



Australian Government
Australian Transport Safety Bureau

Runway excursion involving ATR72, VH-FVY

Moranbah Airport, Queensland | 8 July 2013



Investigation

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Addendum

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Safety summary

What happened

On 8 July 2013, an Avions de Transport Regional ATR72-212A, operated by Virgin Australia Regional Airlines Pty Ltd (VARA) and registered VH-FVY, touched down at Moranbah Airport, Queensland. During the landing roll, the aircraft changed direction a number of times. At one point, the aircraft departed the right side of the runway. One passenger reported a minor injury. The aircraft was not damaged as a consequence of the runway excursion.

VH-FVY



Source: A. Zhao

What the ATSB found

During the landing roll, the rudder and nose wheel steering control inputs overcorrected the heading deviations, leading to the runway excursion. Furthermore, the positioning of the rudder pedals could have contributed to the captain inadvertently over-controlling the rudder to counter the aircraft yaw.

What's been done as a result

As a result of this occurrence, VARA released Safety Message SAM-ATR-004/13. The safety message advised pilots of the hazards associated with crosswind landings. In addition, VARA has included this scenario as part of its regular simulator training programme.

Safety message

This occurrence highlights the importance of the correct cockpit set-up and use of correct control inputs during the landing roll, especially at high speed. Correct positioning of primary flight controls can reduce the risk of inadvertent control inputs.

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The occurrence

On the morning of 8 July 2013, the crew of an ATR-GIE Avions de Transport Regional ATR72-212A (ATR72), registered VH-FVY and operated by Virgin Australia Regional Airlines Pty Ltd, commenced their tour of duty in Gladstone, Queensland. The crew were scheduled to fly from Gladstone to Brisbane, on to Moranbah and then back to Brisbane. The captain was the pilot flying¹ for the first two sectors.

During the flight to Moranbah, the crew obtained the current weather forecast. The forecast indicated a crosswind of about 15 kt (28 km/h) from the right at 110 °(M) on arrival. At 1108 Eastern Standard Time², the aircraft touched down on runway 34³ at 112 kt or 207 km/h airspeed (about 110 kt or 204 km/h ground speed). The aircraft was rolled slightly right by the crew to counter the crosswind. As the ground speed slowed through 100 kt, the crew felt the aircraft veer to the right. The aircraft was returned to the centre-line by the captain applying rudder input. As the aircraft reached about 80 kt the captain handed over the control yoke to the first officer while maintaining directional control with the nose wheel steering tiller. Shortly after, the aircraft turned right again and departed the runway. The captain regained directional control as the aircraft approached 20 kt (37 km/h) (Figure 1 and appendix A).

One passenger reported receiving a minor injury during the occurrence. That injury was consistent with a 'whiplash' from lateral acceleration.

Subsequent examination found no aircraft damage. Runway tyre marks associated with the landing showed that at least one of the right main landing gear wheels had departed from the runway.

Figure 1: Aircraft path along runway 34 during the landing roll

The aircraft's path during the touchdown and landing roll are derived from recorded flight data, and matched the runway tyre marks. The aircraft touched down in the correct location and the changes in direction did not start immediately. The aircraft had a number of larger changes in direction before slowing to taxi speed before the end of the runway.



Source: Google earth, modified by the ATSB

¹ Pilot flying (PF) and Pilot monitoring (PM) are procedurally-assigned roles with specifically-assigned duties at specific stages of a flight. The PF does most of the flying, except in defined circumstances; such as planning for descent, approach and landing. The PM carries out support duties and monitors the PF's actions and aircraft flight path.

² Eastern Standard Time (EST) was Coordinated Universal Time (UTC) + 10 hours.

³ Runways are named by a number representing the magnetic heading of the runway.

Context

Personnel information

The flight crew flew the aircraft from Brisbane to Gladstone on the previous afternoon. The aircraft and the flight crew remained at Gladstone overnight.

Captain

The captain had a total aeronautical experience of about 5,000 hours, of which about 4,500 hours was on the aircraft type. The captain reported being on duty for 4.5 hours at the time of the occurrence. They did not report any fatigue-related concerns associated with the occurrence flight.

First officer

The first officer (FO) had a total aeronautical experience of about 2,600 hours, of which about 1,800 hours was on the aircraft type. The FO also reported being on duty for 4.5 hours at the time of the occurrence. The FO did not report any fatigue-related concerns associated with the occurrence flight.

Aircraft information

Wheel braking system and tyre marks

The wheel brakes for each main landing gear are applied by pressing the top of the respective rudder pedal. This allows for differential braking across the aircraft.

