Australian Government
Australian Transport Safety Bureau

Engine malfunction involving Cessna 441, VH-JFU

100 km north-east of Tindal Airport, Northern Territory, on 7 September 2021

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Addendum

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Executive summary

What happened

On 7 September 2021, a Cessna 441, registered VH-JFU, was being operated on a passenger charter flight from Sawfish Camp to Darwin, Northern Territory. During cruise, the pilot observed abnormal indications (torque fluctuations, high oil pressure and high oil temperature) from the right engine and diverted to Tindal. Maintenance checks identified that the air/oil cooler return line and air/oil separator vent line had been (incorrectly) transposed during a recent engine change.

After rectifications and checks were carried out, the aircraft was released to service. During a flight on 28 September 2021, the pilot observed abnormal indications (torque and oil pressure fluctuations) from the right engine. After landing, oil was observed throughout and under the right engine cowling. The reduction gearbox scavenge pump was found to be unserviceable.

What the ATSB found

The oil lines could be easily transposed given that they were flexible and long enough to reach the 2 ports that were adjacent to each other, were the same size, used the same thread and were almost identical in appearance. This presented a risk of the lines being transposed without hindrance.

It was not possible to determine whether there were any individual or environmental factors associated with the error, and the requirements to carry out an independent inspection did not include checking the oil lines.

The incorrect oil flow resulting from the transposed oil lines damaged the air/oil separator, which then increased the reduction gearbox scavenge pump pressure. This compromised the structural integrity of the pump housing and led to its subsequent failure and, ultimately, abnormal engine indications on the later flight.

The engine manufacturer had issued a service information letter (SIL) in 1990 advising that the oil lines had been transposed on several previous occasions. A limited review of previous occurrences involving such transpositions did not identify any that led to in a complete loss of power or an accident.

What has been done as a result

Following the occurrence, the operator, Chartair:

- commenced a fleet-wide program to add markings to engine oil tanks
- conducted toolbox talks with engineering staff about distractions during maintenance
- commenced documenting each stage of engine changes.

In addition, Honeywell (the engine manufacturer) reissued the SIL with additional information and guidance. The manufacturer also indicated that it would revise the inspection/repair manuals with instructions to re-mark the engine oil tanks.

Safety message

The ATSB reminds maintenance engineers that it is important to check relevant documentation rather than relying on experience and memory, and to remain familiar with other data such as manufacturer service information letters.

Furthermore, since maintenance documents do not always provide advice on non-routine technical situations, operators and maintainers should seek technical advice from the manufacturer to ensure that non-routine problems are fully rectified prior to releasing an aircraft to service.

The investigation

Decisions regarding the scope of an investigation are based on many factors, including the level of safety benefit likely to be obtained from an investigation and the associated resources required. 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

Previous maintenance

On 30 July 2021, a Cessna 441, registered VH-JFU and operated by Chartair, commenced scheduled maintenance on the aircraft at Darwin Airport, Northern Territory. The right engine was removed and replaced with an engine removed from one of the operator's other Cessna 441s. The operator had conducted about 10 such engine changes during the previous 18 months.

Throughout the following week, the engine installation and other maintenance tasks were carried out by several aircraft maintenance engineers. During the installation, the air/oil cooler return vent line and the air/oil separator vent line were inadvertently transposed when fitted to the oil tank. The fluid lines (including the lines that were transposed) were checked for tightness by the engineer certifying for the engine installation.

The engine change was recorded as being carried out in accordance with the airframe and engine maintenance manuals in the aircraft maintenance and certification record. This record was not broken down into specific sub-tasks, such as fitment of the oil lines, so there was no record of which engineer had done the work. In addition, several weeks had passed between when the work was completed and the detection of the maintenance error. As a result, it was not possible to determine the manner and context in which the work was carried out.

On 9 August 2021, engine ground runs and leak checks were carried out. No irregularities were detected. Independent inspections were completed on the engine's controls after installation. However, the correct fitment of the oil lines was not part of the regulatory or the operator's independent inspection requirements.[1] The aircraft was released to service on 10 August 2021.

