Cobham Aviation Services Australia***

As a result of this occurrence, Cobham Aviation Services Australia (Cobham) undertook a number of safety actions to identify and capture defects of a similar type prior to their developing into an incident or accident. In addition, Cobham issued the following Technical Service Instructions (TSI):

- TSI-146-72-0015, issue 1 on 17 September 2014. This TSI stated that a detailed visual inspection for cracks was to be performed on each of the four combustion housing welded bosses across the Cobham fleet of ALF502R, LF507-1H and LF507-1F engines. The compliance date for this TSI was 7 October 2014.
- TSI-146-72-0017, issue 1 on 21 April 2015. This TSI required a non-destructive Fluorescent Penetrant Inspection for cracks on each of the combustion housing welded bosses. This included the four combustion housing welded bosses, two drain valve bosses and the four ignitor bosses on all of Cobham's ALF502R, LF507-1H and LF507-1F engines. The compliance date for this TSI was 1 June 2015.

Cobham reported that of the 53 engines inspected, none had cracks in the location of the combustor housing combustion liner locating pin welded boss welds. However, seven previously-unidentified cracks were identified at the location of the ignition boss, which is also part of the combustor housing. Those cracks were routinely-managed in accordance with the manufacturer's maintenance manual.

### ***Honeywell International Inc***

As a result of this occurrence and investigation, Honeywell undertook several safety actions that were designed to identify and capture defects of a similar type prior to their developing into an incident or accident. Honeywell has also proposed amendments to their engine maintenance system, including:

- Chapter 72-41-01 of the maintenance manual, where weld repair of the welded boss was deleted in repair scheme 12. With effect 3 March 2015, repair of a cracked welded boss is achieved by replacing the housing.
- Overhaul/repair instructions P35242, Revision E, changed the allowable crack limitations of the combustor housing welded boss. The changed instructions do not permit continued operation when cracks are identified in the weld.
- Drafting Service Bulletin ALF/LF-72-1119 of 9 January 2015, which affects all Challenger 600, BAe 146 and AVRO RJ aircraft fitted with specific engine part and model numbers. The Service Bulletin states:

C. (1) Cracks in the combustion liner retention bosses have led to separation and have resulted in an engine fire and in-flight shutdown.

Honeywell recommend that a detailed visual inspection be conducted of the weld between the boss and the combustor housing parent material using a 7x power magnifying glass or non-destructive dye-penetrant inspection method within the first access to the affected part or within 500 cycles after the Service Bulletin becomes effective.

- The Standard Practice Manual, in order to highlight the intent of, and processes associated with blending. This includes that:

Blend repairs on static structural components prior to or after weld repairs should not thin the parent metal and provide a smooth transition to the existing surface. Refer to the applicable repair manual/specific repair instruction for minimum wall thickness requirements.

# General details

## Occurrence details

Date and time:	29 April 2014 – 1045 WST	
Occurrence category:	Serious incident	
Primary occurrence type:	Engine fire	
Location:	Departing Perth Airport	
	Latitude: S 31° 56.42'	Longitude: E 115° 58.02'

## Aircraft details

Manufacturer and model:	British Aerospace PLC, AVRO 146-RJ100	
Year of manufacture:	1995	
Registration:	VH-NJI	
Operator:	National Jet Express for Cobham Aviation Services Australia	
Airframe Serial number:	E3265	
Engine No. 2 Total Time In Service	32,355 hours Total Time Since New	
Type of operation:	Air Transport High Capacity	
Persons on board:	Crew – 6	Passengers – 87
Injuries:	Crew – Nil	Passengers – Nil
Damage:	No. 2 Engine-Substantial	

## Sources and submissions

The sources of information during the investigation included:

- Honeywell International Inc
- Cobham Aviation Services Australia
- the flight crew.

### References

Chabris, C.F. and Simons, D.J. (2010). *The invisible gorilla and other ways our intuitions deceive us*. New York, NY: Random House.

Wickens, C.D. and McCarley, J.S. (2008). *Applied attention theory*. Boca Raton, FL: CRC Press.

### Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003* (the Act), the ATSB may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. Section 26 (1) (a) of the Act 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 flight crew, Cobham Aviation Services Australia, Honeywell International Inc and the Civil Aviation Safety Authority.

No submissions were received from those parties.



# Australian Transport Safety Bureau

The 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; 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.

## Purpose of safety investigations

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

## Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes it appropriate. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

## Australian Transport Safety Bureau

**Enquiries** 1800 020 616

**Notifications** 1800 011 034

**REPCON** 1800 011 034

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## Investigation

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

In-flight engine fire involving AVRO 146-RJ100, VH-NJI  
Departing Perth Airport, Western Australia, on 29 April 2014

AO-2014-076

Final – 2 May 2016