Australian Government
Australian Transport Safety Bureau

Loss of control and forced landing involving Bell 206B3 helicopter, VH-ZMN

18 km north-east of Perth Airport, Western Australia | 19 January 2013

Investigation

ATSB Transport Safety Report
Aviation Occurrence Investigation
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Addendum

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Safety summary

What happened

VH-ZMN fuselage

Source: ATSB

On 19 January 2013, a Bell 206B3 helicopter was being operated on an aerial filming task over hilly terrain on the north-eastern outskirts of Perth, Western Australia. The weather was fine with east to north-easterly winds of 10 to 15 kt.

After hovering and manoeuvring at about 500 ft above ground level to allow the camera operator to record footage of a truck accident, the pilot conducted a right orbit to complete filming and depart the area. The pilot had initiated the turn when the nose of the aircraft moved left, then suddenly and rapidly to the right as the helicopter yawed and developed a rotation of about five revolutions.

The pilot regained some control close to the ground, but assessed that the performance of the helicopter was insufficient to avoid a forced landing. In an area with a number of obstacles the pilot selected a clearing and managed the available energy to perform a low-impact landing. The slope was such that the helicopter immediately rolled over with the engine still operating, but importantly for occupant survivability did not catch fire. The pilot and camera operator sustained minor injuries while the helicopter was seriously damaged.

What the ATSB found

The ATSB found that when the pilot turned to the right to commence the orbit, the helicopter was exposed to a crosswind from the left while at an airspeed around the 30 kt threshold value for susceptibility to loss of tail rotor effectiveness (LTE), precipitating an unanticipated right yaw and temporary loss of control. The pilot regained sufficient control for a forced landing, but he did not use full left pedal as recommended for loss of tail rotor effectiveness, resulting in a likely delay in recovery.

What's been done as a result

The helicopter operator advised that as a result of the accident they conducted an internal investigation and implemented a number of safety actions in relation to LTE training and aerial work guidelines. In addition, the camera operators were issued with flight suits and helmets, and the operator advised the television station of the option to fit an externally-mounted gimbal camera that would allow the camera operator to remain seated and permit left or right orbits during filming operations.

Safety message

Aerial photography from most helicopters at relatively low airspeed and height, over hilly terrain in variable winds, is a challenging task with an inherent risk of LTE. In those circumstances, where visual cues can be misleading, pilot attention to airspeed, height and orientation to local wind is critically important. And, as demonstrated in this occurrence, LTE can be preceded by momentary strong yaw in the opposite direction, a characteristic which is counter-intuitive and has the potential to be confusing for the pilot.

As well as understanding how LTE can occur, pilots should be familiar with the recommended recovery techniques and apply them immediately to the fullest extent possible in the situation.

Contents

The occurrence

On the morning of 19 January 2013, a truck driver was injured in a truck rollover on the north-eastern outskirts of Perth, Western Australia. Emergency services attended the site of the truck accident, including a rescue helicopter crew who landed on a private property nearby. Media personnel attended and one media organisation tasked their helicopter crew to conduct aerial filming.

The crew of the Bell 206B3 helicopter, registered VH-ZMN, comprised a pilot in the right front seat and a camera operator in the cabin behind the pilot. The camera was mounted on an overhead rail on the right side of the cabin and, for filming, the camera operator used an approved safety harness that allowed a degree of movement in the cabin.

The helicopter crew departed the television studio helipad at 1030 Western Standard Time[1] and tracked initially north-east in fine weather conditions. After a brief search, they arrived overhead the truck rollover at 1047.

To facilitate filming the pilot established a generally into-wind hover at an altitude of about 1,000 ft above mean sea level (Figure 1), which in that area of the hilly terrain was about 700 ft above ground level (AGL). Air traffic control initially cleared the pilot to operate the helicopter in the vicinity not above an altitude of 1,500 ft, but later reduced this clearance limit to not above 1,000 ft.

Figure 1: View of the accident site recorded from the helicopter in the hover

Source: Network Ten

From data recorded by the on-board global positioning system (GPS) receiver, it was derived that the pilot hovered for about 3 minutes, during which time the helicopter descended gradually to about 500 ft AGL. The wind in the hover was estimated from a number of sources to be from the east to north-east direction at about 10 to 15 kt, which correlated with the pilot's assessment at the time.