The wheel brake system is designed to prevent the wheels from locking up in order to retain wheel brake effectiveness for slowing the aircraft. This is achieved through the following functions:

- Touchdown protection – this prevents activation of the wheel brakes until there is weight on the wheels after landing and:
 - either 5 seconds have elapsed
 - or the wheels have attained a rotational speed of 35 kt or more.
- Anti-skid protection – this operates on the wheels at speeds above 10 kt via the normal braking system. The system relieves brake pressure on wheels that have stopped rotating to the point of incipient wheel lock.
- Locked wheel protection – this protection operates on the wheels at speeds above 23 kt. If a wheel is rotating at less than half the speed of the corresponding wheel on the opposite side of the aircraft, the protection system relieves brake pressure on that wheel. This allows the slowing wheel to rotate faster and retain symmetrical deceleration.

Aircraft examination

After the occurrence and prior to departure from Moranbah, the aircraft was subjected to a range of engineering assessments. The assessments were nominated by the aircraft manufacturer to ensure the aircraft was serviceable. These checks found no evidence of damage to the aircraft as a result of the occurrence.

No defects or aircraft conditions were identified that could have contributed to the directional instability during the landing roll.

Meteorological information

The forecast and reported wind on arrival at Moranbah indicated a 15 kt crosswind from the right. This crosswind was well within the normal crosswind landing capabilities of the aircraft.

Airport information

Moranbah Airport is an uncontrolled airport with one runway, servicing regional airlines and local general aviation traffic. The runway was 30 m wide and 1,524 m long, which was adequate for a normal approach and landing in this aircraft.

The landing at Moranbah was the first landing of the day where it was necessary to apply crosswind landing technique.

Aircraft handling

Crosswind landing and deceleration technique

The aircraft landed at Moranbah with a crosswind from the right. The recommended ATR72 technique for a right crosswind landing involved the application of left rudder and a small amount of right roll. These control inputs aligned the landing gear with the direction of movement over the runway immediately before touchdown.

Once an aircraft touches down in a crosswind, the weathercocking effect of the fin is controlled by maintaining the applied rudder input. In this case, left pedal.

After touchdown, the aircraft is normally decelerated aerodynamically during the first part of the landing roll. This is done by adjusting the propeller pitch so that the propellers create high aerodynamic drag. Propeller pitch is adjusted symmetrically to support deceleration and is not used to provide directional control.

As the aircraft slows, the propeller aerodynamic drag becomes less effective and wheel brakes are progressively applied to achieve the desired rate of deceleration.

Directional control is initially maintained using rudder inputs. This method works well while the aircraft is moving fast enough for the rudder's aerodynamic forces to be effective. As the aircraft slows, directional control is maintained using steering inputs to the nose wheel. The steering inputs are controlled by the tiller in the cockpit.

Directional control during the landing at Moranbah

Shortly after touchdown, a small, quick rudder input was applied that made the aircraft turn slightly right. Following that, changes in direction were corrected by the application of full rudder that in each case initiated a rapid turn. As each turn was corrected, the rudder control input was not reduced until after the aircraft had reached the runway heading. At that point, opposite full rudder input was then applied, and the turn was reversed. After the initial turn, each subsequent turn was larger for the next three corrective turns as the aircraft slowed to taxi speed (see the section *Touchdown and rollout*).

During the third turn, the aircraft slowed through 80 kt. At that time, the captain relinquished control of the control yoke to the FO and then used the tiller to control the nose wheel steering. As the aircraft slowed further, the rudder became less effective for controlling the aircraft's direction. The captain reported sensing the rudder's decreasing effectiveness from the reducing force needed on the rudder pedals.

The two largest heading changes happened when the aircraft was at a speed where the rudder and the nose wheel steering were available to the captain. However, as the nose wheel steering control inputs are not recorded, it was not possible to determine which input had the greatest influence on controlling the aircraft's direction.

Flight recorders

Approach

Data obtained from the aircraft's flight recorder showed the control inputs immediately before touchdown at Moranbah. At that time, the aircraft was flying 3°–4° right wing-low and with 5°–10° left rudder applied. These control inputs changed the aircraft heading 1°–2° left to align the landing gear with the direction of movement over the runway (appendix A).

Touchdown and rollout

Recorded data indicated that neither brake was depressed during the touchdown sequence, although left rudder was being used.

Two seconds after touchdown, the left rudder input changed to a small right rudder input for less than 1 second. At the same time, a very small amount of right wheel brake pressure was applied. There was no indication that asymmetric wheel brake had a significant influence on directional control. The aircraft yawed right by less than 2°.

The right yaw was controlled by the application of full left rudder at 100 kt airspeed for about 2 seconds. The aircraft yawed left until beyond the runway centre-line.

