Australian Government
Australian Transport Safety Bureau

Loss of control involving Robinson R44 helicopter, VH-COK

Jaspers Brush Aerodrome, New South Wales | 4 February 2012

Investigation

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Published by: Australian Transport Safety Bureau
Postal address: PO Box 967, Civic Square ACT 2608
Office: 62 Northbourne Avenue Canberra, Australian Capital Territory 2601
Telephone: 1800 020 616, from overseas +61 2 6257 4150 (24 hours)
Accident and incident notification: 1800 011 034 (24 hours)
Facsimile: 02 6247 3117, from overseas +61 2 6247 3117
Email: atsbinfo@atsb.gov.au
Internet: www.atsb.gov.au

Safety summary

VH-COK early in the lift off

Source: David Bennett

What happened

At about 1555 Eastern Daylight-saving Time on 4 February 2012, a Robinson R44 helicopter, registered VH-COK, lifted off from Jaspers Brush Aerodrome, New South Wales for aerial photography of the launching of a deep sea submarine in nearby Jervis Bay. On board the helicopter were the pilot and a camera operator.

Soon after lifting off the pilot's door opened and the pilot reached out to close the door. Simultaneously the helicopter abruptly pitched nose-up then steeply nose-down, rolling to the right before the right landing gear skid and main rotor blades struck the ground. A fuel-fed fire started in the vicinity of the fuel tanks and lower mast area prior to the helicopter coming to a stop. Both occupants were fatally injured and the helicopter was destroyed.

What the ATSB found

The Australian Transport Safety Bureau (ATSB) found that the pilot's door was not properly latched prior to lift off and opened during the turn to depart. In attempting to shut the door the pilot probably let go of the cyclic control from the normal (right) control hand, allowing for an unintended, abrupt nose-up pitch and the helicopter tail hitting the ground. The helicopter nosed over and impacted the ground. A fire began when one of the fuel tanks was breached.

The ATSB identified that the fatal injuries were due to the post-impact fire, as was the case in a number of other R44 accidents. A number of these R44s, including VH-COK, had not and were not yet required to have been modified in accordance with a manufacturer service bulletin that specified replacement of aluminium fuel tanks with more impact-resistant bladder-type fuel tanks. The installation of these tanks decreased the risk of a post-accident fire. At the time of the accident, these tanks were required to be fitted by 31 December 2014.

What's been done as a result

In response to this and a number of other fatal accidents in other R44 helicopters, the Civil Aviation Safety Authority (CASA) and the ATSB have separately highlighted the benefits of the upgraded bladder-type fuel tank and related modifications to operational and maintenance personnel. In addition, the helicopter manufacturer has progressively reduced the compliance time on service bulletin SB-78 in respect of the installation of the bladder-type fuel tanks to 30 April 2013. A second bulletin aimed at removing a possible impact-related ignition source was also issued and the manufacturer is issuing advisory information emphasising the importance of maintaining control of the helicopter during an unexpected event.

Safety message

This accident highlights the importance of ensuring all doors are secured prior to takeoff. That said, the opening of a door in flight will not normally affect the operation of an R44, but the instinctive reaction to immediately deal with such an event can be quite strong. Pilots need to be aware that this reaction may be hard to overcome and in the event of an unexpected situation occurring such as the opening of the door, it is vital that pilots should continue to 'fly the aircraft'. This includes choosing to land to close the door if necessary. The fitment of bladder-type fuel tanks to R44 helicopters is a worthwhile safety enhancement that could save lives and advice from CASA is that their installation in accordance with the manufacturer's service bulletin by 30 April 2013 is mandatory.

Contents

The occurrence

On 4 February 2012, the pilot of a Robinson R44 Raven II helicopter, registered VH-COK, flew from Wedderburn Aerodrome to Jaspers Brush Aerodrome, New South Wales (NSW) in preparation for an aerial photography flight. The purpose of the aerial photography was to record the launching of a manned deep-sea, submersible vehicle from a ship in Jervis Bay for a television documentary. The flight to Jervis Bay, about 26 km from Jaspers Brush, was to be conducted as a private operation under the visual flight rules. The local weather was fine, with high cloud and a slight easterly breeze.

On arrival at Jaspers Brush the right rear door and some non-essential equipment were removed from the helicopter in preparation for the flight. The pilot and camera operator then conducted a short flight in the local area to prepare for the photography later that day.

At about 1550 Eastern Daylight-saving Time[1], personnel on the ship sent a telephone message to the helicopter crew informing them that preparations had been completed and filming could commence. Witnesses stated that the pilot had previously assessed that he required about 12 minutes to get to Jervis Bay once all was ready. The pilot and camera operator boarded the helicopter, with the pilot in the right front seat, and the operator holding a portable stereo camera, in the right rear seat. The helicopter had sufficient fuel for the planned flight and the aircraft was within both longitudinal and lateral centre of gravity limits.

The pilot lifted off from the grassed surface at about 1555 with a number of flight instructors and students watching. One witness made a video recording of the flight.

After establishing the hover, the pilot turned the helicopter about 90° left to depart in the approximate direction of Jervis Bay (Figure 1). During the turn for departure, the pilot's door opened about halfway (Figure 2).

Figure 1: Helicopter hovering prior to turning left and commencing departure[2]

Source: David Bennett

[1] Eastern Daylight-saving Time was Coordinated Universal Time (UTC) + 11 hours.

[2] Image taken from the witness video.

Figure 2: Pilot's door (arrowed) open as helicopter turned left

Source: David Bennett

About 5 seconds after lift-off, at about 10 feet above ground level, the helicopter abruptly pitched nose-up and moved backwards with the tail skid striking the ground (Figure 3). One witness, who was positioned close to the helicopter at the time, indicated that as the helicopter turned and the pilot's door opened he saw the pilot extend an arm and grab the door in an apparent attempt to close it. The witness reported that at the same time as the pilot's arm was seen, the helicopter pitched up.

Figure 3: Helicopter pitched up with the tail skid contacting the ground

Source: David Bennett

The helicopter then rapidly pitched steeply nose forward and rolled to the right, before the front of the right skid and both main rotor blades contacted the ground (Figure 4).

Figure 4: Helicopter pitched nose-down with the front of the right skid contacting the ground. Note pilot's door closed in toward the fuselage

Source: David Bennett

After this point, the recording of the accident was incomplete as the witness rapidly moved away from the helicopter due to airborne debris. However, the recording showed that a fuel-fed fire started in the vicinity of the fuel tanks and lower main rotor mast area as the right landing gear skid and main rotor contacted the ground (Figure 5), rapidly spreading to the cabin and cockpit areas. This preceded the right side of the fuselage contacting the ground at a relatively low speed. The helicopter was seriously damaged[3] and both occupants were fatally injured.