The pilot decided to give the helicopter a break from hovering and conducted a right orbit at slow speed around the scene. During the orbit the calculated height above ground level varied between 600 ft and 350 ft due to variations in helicopter altitude and elevation of the terrain. Based on a

[1] Western Standard Time (WST) was Coordinated Universal Time (UTC) + 8 hours.

constant easterly wind of 15 kt, the derived airspeed during the orbit reached a peak of 42 kt and averaged 30 kt.

Arriving back at the same side of the truck accident as the initial hover, the pilot adopted a hover at about 500 ft AGL. The camera operator recorded footage while the pilot allowed the helicopter to creep forward. After about a minute the pilot consulted with the camera operator and established that enough footage had been recorded from that position. The pilot then decided to depart the site via another right orbit at slow speed during which filming could continue.

The pilot initiated a right turn and, based on the recorded GPS data, the helicopter had reached somewhere between 20 and 30 kt airspeed at 500 ft AGL when the nose of the helicopter moved abruptly to the left (Figure 2). The pilot responded firmly with right pedal to correct at which point the helicopter suddenly and rapidly yawed to the right.

Figure 2: View of the accident site recorded from the helicopter immediately before the rapid right rotation (Note: camera zoom distorts the apparent height)

Source: Network Ten

The pilot reacted by neutralising the pedals and lowering collective (reducing engine torque) while trying to nose the helicopter over to pick up speed and regain control to fly away. The helicopter rotated about five times while descending at a calculated average of 275 ft/min, initially over rising terrain. During the descent the pilot sensed a performance loss associated with low main rotor RPM, but did not hear any audible warnings such as for engine failure or low main rotor RPM.

The pilot regained some control close to the ground (Figure 3), but assessed that the performance of the helicopter was insufficient to avoid a forced landing. In an area with a number of obstacles the pilot selected a clearing and managed the available energy to perform a low-impact landing in the vicinity of the truck rollover. The slope was such that the helicopter immediately rolled over (Figures 4 and 5) with the engine still operating, but importantly for occupant survivability did not catch fire. The pilot and camera operator sustained minor injuries while the helicopter was seriously damaged.

Figure 3: View from the vicinity of the truck accident, showing the helicopter after the pilot had regained some control and immediately before the forced landing

Source: Channel Nine

Figure 4: Helicopter rolling left after touchdown showing main rotor separation

Source: Channel Nine

Figure 5: Helicopter inverted before coming to rest on its right side

Source: Channel Nine

The crew exited the helicopter with minor injuries and were attended by the emergency services already at the scene. Although the helicopter was seriously damaged (Figure 6), the engine continued to run for a short time, before being shut down by the pilot.

Figure 6: Bell 206 accident site looking west with the truck accident site circled

Source: ATSB

Figure 7: GPS data representing the helicopter's track and height in vicinity of the accident site

Source: ATSB (Mapdata: Google Earth, DigitalGlobe)

Context

Pilot information

The pilot held a Commercial Pilot (Helicopter) Licence issued in 2006 and was endorsed on a number of helicopter types including the Bell 206B3. The pilot also completed low-flying training in 2006. At the time of the accident the pilot's total helicopter flying experience was 2,343 hours including 1,171 hours on the Bell 206 type.

The pilot's last proficiency check was a Line Check conducted by the operator's chief pilot in November 2012. In that simulation of a standard charter flight involving normal operations the pilot was recorded as competent.

Prior to the line check was a Base Check in May 2012. In that check the pilot was tested by one of the operator's check pilots in the conduct of Bell 206B3 normal and emergency procedures. The pilot was found to be competent in all of the elements tested and satisfactory overall.

While no record was kept of the specific emergency procedures encountered by the pilot during the check in May 2012, the operator and pilot reported that such annual checks typically included simulated emergencies such as loss of tail rotor effectiveness (LTE) and engine failures, including while operating at low level. Training records show that the pilot also practiced LTE recovery during flying training in 2007 and 2008.