First flight with abnormal engine indications

On 7 September 2021, about 68 flight hours after the right engine was installed, the aircraft was operated on a charter flight from Sawfish Camp to Darwin, with a single pilot and 9 passengers on board.

During cruise, the pilot saw the following indications for the right engine:

- torque fluctuations (varying by about 200 ft-lb)
- high and fluctuating oil pressure (between about 30 and 75 psi)
- high temperature (100 °C).

The pilot diverted the aircraft to Tindal Airport and landed uneventfully.

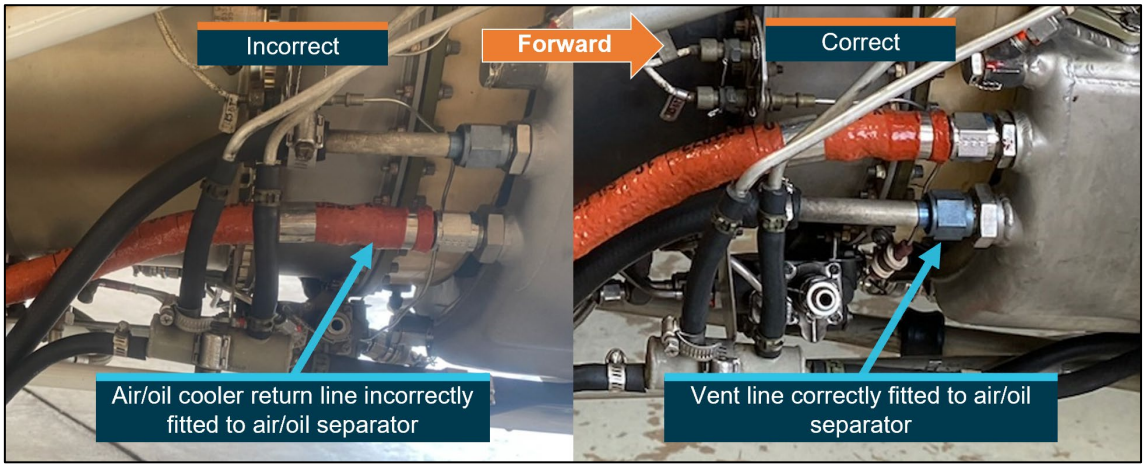
Subsequent rectification actions

At Tindal, it was identified that the air/oil cooler return line and the air/oil separator vent line had been transposed (each incorrectly fitted to the wrong part of the oil tank) when fitted to the oil tank (Figure 1).

[1] CAR 42G required independent inspections to be carried out on flight control systems when they were disturbed during maintenance. The operator expanded these requirements to include engine controls.

Following consultation with an engine overhaul organisation, the air/oil separator was changed, and the engine oil was checked for contamination. After the oil lines were correctly assembled, an engine run was carried out and no further defects were identified. The aircraft was released to service.

Figure 1: Oil tank fittings as found



Source: Chartair, modified by the ATSB

Second flight with abnormal engine indications

During a flight on 28 September 2021, the pilot observed torque and oil pressure fluctuations on the right engine.[2] The flight continued to its destination. After landing, oil was observed throughout and under the right engine cowling. The reduction gearbox scavenge pump was later found to be cracked (see Figure 3). The aircraft had flown about 114 hours since the right engine was installed, and about 46 hours since the transposition of the air/oil cooler return and the air/oil separator vent lines had been rectified.

Context

Aircraft information

The aircraft was a Cessna 441 (Conquest II) 11-seat pressurised aeroplane powered by 2 Honeywell TPE-331-10 engines. It was manufactured in 1980 and first registered in Australia on 2 May 2012.

Engine information

Oil tank and fittings

The externally-mounted engine oil tank incorporated 2 adjacent fittings that were almost identical in appearance, were the same size, and used the same thread (Figure 2). These 2 fittings included:

- an upper fitting for oil returning to the tank from the air/oil cooler
- a lower fitting for an overboard vent line from the air/oil separator.

The fittings were labelled, but the markings were anecdotally reported to wear off in-service (Figure 2). These markings were not present on VH-JFU's right engine at the time of the engine change.