Figure 5: Fire in the lower main rotor mast area of the helicopter (indicated by yellow arrow). Note main rotor damage and flying turf and other debris from the ground impact

Source: David Bennett

3 The *Transport Safety Regulations 2003* definition of 'serious damage' includes the destruction of the transport vehicle.

The video recording showed no fuel spillage or fire prior to the rotor blades impacting the ground, and no indication of any abnormal engine operation or other sounds prior to impact.

Consistent with several witness reports and corroborated by the video recording, there was no indication that the aircraft hit, or was struck by anything prior to pitching up. Witnesses reported no abnormal engine or other sounds prior to impact.

Witnesses reported seeing fuel spray up around the main rotor on impact and fire rapidly engulf the fuselage. Several witnesses reported that they attempted to extinguish the fire with fire extinguishers that were available adjacent to the accident site; however, due to the size and intensity of the fire, they were unable to reach the occupants.

Context

Medical and pathological information

Post-mortem examination of the pilot did not reveal any evidence of a physiological condition that would have contributed to the occurrence. The examining pathologist identified that the fatal injuries sustained by the pilot and passenger were due to the post-impact fire. The report indicated that neither occupant had alcohol or drugs present.

Maintenance information

Examination of the helicopter's maintenance records indicated that it was maintained in accordance with the engine and helicopter manufacturers' requirements and no outstanding maintenance requirements were noted.

The helicopter's last 100-hourly servicing was completed on 9 September 2011. As part of that servicing, the hydraulic servos were repaired and reinstalled. Two rubber engine mounts were also replaced.

The last scheduled maintenance was a 50-hourly inspection that was completed on 6 January 2012. During that inspection, no major defects were identified or required rectification.

Cockpit and cabin doors

The helicopter's door configuration was typical of an R44 and consisted of four removable doors. Door(s)-off operations were approved and quick-release pins allowed easy removal when required.

Gas spring units are fitted to the inside front of each door to hold the doors open for ease of entry and exit and to prevent damage to the doors if they suddenly open on the ground due to the effects of main rotor operation (downwash) or a gust of wind. On the front doors, the gas spring units are attached to an over-centre mechanism that assists in closing the door against the door frame as the door approaches the closed position. Once the door is against the frame, it remains there under gas spring pressure, even though the door may not be securely latched to the door frame. During door opening, the gas spring assists to hold the door in the open position once the mechanism moves past its centre position.

Each door has a latching mechanism operable from the inside or outside of the helicopter. The pilot's door latching mechanism consists of a horizontal (fore/aft) sliding rod situated inside the door. The rod incorporates a looped interior operating handle and a pointed rear end that engages a hole in the door frame. A separate, vertically-oriented rod attaches to the rear of the horizontal rod, via a sliding joint. That rod acts as a secondary latching mechanism, with the top of the rod engaging into a hole in the upper door frame.

To securely latch the door from inside the helicopter, the pilot performs a dual action. First, the horizontal rod is moved to its fullest extent rearward using the looped handle (Figure 6). That movement engages the pointed end of the rod into a hole in the door frame. Once fully rearward, subsequent rotation of the looped handle in a downward direction (arc) moves the vertically-oriented rod upward about the sliding joint and engages into the upper door frame.

Once both rod ends are fully engaged in the door frame, a 'box' spring attached to the internal door structure acts in concert with a nylon cam on the horizontal rod, to keep the looped door handle securely down against the door's inner surface. That prevents inadvertent unlatching of the door lock assembly in flight due to vibration and provides a visual cue that the door is closed and latched.

Figure 7 shows the looped door handle in the unlatched position.

Figure 6: Exemplar R44 pilot's door from the inside showing the looped operating handle fully to the rear and rotated to the down and latched position

Source: ATSB

Figure 7: Exemplar R44 pilot's door from the inside showing the looped handle in the unlatched (fully forward) position

Source: ATSB

A short lever is welded to the opposite side of the horizontal rod to the looped handle and projects on the outside of the door and into an L-shaped slot. This lever allows the door to be opened and closed from the outside of the helicopter, and the L-shaped slot governs the overall travel of the latching mechanism.

Flight controls

The flight controls in an R44 Raven II helicopter control the pitch angle of the main rotor and tail rotor blades through mechanical linkages. The cyclic control, typically operated by the pilot's right hand, varies the angle of each main rotor blade individually to tilt the main rotor disc and control the attitude of the helicopter. Pilot movement of the hand grip on the cyclic control is transferred via an arm to a centrally-mounted control column (Figure 8).

Figure 8: Exemplar R44 cockpit flight controls showing the cyclic column (red arrow) and right grip and the tail rotor pedals (blue arrow)

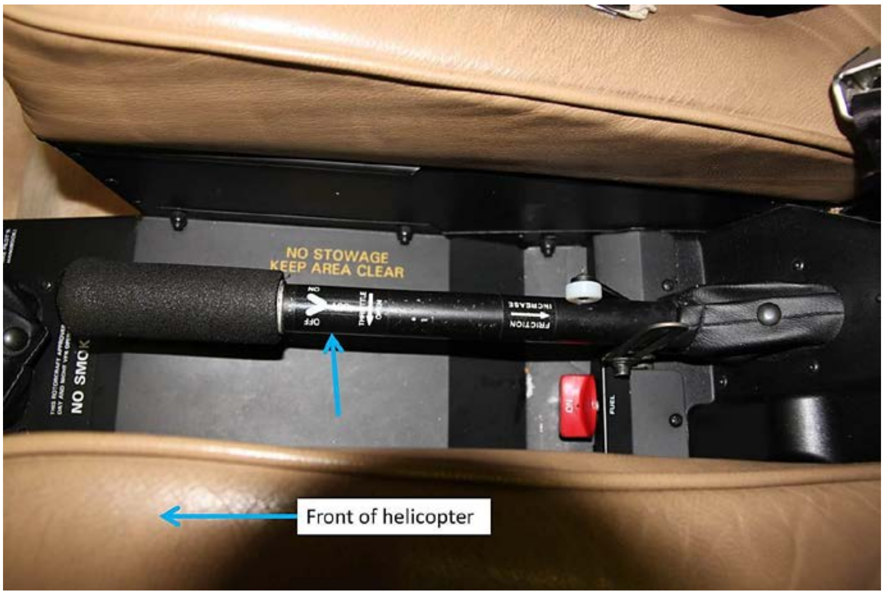
Source: ATSB

The collective control, raised or lowered by the pilot's left hand, varies the angle of both main rotor blades together to produce more or less rotor thrust for climb or descent. The collective is positioned to the left of each front seat and incorporates a twist-grip engine throttle (Figure 9). The main rotor controls on the Raven II helicopter also incorporate hydraulic assistance.