The pilot recalled that during a flying training exercise in 2011 he was placed in a simulated aerial photography situation in a tailwind. At the time he recognised the risk of LTE and avoided a loss of control.

In addition to training, the pilot believed he had experienced LTE during aerial work operations and on those occasions allowed the helicopter to follow the right yaw tendency with almost immediate recovery. In no cases had the yaw been as rapid or as enduring as that experienced on the day of the accident.

The pilot held a Class 1 Medical Certificate valid until October 2013. He considered himself fit and healthy and post-accident drug and alcohol testing results were negative.

Weather reports

The pilot of the rescue helicopter responding to the truck rollover had landed about 500 m to the north of that site at 1008. On arrival in the area the pilot experienced gusty easterly winds and turbulence that resulted in a couple of missed approaches. Once on the ground the wind was generally from the east at 10 to 20 kt.

The closest weather observation site was at RAAF Base Pearce, 15 km to the north of the accident site. At 1000 and 1100, the recorded wind at Pearce was from the east at 11 kt.

Wreckage examination

The ATSB attended the accident site and conducted a preliminary examination of the wreckage. The operator then moved the wreckage to a secure location where the ATSB examined it in more detail with the assistance of the operator's maintenance personnel.

The examination covered the relevant cockpit warning systems, engine fuel control system, rotor drive systems and flight controls. No defects or anomalies were identified.

Operator information

The helicopter operator contracted the helicopter and pilot to the media organisation, and as such, was responsible for the requisite operational approvals. In addition to the standard operating approvals, the operator was approved by the Civil Aviation Safety Authority to conduct aerial photography including permission to operate at heights lower than the regulations ordinarily allowed.

That low-flying permission was subject to a number of conditions including suitable pilot training and performance of the aerial work activity in accordance with the applicable sections of the company's operations manual. The operations manual contained procedures specific to aerial photography with reference to aircraft configuration, planning and flying techniques. No minimum height or airspeeds were specified.

Relevant operational data

In 1983 the helicopter manufacturer issued Operations Safety Notice 206-83-10 to provide supplemental operating and emergency procedures. The notice informed operators that flight testing had shown that variants of the Bell 206, including the B3, could be subject to unanticipated right yaw (also known as LTE) unrelated to a mechanical malfunction and provided recommended recovery techniques.

In 1984 the helicopter manufacturer issued Information Letter 206-84-41 to extend the applicability of the operations safety notice to include the Bell 206L series helicopters. The letter referred to US Army experience of a similar helicopter type and described the low speed flight characteristics that could result in unanticipated right yaw and provided recommended recovery techniques.

In 1995 the US Federal Aviation Administration issued Advisory Circular 90-95 to address unanticipated right yaw in helicopters generally and recommended recovery techniques and considerations.

All three publications, that were publicly available, recommended that if a sudden unanticipated right yaw occurred, the pilot should apply full left pedal and move the cyclic forward to increase speed. Further action, if altitude permitted, was a reduction of power.

Accident data

A search of the ATSB database for relevant occurrences in the last 10 years yielded 14 occurrences where loss of control was attributed to LTE. Of those, five involved Bell 206 series helicopters which were engaged in either private, charter or fire control operations.

The other helicopter types appearing in the search results were Hughes 369, Robinson R22 and Robinson R44. Two of the three R44 occurrences involved aerial filming.

Safety analysis

Introduction

The pilot lost control of the helicopter during a turn when it yawed initially left then suddenly and rapidly to the right, and continued to rotate for about five revolutions. In spite of the pilot's efforts to recover control, by the time the pilot regained some control the helicopter was close to the ground. In an area with a number of obstacles the pilot selected a clearing and managed the available energy to perform a low-impact landing. The slope was such that the helicopter immediately rolled over with the engine operating, but importantly for occupant survivability did not catch fire. This analysis will identify the factors in the loss of control and consequent forced landing.

Loss of directional control

In a helicopter with a single main rotor being driven in an anticlockwise direction (from above), such as the Bell 206B3, there is a torque reaction that acts to rotate the fuselage in the opposite, clockwise direction. That torque reaction, producing a right yaw (nose right) effect, is countered by tail rotor thrust that is designed to act on the tail to generate a left yaw (nose left) effect. In normal operations the pilot is able to maintain directional control through the anti-torque pedals that change the pitch, and consequently the thrust produced by the tail rotor. This control is supplemented during forward flight by a vertical fin on the tail boom.