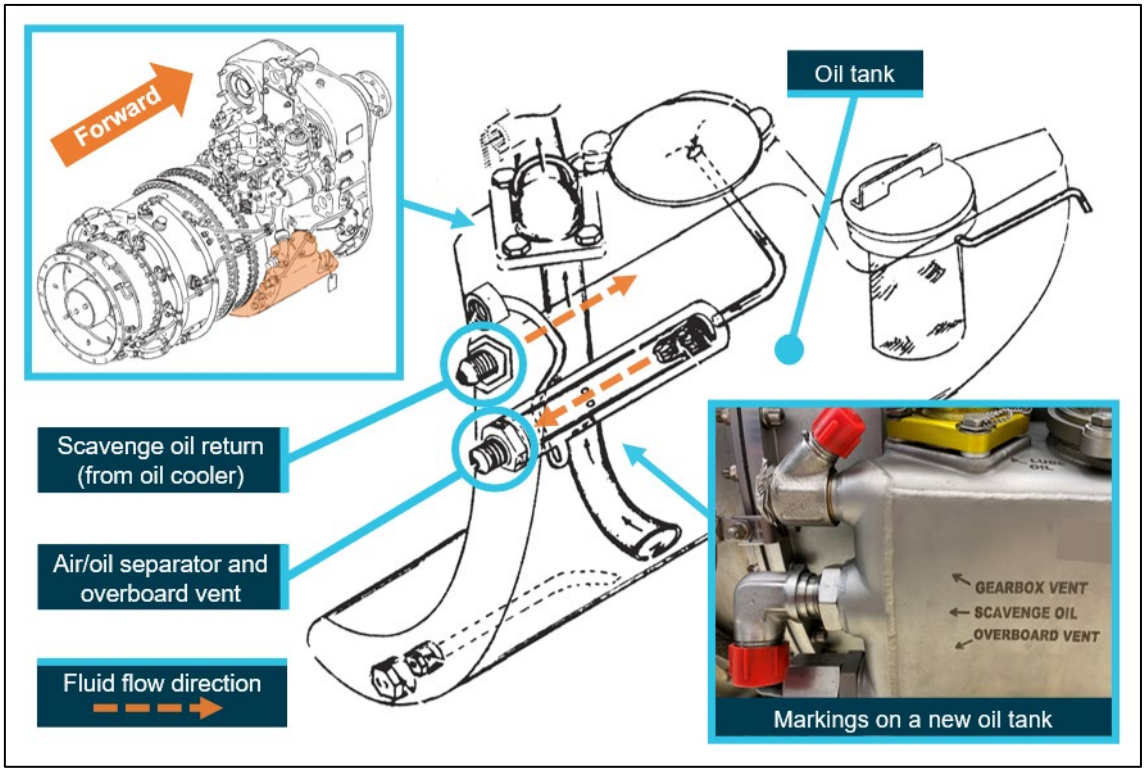
The air/oil separator was mounted inside the oil tank and consisted of a tube that contained a screen and several Teflon ribbons. Air/oil vapour returning to the oil tank passed through the air/oil

[2] Details of this flight, such as origin and destination, were not provided.

separator (where the oil vapour adhered to the Teflon ribbons) and, after coalescing, re-entered the oil supply. The remaining air was vented overboard.

When installed on a Cessna 441, separate flexible lines were attached to the air/oil cooler return and the air/oil separator. The lines were removed and installed using the same size spanner and the lines were typically long enough to reach both ports.

Figure 2: TPE331 oil tank assembly



Source: Honeywell, modified by the ATSB

Service information letter

In May 1990, the engine manufacturer published service information letter (SIL) P331-115 to advise maintenance and engineering personnel that the air/oil cooler return line and the air/oil separator vent line could be transposed. It stated:

> There have been several instances in the field where the lines attached to the oil tank were reversed. Specifically, the oil "scavenge return" line has been reversed with the "overboard vent" line. In this case, some of the teflon ribbons in the air-oil separator at the top interior of the oil tank have been forced into the oil tank by the greater pressure exerted by the scavenge return oil. The teflon ribbons may eventually pass from the oil tank through the pressure oil pump in the gearbox and on to the oil filter.

The SIL included 2 illustrations showing the correct orientation of the lines.