The tail rotor controls consist of two sets of left and right tail rotor pitch control pedals located on the cockpit floor. These vary the pitch angle of the tail rotor blades and allow the pilot to control yaw, or in other words to rotate the nose left or right in the hover (Figure 8), or to balance the helicopter in flight.

The left cockpit flight controls in the R44 are able to be removed and fitted to the helicopter as operationally required.

Figure 9: Exemplar R44 cockpit flight controls, pilot's collective (blue arrow)



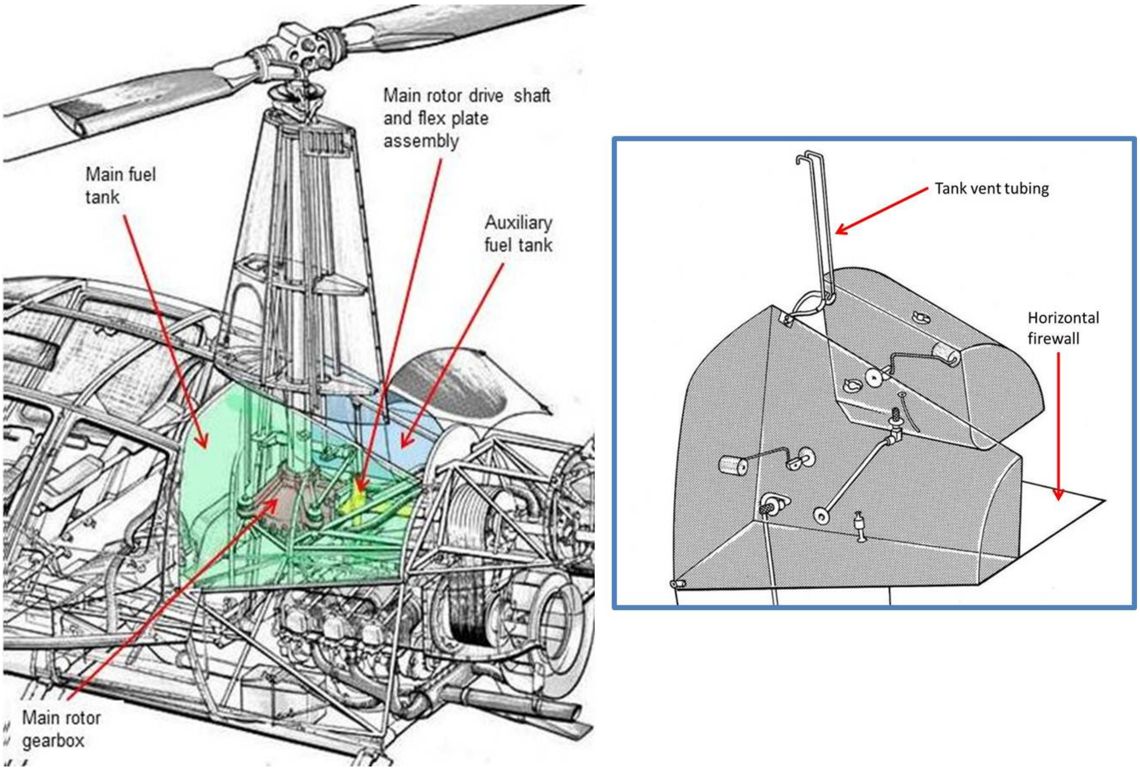
Source: ATSB

Fuel and fuel system

The fuel-injected piston engine fitted to VH-COK operated on aviation gasoline (Avgas). Avgas is a volatile fuel which can ignite easily if a fuel tank is ruptured in the presence of an ignition source, such as during an impact sequence.

Two all-aluminium fuel tanks were installed above the engine to either side of the main rotor gearbox (Figure 10). Both tanks were originally interconnected by rigid-tubing fuel lines,[4] with the right-side-mounted auxiliary tank draining into the left-side-mounted main tank. The main tank had a maximum capacity of 120 L and the auxiliary tank a maximum of 70 L. Both tanks vented to atmosphere in the enclosed area inside the main rotor mast fairing, above the tanks (Figure 10).

Figure 10: R44 helicopter[5] fuel tanks surrounding the lower main rotor gearbox assembly and main rotor driveshaft. Inset - fuel tank system diagram showing the original inter-tank plumbing and vent tubes



Source: Flight International; David Hatchard, Torrance, California July 1992

Wreckage and impact information

The wreckage was located on a grassed area about 12 m from the nearest structure (Figure 11). All of the helicopter's major components were identified at the accident site.

Much of the wreckage was consumed by the post-impact fuel-fed fire (Figure 12), with little of the aluminium fuselage structure remaining.

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4 Refer to the *Manufacturer Service Bulletins* section of this report.

5 The drawing is of an earlier 'Astro' variant of the R44 helicopter which, although very similar to the Raven II in most ways, including the location and number of fuel tanks, did not have hydraulically-assisted main-rotor flight controls.

Figure 11: Aerial view of the accident site

Source: NSW Police Airwing

Figure 12: Helicopter wreckage from the ground

Source: ATSB

Most of the aluminium alloy flight control tubes had been burnt away, precluding a full examination of the flight control system. However, examination of the helicopter's main and tail rotor flight control connections, engine control connections, main and tail rotor drive and remaining fuselage structure, revealed no evidence of any pre-existing anomalies.

Several components were recovered from the wreckage for technical examination. These included the remains of the pilot's door and the main rotor hydraulic flight control servos.

After the accident, a patch of dead grass developed at a point thought to be the helicopter's point of lift off. Such marking may occur from the heat emitted from an R44 during run-up and cool down or from the effects of a liquid such as fuel leaking onto the ground. A sample of soil from that area was obtained for further examination by the NSW Police as to the reason for the damage to the grass. At the time of writing this report, no conclusive results of the examination of that sample had been received.