Loss of tail rotor effectiveness

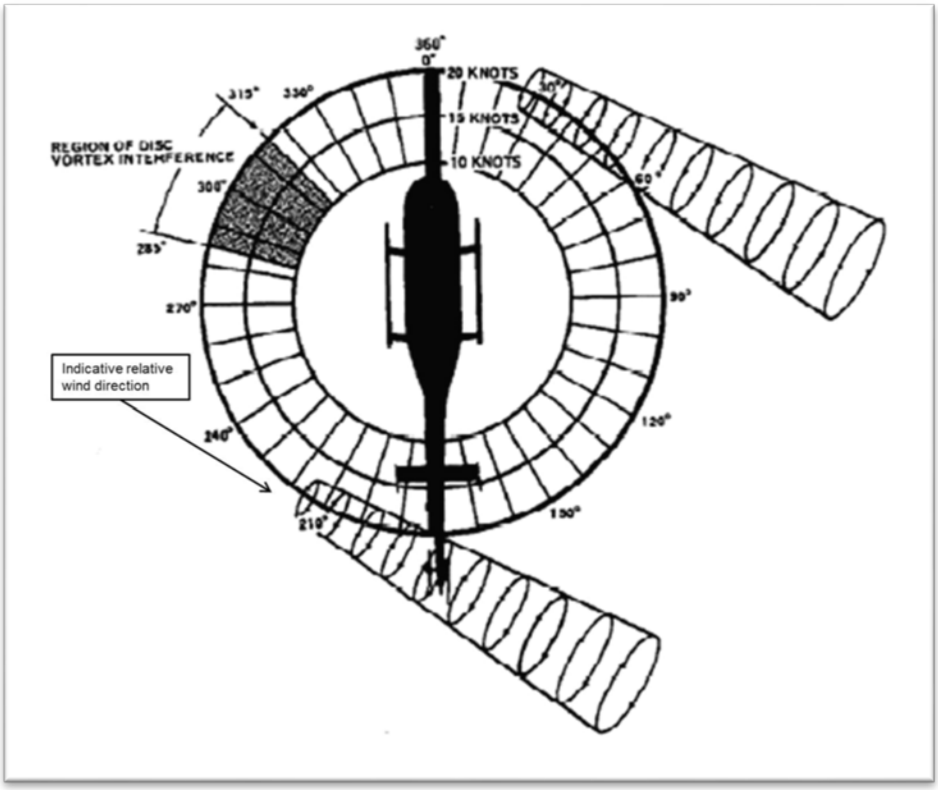
In this event involving a Bell 206B3 in powered flight, the unanticipated yaw to the right was symptomatic of the main rotor torque reaction rotating the fuselage in the sudden absence of the countering effect of tail rotor thrust. This rapid loss of tail rotor thrust can occur as a result of a tail rotor system failure or a particular combination of aerodynamic factors. Given no defects were identified in the tail rotor system and the pilot managed to regain some control late in the sequence, the loss of tail rotor thrust was attributed to the aerodynamic condition known as loss of tail rotor effectiveness (LTE).

This occurs at airspeeds below 30 kt, where the main rotor is generally less efficient and requires more engine power and consequently, more anti-torque thrust from the tail rotor. Also, at low airspeeds the vertical fin is less effective and directional control more reliant on thrust from the tail rotor. In this situation, if the helicopter is exposed to a crosswind of between 10 and 30 kt from the left, airflow through the tail rotor will likely be unsteady, thrust variable, and directional control difficult. Tailwinds from either quarter can also affect directional stability by acting on the tail and fuselage to accelerate yaw rates in either direction.

It is likely that as the pilot manoeuvred the helicopter into the right turn, exposing it to a left quartering crosswind of at least 10 to 15 kt, some of the main rotor vortices disturbing the airflow were blown into the tail rotor to increase thrust momentarily and generate the left yaw experienced by the pilot (Figure 8). As the pilot corrected with right pedal, the main rotor vortices probably passed through the tail rotor with the effect of immediately reducing tail rotor thrust and accelerating the right yaw. This reversal of yaw surprised the pilot and developed into a number of rotations.