The SIL was revised in August 2022 (after the occurrence involving VH-JFU), adding a template for the reapplication of the oil tank markings. It also noted:

> Blockage of the air/oil separator from the collapsing teflon ribbons may result in severe damage to the gearbox scavenge pump, including fracture of the pump housing with a resultant loss of oil supply and pressure.

Operator requirements for engine changes

The operator conducted maintenance in accordance with its system of maintenance and the manufacturer's technical documentation. Technical documentation was produced by the

manufacturers of aircraft, engines, and components. Manufacturer documentation was also available from third-party providers.

Aircraft Technical Publishers (ATP) provided operators with an alternative source for maintenance information and was used by the operator for this purpose. The operator used the airframe and engine maintenance manuals for engine removal and installations. The engine removal and installation sections of these manuals correctly showed the orientation of the air/oil cooler return and the air/oil separator vent lines.

Effects of transposed oil lines

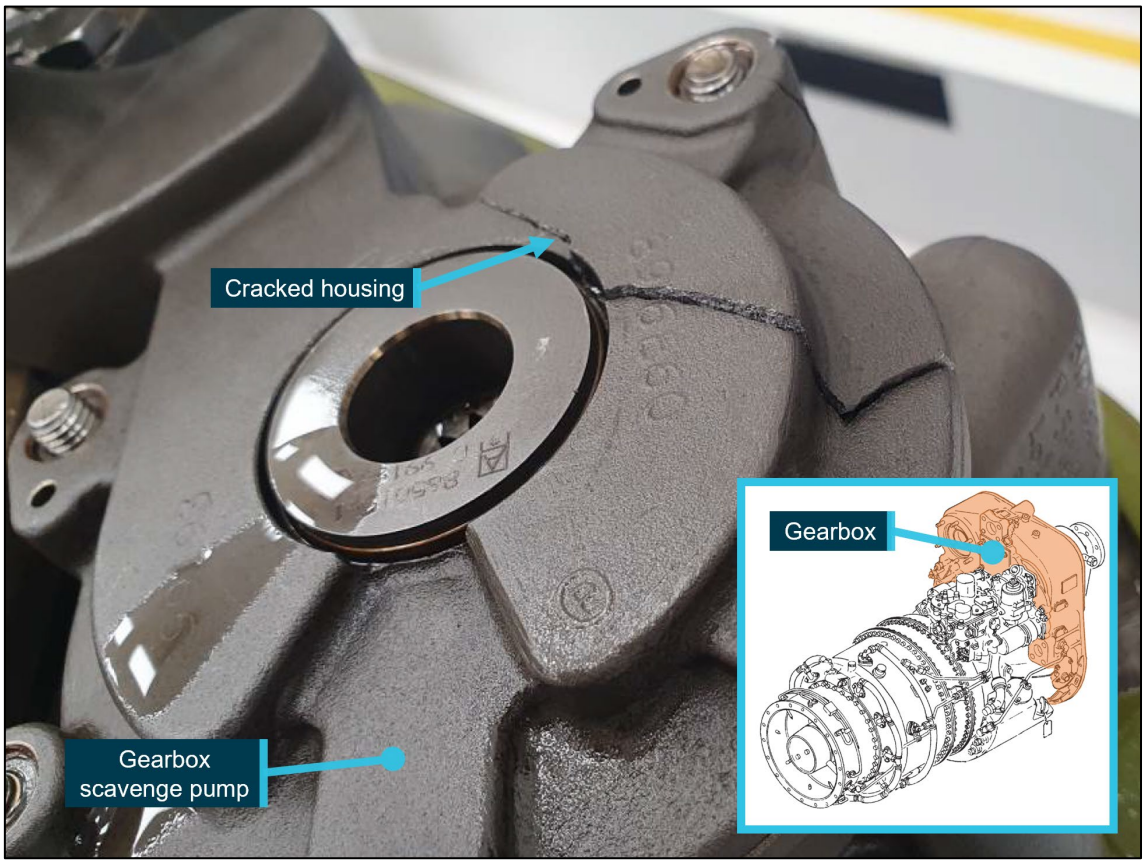
The engine manufacturer advised that flow reversal from the incorrect fitment of the air/oil cooler return line to the air/oil separator would have compacted the Teflon[3] ribbons inside the air/oil separator.