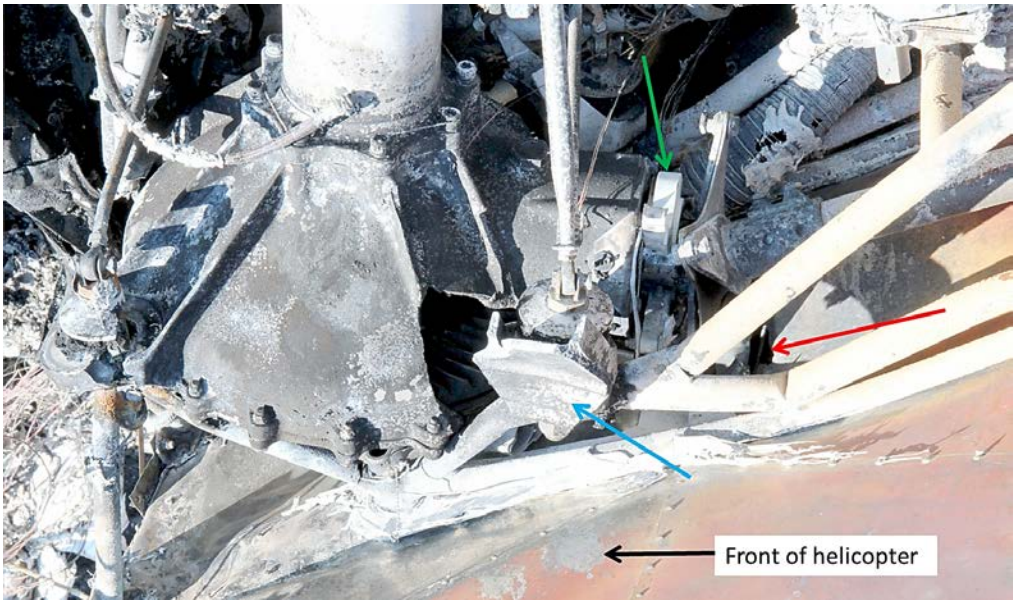
The structure of the helicopter's all-aluminium main fuel tank had been almost completely consumed by the fire, with only the fuel cap assembly, a small section of the tank's inner wall and the burnt fuel quantity sender unit remaining. The auxiliary fuel tank was almost completely intact with some fire-related damage noted to the tank's inner wall. About 20 L of Avgas and an unmeasured quantity of water was recovered from this tank.

The main rotor gearbox, which was situated in the space between the two fuel tanks and relatively close to their inner walls (Figure 10), was displaced from three of its four mounting points. Only the front right gearbox mount remained intact.

The fracture during the impact sequence of the rear left gearbox mount had broken away a significant section of the gearbox casing, exposing the gearbox internals. The movement of the gearbox rotated the casing section around the mount fitting and outward toward the inner wall of the adjacent main fuel tank (Figure 13). The flexible coupling connecting the gearbox input to the input-drive shaft remained intact, with the coupling and shaft having been forced down into the stainless steel, horizontal firewall while under rotation by the movement of the gearbox.

The rotor brake assembly and attached rotor brake activation micro switch assembly had been significantly damaged by the impact and fire (Figure 13).

Figure 13: Gearbox mount damage as noted on site with the broken section of the gearbox casing rotated outward toward the main fuel tank inner wall (blue arrow). The damaged rotor brake and micro switch assembly (green arrow) and flexible coupling cut into the firewall (red arrow) are also shown



Source: ATSB

Component examination

Pilot's door

The accident-damaged pilot's door was returned to the Australian Transport Safety Bureau (ATSB) for examination of the latching mechanism. Recognising that the position of the pilot's door handle may have been affected by the impact sequence, the examination of the latching mechanism found that the internal door handle was positioned about two-thirds rearward, in the up or unlatched position (Figure 14). This position was also reflected on the outside door handle, with the upper rod protrusion in the fully unlatched condition (Figure 15).

In this position, if the door was seated home, it would be partly latched at its rearward point. If ajar, the protruding rod would have prevented closure of the door.

Figure 14: Pilot's door internal handle position as noted post-accident

Source: ATSB

Figure 15: Rear right door alongside pilot's door (burnt) as noted on-site. Note the position of the external door handle

Source: ATSB

Examination of the door-latching mechanism showed that all latching components were in their correct relative positions, although heat affected. On that basis, it was concluded that the door-latching mechanism was likely to have been functional prior to the accident.

Hydraulic flight control servos

All of the hydraulic flight control servos showed superficial damage from the post-impact fire. Examination and disassembly of the three servos revealed nothing abnormal that would have affected the operation of the helicopter.

Manufacturer service bulletins

On 20 December 2010, the manufacturer issued R44 Service Bulletin SB-78 (SB-78)[6] requiring that R44 helicopters with all-aluminium fuel tanks be retrofitted with bladder-type tanks as soon as practical, but no later than 31 December 2014. This SB was not necessarily mandatory depending on the wording of the individual aircraft's System of Maintenance[7]. The background information to the service bulletin stated that:

> *To improve the R44 fuel system's resistance to a post accident fuel leak, this retrofit must be performed as soon as possible.*

The manufacturer advised that the bladder-type tanks provided improved resistance to post-accident fuel leaks due to their improved cut and tear resistance. In addition, the bladders were able to sustain large deformations without rupture.

SB-78 also incorporated the fitment of:

> *…reinforced fuel filler caps, to increase their ability to retain fuel under internal pressure loads, rollover vent valves, designed to minimise fuel spillage should the helicopter come to rest at an attitude that permitted fuel to reach a fuel tank vent opening.*

Prior to the issue of SB-78, the manufacturer had issued service bulletins SB-67[8], SB-68[9] and SB-69[10] that were also designed to reduce the likelihood of post-accident fuel leaks. SB-67 and SB-68 involved modifications that increased the allowable movement of fuel lines during an accident and included the replacement of the previously rigid, inter-tank fuel lines with flexible hoses. SB-69 detailed a modification that was designed to improve retention of the gascolator[11] sediment bowl under impact loads.[12]

The accident helicopter had been modified to include SB-67, SB-68 and SB-69. The bladder-type fuel tank retrofit detailed in SB-78 had not been incorporated in the helicopter, although there was an entry in the helicopter's logbooks dated 24 January 2011 acknowledging that the SB was to be carried out.

The helicopter manufacturer advised that about 4,000 helicopters were manufactured with the all-aluminium tanks. The manufacturer indicated that, at the time of report release, over 1,800 SB-78 retrofit kits had been shipped worldwide for fitment.