It was also surprising to the pilot because he had not previously experienced unanticipated right yaw of the severity or duration evident on this occasion. In addition, the pilot had already completed a right orbit in apparently similar circumstances without any difficulty and at the time had no reason to suspect that a second orbit would present any difficulties.

Figure 8: Main rotor disc vortex interference



Source: US Federal Aviation Administration

By applying a steady easterly wind of 15 kt to all of the recorded global positioning system groundspeeds and tracks, the ATSB estimated airspeeds of 26 and then 28 kt at the likely point of entry to the second orbit. In contrast, the estimated airspeeds at the comparable part of the first orbit were 38 and then 43 kt. Changing the wind direction value in the calculations to be from the east-north-east did not have a significant effect on these figures. Acknowledging that the actual winds would have been variable, the airspeeds on entry into the second orbit were comparatively 10 kt lower than those in the first.

Based on the available information, the airspeed entering the second orbit was probably around the threshold value for susceptibility to LTE, which in the wind conditions at the time was influential in the development of the loss of control. Control of airspeed during low-speed, low-level operations is necessarily more reliant on visual cues outside the cockpit than on monitoring of the airspeed indicator. In this case the pilot misjudged the airspeed from the apparent groundspeed, possibly as a result of a focus on positioning for the aerial filming task.

Response to and recovery from loss of tail rotor effectiveness

The time required to recover from LTE depends on a number of variables including the magnitude of the initial yaw rate and subsequent pilot control inputs. Although the circumstances of each LTE event and recovery will be different, the helicopter manufacturer advised that recovery could be expected to be achieved within two to three revolutions.

On this occasion, the rate of right yaw was severe and the scope of pilot control inputs was constrained by the minimal height of the helicopter above the terrain. Any lowering of collective to reduce the main rotor thrust and consequently torque reaction that was driving the fuselage rotations would have increased the rate of descent and further reduced the already marginal terrain clearance.

With limited scope available for favourable collective input, the pilot was reliant on cyclic input to tilt the rotor in an effort to generate forward speed, and left pedal input to generate tail rotor thrust in opposition to the rotation. The pilot advised that he applied the appropriate cyclic input and neutralised (centred) the pedals. This pedal configuration, the pilot explained, was consistent with his training that generally sought to avoid the power demand that would occur with full left pedal. In a situation where the pilot sensed degraded performance that he associated with low main rotor RPM, the intention was to maximise the power available to the main rotor.

It is evident that the pilot's response to the loss of directional control was influenced by a combination of factors that perplexed the pilot at the time such as the preceding trend of left yaw, and a more severe right yaw and perception of degraded performance compared with his training and prior experience of uncommanded right yaw. The pilot's sense of degraded performance gave the feel of low main rotor RPM, although there were no associated warnings and audible indications of that condition.

The pilot responded with control inputs and regained sufficient control to carry out a forced landing, but did not apply full left pedal as recommended for loss of tail rotor effectiveness, resulting in a likely delay in recovery.

Operational safety considerations

The Bell 206B3 flight manual did not include any reference to LTE, and there was no evidence it was required to do so. In that absence, pilots could refer to the supplemental operating and emergency procedures published by the manufacturer in 1983 and 1984, and to the advisory circular published by the US Federal Aviation Administration in 1995. Those documents address the issue of LTE, but it is not clear how well distributed and understood they are in the contemporary Australian context.

Irrespective of LTE documentation and its availability, the pilot demonstrated an understanding of LTE, especially as it related to the Bell 206 helicopter type. This was primarily influenced by the training provided by the operator and experience in the Bell 206 of at least incipient LTE.

The operator was approved by the Civil Aviation Safety Authority for low-level aerial photography subject to a number of conditions, including that such operations be conducted in accordance with the operator's procedures. The applicable procedures addressed some low-flying risks and required that for operations at less than 500 ft above ground level the pilot was to hold a low-level approval authorised by the chief pilot.

The operator's procedures did not specifically address LTE or stipulate any minimum airspeed while manoeuvring at low level. However, this was compensated for by training in emergencies at low level including LTE, and by promotion of a 'not below 30 kt when below 500 ft' informal company policy.