Full right rudder was then applied at 90 kt airspeed, which stopped the left yaw. However, the aircraft then started a faster right yaw.

There was a momentary application of wheel brakes, with more brake pressure applied to the right landing gear. Again, there was no indication that asymmetric wheel brake had a significant influence on directional control. About 3 seconds later, after the aircraft had turned past the runway heading, full left rudder was applied at 80 kt airspeed. The right yaw was stopped after a 15° heading change.

During the next 4 seconds with full left rudder application, the aircraft yawed left through the runway heading. During this time, the aircraft continued right, departing the runway for a short period. The left wheel brake was increasingly applied until the aircraft passed through the runway heading. From then, symmetrical wheel braking was applied to the wheel brakes.

After the 4-second period and the aircraft had turned past the runway heading, rudder input was changed from full left to full right over 2 seconds at about 40 kt airspeed. The left yaw stopped after a 26° left heading change. The aircraft had slowed to about 40 kt ground speed by this time.

The aircraft then yawed 20° right as the aircraft slowed to a taxi speed. Full left rudder input was then applied and the left wheel brake pressure increased while the right wheel brake pressure reduced to zero.

Engine power was applied symmetrically to both engines throughout the landing sequence.

Tests and research

Tyre marks

An examination of the runway tyre marks was carried out. Striation marks running in the same direction as the tyre marks indicated that the main wheels were braking. However, the tyres were approaching their limits of adhesion.

There was no evidence of any oblique striation patterns. This indicated that there was sufficient friction available to overcome the cornering forces exerted at the tyre/runway interface.

The darker edges on the outside of the turn indicated a shift of the weight to the outside of the tyres. There was no indication that any of the wheels locked up. This indicated the correct operation of the aircraft anti-skid system (Figure 2).

Figure 2: Runway tyre marks

The four tyre marks preceding the runway excursion were produced by the main landing gear. They indicated:

- *hard wheel braking was applied*
- *the braking did not exceed the limits of adhesion on any tyre*
- *the aircraft was turning left exerting more force on the outside-right of the tyre*
- *at least one wheel left the runway surface and rolled onto the adjacent grass.*



Source: Moranbah Airport, modified by the ATSB

Additional information

Rudder pedal position adjustment

The captain stated that the rudder pedal position was adjustable fore and aft and that he normally adjusted the rudder pedal position on the first flight in a particular aircraft. This meant that normally the rudder position needed to be adjusted forward to suit his size.

The captain's preferred rudder pedal position enabled rudder control inputs using the heel of his feet with his feet in a natural position. The captain reported that in this position he operated the rudder with his heels off the floor. This ensured that inadvertent force would not be applied to the top of the rudder pedal by the balls of the feet. When the captain operated the wheel brakes, he moved the balls of his feet to the top of the rudder pedals.

The captain did not recall adjusting the rudder pedal position before departing Gladstone. However, the captain and first officer flew the aircraft on the day before and the pedals were likely still in the captain's preferred position after the flights that day.

Related occurrences

On 5 October 2005, an ATR72 that was operated by a different operator departed the runway during a landing roll at Queenstown Airport, New Zealand. In that incident, the aircraft touched down without incident, but was then exposed to a strong crosswind gust that exceeded the aircraft's maximum crosswind limit. The aircraft turned and continued its landing roll on the grass adjacent to the runway. Forecasts and observations at Queenstown immediately before the landing did not indicate the potential for a crosswind that exceeded the aircraft's maximum crosswind limit.

ATSB research reports AR-2008-018 (1) and (2)

In 2008, the ATSB produced two research reports related to runway excursions. One encompassed a worldwide review, and the other provided an Australian perspective. Between them, they identified a number of risks that can increase the likelihood of a runway excursion. The reports also identified tools for mitigating the risk. However, the identified risks were not relevant to this occurrence.

Safety analysis

Introduction

VH-FVY had a number of heading variations of increasing magnitude shortly after touchdown on runway 34 at Moranbah. The aircraft momentarily departed the runway before being recovered by the flight crew. This analysis discusses the factors that influenced the aircraft's directional stability during the landing, leading to a runway excursion.

Crosswind landing technique

The occurrence happened at the end of the second flight in a series of sectors by the same flight crew that day. The landing was the first landing of the day that required crosswind control input during the touchdown and rollout. The captain commenced applying the expected control inputs to manage a crosswind landing.

After touchdown, wheel brakes are not normally applied until the aircraft is first slowed by aerodynamic drag created by the propellers at higher landing speeds. However, small rudder control inputs are applied to maintain directional control at the higher speeds during the touchdown and initial rollout.