The manufacturer also advised being aware of four accidents involving R44 helicopters fitted with bladder-type tanks.[13] Each accident was of sufficient severity to result in fatal or serious injury to the occupants. Whereas the manufacturer advised that three of these accidents did not result in a post-accident fire, at the time of writing, the manufacturer was unable to confirm whether a post-accident fire occurred in the fourth instance.

Subsequent revisions of SB-78 have reduced the compliance period for the installation of the bladder-type fuel tanks to 30 April 2013 (see the *Safety action* section of this report).

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6 SB-78, Bladder Fuel Tank Retrofit, has since been superseded by SB-78A (21 February 2012) and SB-78B (28 September 2012).

7 VH-COK's Maintenance Schedule included a requirement to carry out scheduled maintenance, overhauls and inspections in accordance with Section 1.101 of the manufacturer's maintenance manual. That section required the checking of manufacturer SBs for applicability.

8 SB-67, R44 II, Fuel Hose Supports, dated 6 November 2008.

9 SB-68, R44 and R44 II, Rigid Fuel Line Replacement, dated 25 March 2009.

10 SB-69, R44 and R44II, Gascolator Assembly, dated 25 March 2009.

11 A fuel filter fitted at the lowest point of the fuel system.

12 In 2006, the helicopter manufacturer also issued Safety Notice SN-40 that strongly recommended all occupants of its helicopters wear fire retardant flight suits, gloves and hoods or helmets in case of fire.

13 None of these accidents occurred in Australia.

Australian R44 accidents involving post-impact fire

There have been a number of other R44 helicopter accidents in helicopters without bladder tanks fitted, including in Australia (Appendix A). The ATSB established that in four of the Australian accidents, there was a post-impact fire.

Operating information

The Robinson R44 Raven II pilot's operating handbook (POH) lists, among other information, the actions to be carried out by the pilot for normal and emergency procedures.[14] The POH *Daily and Pre-Flight checks, Starting engine and Run-up and Take-off procedures* all mentioned checking the doors for 'latching'. Item 1 in the helicopter's take-off procedures indicated that the pilot should:

> *Verify doors latched, governor and hydraulics ON, and RPM stabilised at 101 to 102%.*

There was no emergency procedure in the POH detailing actions to be followed in the event of a door coming open in flight.

The POH also contained a number of safety notices relating to operation of the manufacturer's helicopters. In particular, Safety Notice SN-40[15], advised in part:

> *There have been a number of cases where helicopter or light plane occupants have survived an accident only to be severely burned by fire following the accident. To reduce the risk of injury in a postcrash fire, it is strongly recommended that a fire-retardant Nomex flight suit, gloves, and hood or helmet be worn by all occupants.*

A manufacturer of clothing containing NOMEX® fibre described its effectiveness in part as follows:[16]

> *Inherently flame-resistant, fabric made of NOMEX® will not continue to burn after the flame source is removed. It also creates an insulating barrier against the heat of a fire, slowing the transfer of heat and giving the wearer time to escape. Something else to consider NOMEX® chars when exposed to intense heat, increasing the protective barrier and reducing the chance of injuries from burns.*

Manufacturer advice and flight testing

Flight controls

Following discussions with the ATSB, the manufacturer undertook a factory test flight of an R44 helicopter that was similarly loaded and configured to the accident helicopter. This was done in order to ascertain the effect on the helicopter of the release by the pilot of the cyclic in the hover and low-forward speed flight, and of the operation of a helicopter with an open pilot's door.

The flight testing demonstrated that given the ambient conditions affecting the test, release of the cyclic flight control during hover flight produced a nose-up attitude. In addition, releasing the cyclic during low-speed forward flight caused the helicopter to quickly move to a nose-up condition and roll.

Door open in flight

Discussions with the helicopter manufacturer indicated that a door opening in flight was a situation that, if left, did not adversely affect control of the helicopter.

Flight testing showed that, if left alone, an open pilot's door was a benign condition. In this situation, the door would simply close back toward the door frame under the control of the gas spring unit as forward speed increased.

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[14] Emergency Procedures are detailed in Section 3 and Normal Procedures are detailed in Section 4 of the POH.

[15] Issued July 2006

[16] www2.dupont.com/Government/en_US/assets/downloads/MilitaryBrochure.pdf

The helicopter manufacturer further indicated that, if the right door was open even halfway, it was unlikely, due to the distance out from the side of the helicopter, that a person seated in the pilot's seat would be able to reach the open door's handle with their left hand while maintaining cyclic control with their right hand. It was considered likely that in order for a person to reach the open right door's handle, they would have to reach out with their right hand.

Safety analysis

Introduction

This analysis will examine the operational and technical factors and risks surrounding the accident in the context of the pilot being qualified for the flight in an airworthy helicopter and the weather being benign. In addition, a number of survivability issues will be discussed.

Operational considerations

The first indication of a problem in the operation of the helicopter was the pilot's door opening to about a halfway position when the helicopter turned left soon after lift-off. In the absence of any defects or anomalies in the door latching mechanism, the pre-flight check of closing and latching the door must have been overlooked or ineffective. There was no clear reason for this, but the pilot probably wanted to expedite the departure to avoid a delay to the operation to be filmed. Also, lacking in this situation was the visual cue of incomplete door closure because the gas spring unit held the door closed until some combination of airflow and centrifugal force sprung it open during the turn.

All evidence pointed to the helicopter being stable and under control until the door came open. In that case, it is reasonable to propose that the door opening had a direct or indirect effect on the control of the helicopter.

Discussions with the helicopter manufacturer indicated that a door opening in flight was a situation that in and of itself would not adversely affect control of the helicopter. Their flight testing showed that, if left alone an open pilot's door was a benign condition. A direct effect from the door opening was therefore ruled out.

An indirect effect of the door opening would be pilot surprise and concern as to the possible effect on the helicopter's control and performance. In that context, it is understandable that the pilot attempted to immediately close the door as observed by one of the witnesses.

However, it was the action of attempting to close the door that required the pilot to release at least one of the flight controls. This exposed the helicopter to instability and potential loss of control in close proximity to the ground. While not specifically prohibited in the R44 pilot's operating handbook, release of any helicopter flight control at low level is high risk and release of the cyclic in any phase of flight is undesirable due to the inherent instability of a helicopter.

As it turned out, the helicopter abruptly nosed up and struck the tail on the ground. That outcome was consistent with manufacturer flight testing of the effects of release of the cyclic flight control during hover and low-speed forward flight. Taken with information from the helicopter manufacturer that the pilot would likely not have been able to reach the door handle of a half-open right door with his left hand, it is likely that the pilot probably removed his right hand from the cyclic. It is also possible that the forward pitching of the helicopter may have been the result of the pilot instinctively reacting to the tail low pitching and returning his hands to the cyclic in an attempt to regain control.