In August 2011, the operator conducted a risk assessment of their media operations and identified LTE, among others, as a hazard. Although this risk was recorded as reduced by aircraft currency and role-specific training, those controls were not effective in this instance.

Aerial photography from a helicopter at relatively low airspeed and height and over hilly terrain in variable winds is a challenging task that has elevated risk of LTE. In those circumstances, where visual cues can be misleading, pilot attention to airspeed, height and orientation to local wind is critically important. This occurrence also demonstrates that LTE can be preceded by momentary strong yaw in the opposite direction, a characteristic which is counter-intuitive and has the potential to be confusing.

The pilot was wearing a helmet and fire retardant clothing, but the camera operator was not wearing either elements of personal protective equipment. This exposed the camera operator to increased risk of incapacitating injury and the flash effects of any post-impact fire.

Findings

From the evidence available, the following findings are made with respect to the loss of control involving Bell 206B3, registered VH-ZMN that occurred 18 km north-east of Perth on 19 January 2013. They should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing factors

- During low-level aerial filming, the helicopter was exposed to a crosswind from the left while at an airspeed around the 30 kt threshold value for susceptibility to loss of tail rotor effectiveness, precipitating an unanticipated right yaw and temporary loss of control.
- The pilot responded with control inputs and regained sufficient control to carry out a forced landing, but did not apply full left pedal as recommended for loss of tail rotor effectiveness, resulting in a likely delay in recovery.

Other factors that increase risk

- The camera operator was not wearing a helmet or fire retardant clothing, increasing the risk of injury and associated difficulty of egress.

Other findings

- The pilot persisted with his attempts to recover from the loss of control and managed to recover sufficiently to land the helicopter in a clearing on sloping ground without serious injury to the occupants.

Safety issues and actions

The ATSB did not identify any organisational or systemic issues that might adversely affect the future safety of aviation operations. However, the following proactive safety action was reported in response to this occurrence.

Proactive safety action

Operator

The helicopter operator advised that as a result of this accident they conducted an internal investigation and implemented the following safety actions:

- a training package was developed on loss of tail rotor effectiveness (LTE) and presented to all single-engine helicopter pilots
- a training package was developed for all of the operator’s other aircraft types covering relevant characteristics
- all of the operator’s pilots were refreshed on specific aerial work instruments issued by the Civil Aviation Safety Authority
- the pilot involved in the accident was debriefed on the internal investigation outcomes and completed a ground and flight training package relevant to LTE
- all camera operators were issued with flight suits and helmets
- the television station was provided with costings on the utilisation of a gimbal-mounted camera to allow the camera operator to remain seated during filming and provide options of both left- and right-hand orbits.

General details

Occurrence details

Date and time:	19 January 2013 – 1053 WST	
Occurrence category:	Accident	
Primary occurrence type:	Loss of control	
Location:	18 km north-east of Perth Airport, Western Australia	
	Latitude: 31° 47.99’ S	Longitude: 116° 03.85’ E

Aircraft details

Manufacturer and model:	Bell Helicopter Company 206B3	
Registration:	VH-ZMN	
Serial number:	3591	
Type of operation:	Aerial work – aerial photography	
Persons on board:	Crew – 1	Passengers – 1
Injuries:	Crew – minor	Passengers – minor
Damage:	Substantial	

Sources and submissions

Sources of information

The sources of information during the investigation included:

- the pilot and operator of VH-ZMN
- Bell Helicopter
- Bureau of Meteorology
- local television stations.

References

Federal Aviation Administration, 26/12/1995, *Advisory Circular 90-95 Unanticipated Right Yaw in Helicopters*, FAA, Washington D.C.

Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003* (the Act), the Australian Transport Safety Bureau (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 pilot and operator of VH-ZMN, Bell Helicopter, the Civil Aviation Safety Authority (CASA) and the media organisation contracting the helicopter for aerial filming. Submissions were received from Bell Helicopter, the pilot and operator of VH-ZMN and CASA. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

Australian Transport Safety Bureau

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

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

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Investigation

ATSB Transport Safety Report
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