After the 28 September 2021 (second) occurrence involving VH-JFU's right engine, the operator's maintenance personnel consulted with an engine overhaul facility regarding the possible nature of the defect. The facility suggested the reduction gearbox scavenge pump may be unserviceable and provided a method to check its output pressure. When tested, the pump pressure was considerably lower than specification.

The engine was removed and sent to an overhaul facility. The engine was disassembled and the reduction gearbox scavenge pump housing was found to be cracked (Figure 3). The engine manufacturer advised the ATSB that the Teflon ribbons would have been compacted inside the air/oil separator following incorrect fitment of the air/oil cooler return line. This would have increased the reduction gearbox scavenge pump pressure and compromised the structural integrity of the pump housing.

[3] Teflon: a trade mark used for polytetrafluoroethylene (PTFE) and other fluoropolymers.

Figure 3: Cracked reduction gearbox scavenge pump housing



Source: TAE Aerospace and Honeywell, modified by the ATSB

The air/oil cooler return and the air/oil separator vent lines had been incorrectly transposed on other aircraft previously. Although the frequency of this is not known, a limited ATSB search of other occurrences did not identify any that led to a complete loss of power or an accident.

The engine manufacturer advised the ATSB that, as well as being detectable through visual inspection of the engine, an early symptom of this transposition occurring could be excessive engine oil venting out of the vent line. The engine manufacturer advised that, when there was no damage to the engine, this could be resolved by returning the lines to the correct configuration. However, if there was also a loss of reduction gearbox scavenge pump pressure, this might indicate damage to the air-oil separator and gearbox oil scavenge pump.

Safety analysis

Unintentional transposition of oil lines

When the right engine was fitted to VH-JFU, the air/oil cooler return and the air/oil separator vent lines were incorrectly transposed. The airframe and engine maintenance manuals correctly showed the orientation of the air/oil cooler return and the air/oil separator vent lines. Accordingly, there was sufficient accurate information available for engineers to be aware of the possibility of inadvertent oil line transposition.

As there was no record of which engineer had done the work, it was not possible to determine whether there were any individual or environmental factors associated with the error, or the extent to which the available maintenance documentation had been checked.

Memory of how to do specific tasks is not always reliable, especially for tasks that are not performed frequently. Ideally, the potential for this type of foreseeable error needs to be designed

out of the task or, if that cannot be practicably achieved, brought to the engineer's attention (through referral to instructions, diagrams, or other information) as the task is performed.

This type of error was possible because the 2 lines were flexible, and could reach (and be fitted to) both ports, which were adjacent to each other. The fittings were the same size, visually similar, and the same spanner would have been used to attach the lines. This presented a risk of the lines being transposed without hindrance. A limited review of occurrences did not identify any previous occurrences that led to in a complete loss of power or an accident.

The manufacturer had implemented controls that would help prevent this error occurring. These included markings showing the correct position of the lines, but they could wear off in service. The markings were not present on VH-JFU's engine oil tank at the time of the maintenance error and therefore there was no prompt to check the correct fitment. As a result, there would have been no clear indications of which way around the 2 lines should be fitted, and there was a risk of inadvertent transposition.

The engine manufacturer had identified this possibility of these lines being transposed and published a service information letter about it in 1990 and revised in 2022. Although there was no change to the oil tank design, so the possibility of transposition of the oil lines remained, the 2022 service letter included a template for the reapplication of its markings.

The error was not detected by the person carrying out the work or when the certifying engineer checked the engine installation prior to releasing the aircraft. The requirements to carry out an independent inspection did not include checking the oil lines.

Non-detection of engine damage

During the flights totalling 68 hours with the oil lines transposed, the right engine was damaged to an extent that later led to further engine malfunction. This damage was not initially detected during post-occurrence maintenance activities. Since this occurrence, the engine manufacturer added information to the existing service information letter to reduce this risk.

As non-normal configurations such as the oil cooler return line and the air/oil separator outlet line being transposed are generally not included in maintenance documents, operators and maintainers should seek technical advice from the manufacturer to ensure that non-routine problems are fully rectified prior to releasing the aircraft to service.