Individuals can react to a situation instinctively in response to a cue from the environment, such as a door opening in flight. This reaction can occur automatically without a conscious decision, meaning it is not actively considered by the individual.[17] Given that context, the pilot's action in reaching to close the door in-flight was probably the result of an automatic reflex to the door opening, or a briefly-considered decision to close the door before continuing the flight. Irrespective of whether it was an automatic response or a conscious action, it is important that during this

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[17] Wickens, C.D. & Hollands, J.G. (2000). *Engineering psychology and human performance, 3rd Edition.* Prentice Hall: New Jersey.

phase of flight, a pilot's attention is on maintaining control of the helicopter and any non-critical distracting events are dealt with once the helicopter is stable. However the instinctive reaction to deal with such an event can be quite strong and this reaction may be hard to overcome.

Survivability and bladder fuel tanks

The occupants received fatal injuries from the post-accident fire. That fire started after the main rotor blades contacted the ground and before the helicopter came to rest. The fire spread quickly and its size and intensity gave no time for the occupants to successfully release themselves from the wreckage or for the bystanders to be able to extinguish the flames.

It is likely that the fire resulted from the breaching of the all-aluminium main fuel tank's inner skin following impact with the lower section of the main rotor gearbox, or a section of it, as a result of the main rotor impact with the ground. The degree of fire damage to the helicopter prevented identification of the exact ignition source. However, the video evidence showed that the fire started in the lower, main rotor mast area between the two fuel tanks.

Advice provided by the manufacturer indicated that incorporation of the modifications in service bulletins (SB) SB-78/SB-78A/SB-78B has been effective in reducing instances of post-accident fuel-fed fires. Therefore it is possible that, had this helicopter been fitted with these tanks, the fire may not have occurred. The Civil Aviation Safety Authority has subsequently advised that their installation in accordance with the manufacturer's service bulletin by 30 April 2013 is mandatory.

The use of fire-retardant clothing and equipment, as detailed in the manufacturer's Safety Notice SN-40, has the potential to enhance post-accident survivability in some accidents. However, in this instance the speed and intensity of the fire, together with the impeded egress meant that the use of such equipment would probably not have reduced the severity of the outcome.

Findings

From the evidence available, the following findings are made with respect to the loss of control and subsequent collision with terrain involving R44 Raven II helicopter, registered VH-COK that occurred at Jaspers Brush Aerodrome, New South Wales on 4 February 2012. They should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing safety factors

- The pilot's door latching mechanism was not in the latched closed position prior to flight.
- At the commencement of the takeoff the pilot's door opened and, in response, the pilot probably released his right hand from the cyclic control to close the door, resulting in the loss of control of the helicopter that was unable to be recovered before impacting the terrain.

Other safety factors

- A significant number of R44 helicopters, including VH-COK, were not fitted with bladder-type fuel tanks and the other modifications detailed in the manufacturer's Service Bulletin, SB-78 to improve resistance to post-impact fuel leaks and fire. *[Significant safety issue]*

Other key findings

- Testing conducted by the helicopter manufacturer found that an R44 helicopter, when similarly configured to the accident helicopter, would tend to pitch to a nose-up attitude when the cyclic flight controls were fully released during a hover or in slow, forward flight.
- Examination of the recovered hydraulic system flight control hydraulic-boost servos found nothing that would have prevented normal operation of the flight control system prior to the accident.

Safety issues and actions

The safety issues identified during this investigation are listed in the Findings and Safety issues and actions sections of this report. The Australian Transport Safety Bureau (ATSB) expects that all safety issues identified by the investigation should be addressed by the relevant organisation(s). In addressing those issues, the ATSB prefers to encourage relevant organisation(s) to proactively initiate safety action, rather than to issue formal safety recommendations or safety advisory notices.

All of the directly involved parties were provided with a draft report and invited to provide submissions. As part of that process, each organisation was asked to communicate what safety actions, if any, they had carried out or were planning to carry out in relation to each safety issue relevant to their organisation.

Fitment of rubber, bladder-type fuel tanks to R44 helicopters

Number:	**AO-2012-021-SI-01**
Issue owner:	Robinson Helicopter Company
Operation type:	Private operation
Who it affects:	All owners and operators of R44 helicopters
Risk:	Significant

Safety issue description:

A significant number of R44 helicopters, including VH-COK, were not fitted with bladder-type fuel tanks and the other modifications detailed in the manufacturer's Service Bulletin, SB-78 to improve resistance to post-impact fuel leaks and fire.

Proactive safety action taken by: Robinson Helicopter Company

The manufacturer had initially issued SB-78 on 20 December 2010. On 21 February 2012, following this and the R44 accident at Cessnock, New South Wales (NSW) on 4 February 2011 involving VH-HFH, the manufacturer issued a revision to SB-78, numbered SB-78A. That revision reduced the time frame for compliance with the bladder-type tank fitment from 31 December 2014 to 31 December 2013.

On 15 June 2012, the manufacturer forwarded a letter of offer to all R44 Dealers, Service Centres and Owners, advising them of a financial incentive for them to install the SB-78A fuel tank kits '*on or before 31 December 2012*'.

Subsequently, on 28 September 2012 the manufacturer again revised the compliance date with the issue of SB-78B. That revision further reduced the date for compliance to 30 April 2013.

In addition to the manufacturer's bulletins in respect of the requirement to install bladder-type fuel tanks, on 21 February 2012, the manufacturer issued SB-82 relating to the fitment of a '*more rugged, environmentally sealed [sic]*' type rotor brake activation switch. The manufacturer indicated that the new switch was less likely to cause a spark in the event of an accident. SB-82 had a compliance date of 31 May 2012. Owners of R44 helicopters should give consideration to incorporation of this SB.

In conjunction with the United States Federal Aviation Administration, the manufacturer is also examining other methods to ensure greater compliance with the bladder-type fuel tank upgrade.

Proactive safety action taken by: Civil Aviation Safety Authority

On 26 June 2012, following this accident and the R44 accident at Cessnock, NSW involving VH-HFH, the Civil Aviation Safety Authority (CASA) introduced Airworthiness Bulletin

AWB 28-012 titled *Robinson R44 Fuel Tanks*.[18] That AWB highlighted the improvement in the 'post-crash survivability' of R44 helicopters that had been fitted with bladder-type fuel tanks.