Directional control during the landing rollout

Following a small rudder input after touchdown, the captain applied a sequence of full rudder inputs to correct a number of heading changes during the landing roll. These inputs were initially applied at a high airspeed, when rudder forces are highly effective for turning the aircraft.

Directional control is primarily achieved by rudder and nose wheel steering as the aircraft slows. There were some short, asymmetric wheel brake applications during the landing roll. However, this would have a relatively minor effect on directional control, compared with the effectiveness of the rudder and nose wheel steering inputs.

The captain's rudder inputs were not reduced until the aircraft had reached the intended heading. The turns therefore overshot the runway heading for the next three corrections as the aircraft slowed.

Pilot induced oscillations occur 'when the pilot unintentionally commands an increasing series of control corrections in opposite directions...each one in an attempt to counteract the aircraft's response to the previous input' and result in an overcorrection in the opposite direction (Harris, 2011). They occur due to 'a mis-match between the frequency of the pilot's inputs and the response frequency of the aircraft' and '...are a product of a large response lag in the system...' (Harris, 2011). Management of such oscillations can be achieved through a number of strategies. These include varying the sensitivity of aircraft controls at the design stage as well as pilot training, which highlights the importance of not over controlling the aircraft.

As the aircraft slowed through about 80 kt airspeed, the captain followed normal procedures and used the tiller to control the aircraft's direction via nose wheel steering.

During the occurrence, directional control was not regained until the aircraft had reached a relatively low airspeed.

Rudder pedal adjustment

The captain normally checked and adjusted the rudder pedal neutral position to ensure the angle of his foot on the rudder pedals enabled unrestricted control of both rudder and wheel brakes. On the morning of the occurrence, the captain did not recall adjusting the rudder pedal position.

Despite this, there was no reason for the rudder pedal position to have been moved between the occurrence flight and the flights on the previous day. Those flights were operated by the same crew. Furthermore, an inappropriate rudder pedal adjustment would be expected to be detected during the flight control check performed before take-off. However, the captain recalled unusual muscular feedback when operating the rudder pedals during the occurrence flight. This recollection could be explained by the rudder pedal position being different than that normally applied by the captain, or by the rudder reaching its mechanical stops. A different rudder pedal position could have contributed to the captain inadvertently over-controlling the rudder to counter the aircraft yaw.

Findings

From the evidence available, the following findings are made with respect to the runway excursion involving ATR72-212A, registered VH-FVY, at Moranbah Airport, Queensland on 8 July 2013. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing factors

- Consistent with pilot-induced oscillations, the captain's rudder and nose wheel steering inputs overcorrected heading deviations during the landing roll.

Other findings

- The landing required crosswind control input, which was applied.

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.

Proactive safety action taken by Virgin Australia Regional Airlines Pty Ltd

As a result of this occurrence and Virgin Australia Regional Airline Pty Ltd's internal investigation, a safety alert message SAM-ATR-004/13 was promulgated internally that highlighted the risks associated with inadvertent application of wheel brake during touchdown.

Virgin Australia Regional Airline Pty Ltd also implemented a review of flight crew feet position during landing through its training staff and included training to manage the risks of runway excursions during landing in its training programme.

General details

Occurrence details

| | | |
|--------------------------|---|--------------------------|
| Date and time: | 8 July 2013 – 1109 EST | |
| Occurrence category: | Incident | |
| Primary occurrence type: | Runway excursion | |
| Location: | Runway 34, Moranbah Airport, Queensland | |
| | Latitude: 22° 08.38' S | Longitude: 148° 04.39' E |

Pilot details

| | Captain | First Officer |
|-------------------------|--|--|
| Licence details: | Australian Air Transport Pilot Licence (Aeroplane) | Australian Air Transport Pilot Licence (Aeroplane) |
| Endorsements: | ATR 42/72 | ATR 42/72 |
| Medical certificate: | Class 1 | Class 1 |
| Aeronautical experience | 5,000 hours | 2,600 hours |

Aircraft details

| | | |
|-------------------------|--|-----------------|
| Manufacturer and model: | Avions de Transport Regional ATR72-212A (or ATR72-600) | |
| Registration: | VH-FVY | |
| Operator: | Virgin Australia Regional Airline Pty Ltd | |
| Serial number: | 1073 | |
| Type of operation: | Air Transport High Capacity | |
| Persons on board: | Crew – 5 | Passengers – 55 |
| Injuries: | Crew – 0 | Passengers – 1 |
| Damage: | None | |

Sources and submissions

Sources of information

The sources of information during the investigation included:

- Virgin Australia Regional Airline Pty Ltd (VARA)
- the flight crew of VH-FVY
- a number of passengers
- the aircraft's Digital Flight Data Recorder.