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 engine malfunction involving a Cessna 441, registered VH-JFU, 100 km north-east of Tindal Airport, Northern Territory, on 7 September 2021.

Contributing factors

- During the installation of the right engine, the oil cooler return line and the air/oil separator outlet line were transposed when attached to the oil tank.
- The oil cooler return and the air/oil separator outlet flexible lines could be easily transposed given that their fittings were adjacent to each other, of the same size, and visually similar. Additionally, as occurred in this case, their markings on the oil tank could wear off in service.

- The inspections carried out to check the newly-installed engine did not detect the incorrect transposition of the oil cooler return and the air/oil separator outlet lines.

Other factors that increased risk

- When the oil lines were returned to the correct position, the damage to the reduction gearbox scavenge pump housing was not detected and the aircraft was returned to service.

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 Chartair

After the occurrence, the operator:

- commenced a fleet-wide program to apply markings to the oil tanks on its Cessna 441 fleet
- conducted toolbox talks with engineering staff
- expanded the maintenance log entry requirements for engine changes.

Safety action by Honeywell

On 18 August 2022, Honeywell (the engine manufacturer) reissued service information letter (SIL) P331-115 about the potential transposition of the oil lines with additional information and guidance. Specifically, the manufacturer provided a template for the reapplication of the oil tank markings. It also noted:

> Blockage of the air/oil separator from the collapsing teflon ribbons may result in severe damage to the gearbox scavenge pump, including fracture of the pump housing with a resultant loss of oil supply and pressure.

The manufacturer also advised that it would revise the inspection/repair manuals with instructions to re-mark the engine oil tanks.

General details

Occurrence details

Date and time:	7 September 2021 – 09:00 CST	
Occurrence class:	Incident	
Occurrence categories:	Abnormal engine indications, Diversion / Return	
Location:	100 km north-east of Tindal Airport, Northern Territory	
	Latitude: 13º 53.500' S	Longitude: 133º 1.600' E

Aircraft details

Manufacturer and model:	Cessna Aircraft Company 441 (Conquest II)	
Registration:	VH-JFU	
Operator:	Chartair Pty Ltd	
Serial number:	441-0158	
Type of operation:	Charter-Passenger - (Charter)	
Activity:	Commercial Air Transport / Non-scheduled / Passenger transport charters	
Departure:	Sawfish Camp Aerodrome, Northern Territory	
Destination:	Darwin Airport, Northern Territory	
Actual destination:	Tindal Airport, Northern Territory	
Persons on board:	Crew – 1	Passengers – 9
Injuries:	Crew – 0	Passengers – 0
Aircraft damage:	Nil	

Sources and submissions

Sources of information

The sources of information during the investigation included the:

- aircraft operator
- aircraft manufacturer
- engine manufacturer.

References

Cessna Aircraft Company, *Model 441 Maintenance Manual*, chapter 71-00-03, 3 September 1984.

Garrett Airesearch, *Maintenance Manual TPE331-8/-9*, chapter 79-10-01, 31 July 1984.

Submissions

Submissions were received from:

- the aircraft operator
- the engine manufacturer.

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

Australian Transport Safety Bureau

About the ATSB

The ATSB is an independent Commonwealth Government statutory agency. It is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers.

The ATSB's purpose is to improve the safety of, and public confidence in, aviation, rail and marine transport through:

- 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, as well as participating in overseas investigations involving Australian-registered aircraft and ships. It prioritises investigations that have the potential to deliver the greatest public benefit through improvements to transport safety.

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

Purpose of safety investigations

The objective of a safety investigation is to enhance transport safety. This is done through:

- identifying safety issues and facilitating safety action to address those issues
- providing information about occurrences and their associated safety factors to facilitate learning within the transport industry.

It is not a function of the ATSB to apportion blame or provide a means for determining 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. The ATSB does not investigate for the purpose of taking administrative, regulatory or criminal action.

Terminology

An explanation of terminology used in ATSB investigation reports is available on the ATSB website. This includes terms such as occurrence, contributing factor, other factor that increased risk, and safety issue.