The AWB referred to Robinson Helicopter Company Service Bulletin SB-78 that, depending on the System of Maintenance affecting the individual helicopter, required the fitment of bladder-type tanks to all R44 helicopters in lieu of the all-aluminium fuel tanks. The AWB also strongly recommended that all operators of R44 helicopters incorporate the additional service bulletins SB67, SB68, SB69 and SB82.

On 19 December 2012, in response to a question from the ATSB, CASA advised that:

> *CASA has drafted a Notice of Proposed Rule Making (NPRM) relating to a unique Australian Airworthiness Directive (AD) that will mandate the Robinson Helicopters R 44 SB 78B Bladder Fuel Tank Retrofit. Release of this NPRM, expected in early in 2013, is subject to confirmation from the FAA as to their intended actions, which will follow their current investigation.*

On 15 March 2013, in response to the draft report into this accident, CASA advised that:

> *CASA has been liaising with the Federal Aviation Administration (FAA) certification office regarding the subject of mandating the R44 Service Bulletin (SB) SB-78B. The FAA advised CASA that, after analysis of the data, the R44 fuel system crashworthiness does not appear inconsistent with that of other similar helicopters and they will be taking no corrective action.*
>
> *Robinson Helicopters advised that they brought forward the compliance date for SB-78B for all affected R44 rotorcraft to April 2013. Given this reduced compliance time, CASA issued a letter to all R44 operators recommending the installation of the bladder tanks and highlighting their responsibilities under Civil Aviation Regulation 42A (4). CASA is also taking steps to determine the SB-78B industry take-up rate.*

On 3 April 2013, CASA issued AWB 02-044 *Robinson R44 Helicopter Maintenance Requirements* (Issue 1), which stated in part that:

> *Registered operators of Robinson R44 helicopters that are maintained using the manufacturer's maintenance schedule are reminded that they must comply with Service Bulletins by their due date. The registered operator will be contravening regulation 41 of the CAR and the pilot and registered operator may also contravene regulation 47 of the CAR if they do not comply with Service Bulletins by their due date.*
>
> *If the helicopter is maintained to an approved SOM then the SOM must have consideration for compliance with Robinson Helicopter Company Service Bulletins. With regards to Robinson Helicopter Company Service Bulletins mentioned in AWB 28-012, CASA would regard an SOM that does not include these Service Bulletins as deficient.*

The full AWB is available at www.casa.gov.au/wcmswr/_assets/main/airworth/awb/02/044.pdf

Action by the US Federal Aviation Administration

On 26 December 2012 the US Federal Aviation Administration issued a Special Airworthiness Bulletin (SAIB) alerting R44 owners and operators of the availability of a fuel tank bladder retrofit program for enhanced safety on R44 and R44 II helicopters.

That SAIB recommended that owners/operators of affected R44 helicopters incorporate SB-78B, Revision B, of 28 September 2012.

Action by the Australian Transport Safety Bureau

On 9 March 2012, following this and the R44 accident at Cessnock, NSW on 4 February 2011 involving VH-HFH, the ATSB released safety advisory notice AO-2012-021-SAN-001.[19]

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18 Available at www.casa.gov.au/wcmswr/_assets/main/airworth/awb/28/012.pdf

19 Available at www.atsb.gov.au/publications/investigation_reports/2012/aair/ao-2012-021/san-001.aspx

In that notice, the ATSB encouraged operators of R44 helicopters to actively consider the installation of bladder-type fuel tanks in their aircraft as follows:

> *The Australian Transport Safety Bureau encourages all operators and owners of R44 helicopters that are fitted with all-aluminium fuel tanks to note the circumstances of this accident as detailed in this preliminary report. It is suggested that those operators and owners actively consider replacing these tanks with bladder-type fuel tanks as detailed in the manufacturer's Service Bulletin (SB) 78A as soon as possible.*

Current status:

Residual risk:	Significant
Issue status:	Adequately addressed
Justification:	Despite the availability of the bladder-type fuel tanks to replace the all-aluminium tanks in R44 helicopters, the number of such helicopters yet to be installed represents a significant residual risk. The manufacturer's emphasis on the safety benefits of the installation of these tanks, and encouragement for their installation by owners and operators of R44 helicopters is supported. Further emphasis on the enhanced survivability likely from the installation by operators of bladder-type tanks in their R44 helicopters has been provided by CASA and the ATSB. The ATSB will monitor the progress of CASA's NPRM concerning the development of a unique Australian airworthiness directive to mandate the incorporation in R44 helicopters of the SB-78B bladder-type fuel tank retrofit.

Further action by the Australian Transport Safety Bureau

Another low-impact energy accident that resulted in a fatal post-impact fire occurred at Bulli Tops near Wollongong, NSW on 21 March 2013 and involved R44 Raven helicopter VH-HQH (ATSB investigation AO-2013-055, available at www.atsb.gov.au). As a result of this additional accident, and concerns that a significant number of Australian R44 owners and operators were very unlikely to be able to comply with the requirements of SB-78B by the required compliance date of 30 April 2013, the ATSB issued a safety recommendation to CASA on 5 April 2013. That recommendation sought further action by CASA to ensure that owners and operators of Robinson R44 helicopters were aware of the relevant regulatory requirements affecting compliance with manufacturer's service bulletins, and complied with SB-78B to replace all-aluminium fuel tanks with bladder-type tanks on Robinson R44 helicopters.

Other safety action

Pro-active safety action taken by: Robinson Helicopter Company

Following this accident and the identification of a number of other issues by the manufacturer, the following proactive safety action has been advised by the manufacturer in response to the risk of pilots removing their hand(s) from the flight controls:

> *[The] Robinson Helicopter Company is currently drafting a Safety Notice to emphasize the importance of maintaining control of the helicopter especially in a simple unexpected event, for example; folding or unfolding charts, the sudden opening of an unlatched door or even programming communication/navigational equipment.*

General details

Occurrence details

Date and time:	4 February 2012 – 1555 EST	
Occurrence category:	Accident	
Primary occurrence type:	Loss of control and collision with terrain	
Type of operation:	Private	
Location:	Jaspers Brush Aerodrome, New South Wales, Australia	
	Longitude: 34°48.9' S	Latitude: 150°39.8' E

Pilot details

Licence details:	Commercial Pilot (Helicopter) Licence, issued 1999
Endorsements:	R44, Bell 206
Operational approvals	Low flying training completed 2002
Medical certificate:	Class 1, renewed 5 January 2012 (Distance vision correction to be worn and reading correction to be available)
Aeronautical experience:	1,700 hours total, mostly R44 120 hours R44 in the last 12 months
Last flight review:	March 2010

Aircraft details

Manufacturer and model:	Robinson Helicopter Company R44 Raven II	
Registration:	VH-COK	
Operator:	Private	
Serial number:	10421	
Manufacture date:	June 2004	
Total time:	1,300 hours	
Persons on board:	Crew – 1	Passengers – 1
Injuries:	Crew – 1 fatal	Passengers – 1 fatal
Damage:	Destroyed	

Sources and submissions

Sources of information

The sources of information during the investigation included the:

- New South Wales Police
- witnesses at Jaspers Brush Aerodrome
- helicopter manufacturer
- Civil Aviation Safety Authority (CASA)
- Federal Aviation Administration
- helicopter maintenance organisation
- helicopter operator
- other witnesses.