References

Harris, D 2011, *Human performance on the flight deck*. Ashgate Publishing Ltd, Surrey, England.

Submissions

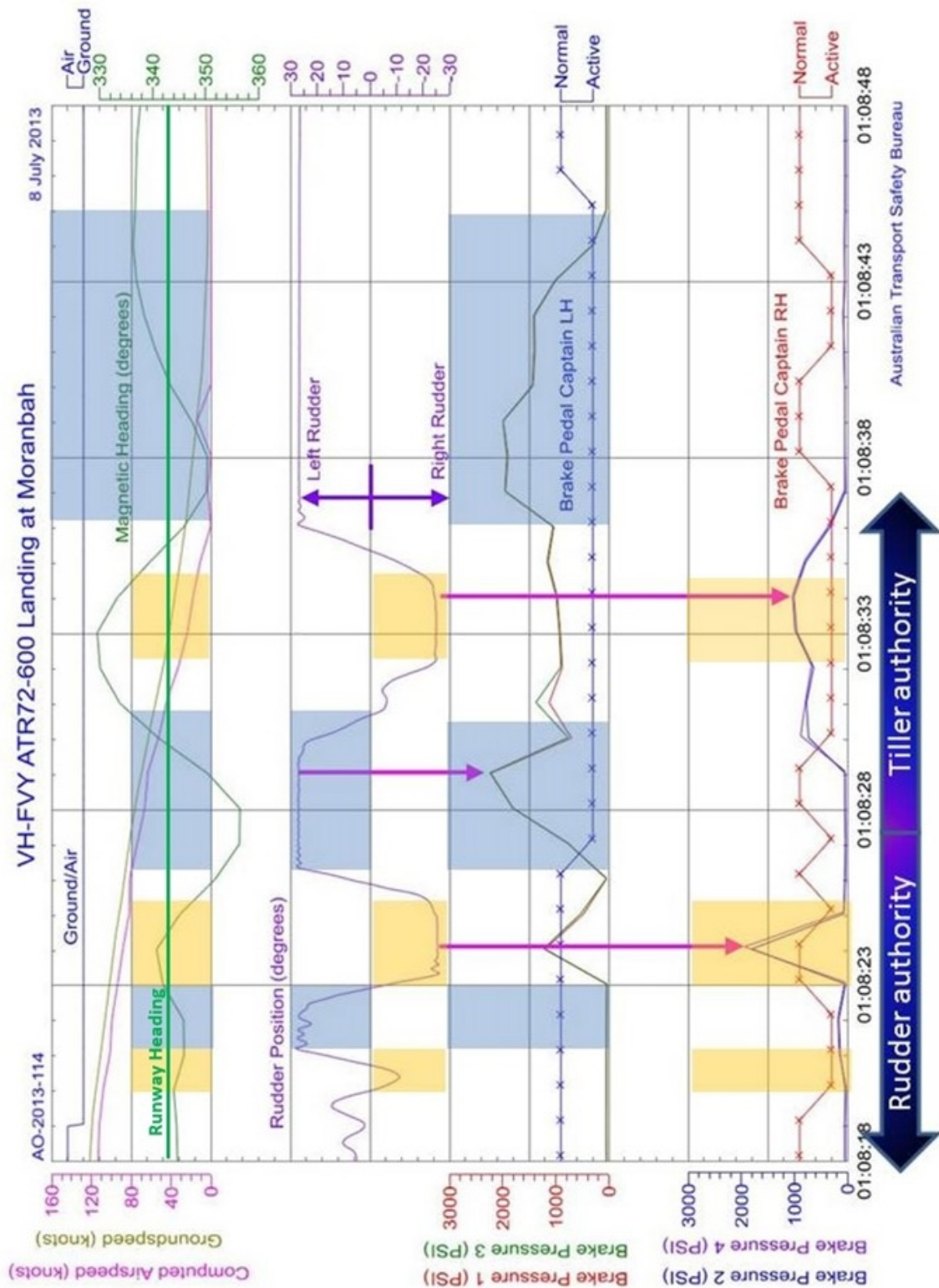
Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003*, the ATSB may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the flight crew, VARA, the Bureau d'Enquêtes et d'Analyses, ATR and the Civil Aviation Safety Authority.

Submissions were received from the flight crew, VARA and ATR. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

Appendices

Appendix A - Recorded flight data



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.

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Investigation

ATSB Transport Safety Report

Aviation Occurrence Investigation

Runway excursion involving ATR72, VH-FVY
Moranbah Airport, Queensland, 8 July 2013

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