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 owner and maintenance engineer of the helicopter, a number of witnesses to the accident, the US National Transportation Safety Board, the manufacturer of the helicopter and CASA.

Submissions were received from the helicopter owner and maintenance organisation, the helicopter manufacturer and CASA. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

Appendices

Appendix A – Australian R44 accidents involving post-impact fire

The following is a list of investigations by the Australian Transport Safety Bureau (ATSB) into accidents involving R44 helicopters in which there was a post-impact fire. A link to the respective investigation report on the ATSB web site is provided.

ATSB investigation AO-2011-016 - On 4 February 2011, the ATSB initiated an investigation into an accident involving an R44 with all-aluminium fuel tanks that occurred at Cessnock, New South Wales. The three occupants of the helicopter survived the initial impact with the ground but two did not survive the post-accident fire.

http://www.atsb.gov.au/publications/investigation_reports/2011/aair/ao-2011-016.aspx

ATSB investigation AO-2008-062 - On 14 September 2008, an R44 Raven helicopter, registered VH-RIO, was being operated on a series of scenic flights in the Bungle Bungle ranges area of the Purnululu National Park, which was about 250 km south of Kununurra, Western Australia (WA). At about 1230 Western Standard Time, the helicopter departed the Purnululu Aircraft Landing Area for an 18-minute scenic flight with the pilot and three passengers on board. When the helicopter did not return by the nominated time, a search was initiated. Shortly after, the burnt wreckage of the helicopter was located. The four occupants were fatally injured.

http://www.atsb.gov.au/publications/investigation_reports/2008/aair/ao-2008-062.aspx

ATSB investigation BO/200600979 - On 21 February 2006, an R44 Astro helicopter with aluminium fuel tanks and registered VH-HBS, was being operated on a series of aerial survey flights about 100 km to the north of Mt Isa Airport, Queensland, with a pilot and three occupants on board. The helicopter impacted the ground with significant force in a nose-down, fuselage-level attitude and burned. The four occupants were fatally injured.

http://www.atsb.gov.au/publications/investigation_reports/2006/aair/aair200600979.aspx

ATSB investigation BO/200304546 - On 8 November 2003, a Bell helicopter Company 206 and an R44, registered VH-YKL, were returning to Kununurra in company from a fishing charter to the Cape Dommett area of far northern WA. About 17 minutes into the flight, the pilot of the leading helicopter, the B206, received a broadcast from the pilot of the R44 stating that 'I'm going in hard'. The pilot of the B206 immediately turned his aircraft around in a tight right turn and, after assuming a reciprocal heading, observed a mushroom cloud of smoke rising from a nearby ridge. The R44 burned and all four occupants received fatal injuries.

http://www.atsb.gov.au/publications/investigation_reports/2003/aair/aair200304546.aspx

Australian Transport Safety Bureau

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The Bureau 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 safety factors related to the transport safety matter being investigated. The terms the ATSB uses to refer to key safety and risk concepts are set out in the next section: Terminology Used in this Report.

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.

Terminology used in this report

Occurrence: accident or incident.

Safety factor: an event or condition that increases safety risk. In other words, it is something that, if it occurred in the future, would increase the likelihood of an occurrence, and/or the severity of the adverse consequences associated with an occurrence. Safety factors include the occurrence events (e.g. engine failure, signal passed at danger, grounding), individual actions (e.g. errors and violations), local conditions, current risk controls and organisational influences.

Contributing safety factor: a safety factor that, had it not occurred or existed at the time of an occurrence, then either: (a) the occurrence would probably not have occurred; or (b) the adverse consequences associated with the occurrence would probably not have occurred or have been as serious, or (c) another contributing safety factor would probably not have occurred or existed.

Other safety factor: a safety factor identified during an occurrence investigation which did not meet the definition of contributing safety factor but was still considered to be important to communicate in an investigation report in the interests of improved transport safety.

Other key finding: any finding, other than that associated with safety factors, considered important to include in an investigation report. Such findings may resolve ambiguity or controversy, describe possible scenarios or safety factors when firm safety factor findings were not able to be made, or note events or conditions which 'saved the day' or played an important role in reducing the risk associated with an occurrence.

Safety issue: a safety factor that (a) can reasonably be regarded as having the potential to adversely affect the safety of future operations, and (b) is a characteristic of an organisation or a system, rather than a characteristic of a specific individual, or characteristic of an operational environment at a specific point in time.

Risk level: The ATSB's assessment of the risk level associated with a safety issue is noted in the Findings section of the investigation report. It reflects the risk level as it existed at the time of the occurrence. That risk level may subsequently have been reduced as a result of z taken by individuals or organisations during the course of an investigation.

Safety issues are broadly classified in terms of their level of risk as follows:

- **Critical safety issue:** associated with an intolerable level of risk and generally leading to the immediate issue of a safety recommendation unless corrective safety action has already been taken.
- **Significant safety issue:** associated with a risk level regarded as acceptable only if it is kept as low as reasonably practicable. The ATSB may issue a safety recommendation or a safety advisory notice if it assesses that further safety action may be practicable.
- **Minor safety issue:** associated with a broadly acceptable level of risk, although the ATSB may sometimes issue a safety advisory notice.

Safety action: the steps taken or proposed to be taken by a person, organisation or agency in response to a safety issue.

Australian Transport Safety Bureau

24 Hours 1800 020 616
Web www.atsb.gov.au
Twitter @ATSBinfo
Email atsbinfo@atsb.gov.au

Investigation

ATSB Transport Safety Report
Aviation Occurrence Investigation
Loss of control involving Robinson R44 helicopter, VH-COK
Jaspers Brush Aerodrome, New South Wales, 4 February 2012
AO – 2012-021
Final - 3 May 2013