Australian Government

Australian Transport Safety Bureau

Loss of control and collision with terrain involving Eurocopter AS350BA helicopter VH-BAA

Hobart Airport, Tasmania, on 7 November 2017

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Addendum

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Safety summary

What happened

On 7 November 2017, a chief flying instructor (CFI) and pilot under instruction (PUI) were flying a Eurocopter AS350BA Squirrel, registered VH-BAA. They were conducting practice emergencies under visual flight rules at Hobart Airport, Tasmania. During hydraulic system failure practice, control of the helicopter was lost and the aircraft collided with terrain. The CFI was fatally injured and the PUI was seriously injured.

What the ATSB found

Flight manual emergency procedures stipulate that in order to maintain control following a hydraulic system failure (or simulated failure), a shallow approach should be made into wind and the helicopter should not enter a hover. On this occasion, the aircraft approached crosswind and came to a high hover without hydraulic assistance. Consequently, the helicopter was rendered uncontrollable. A delay in restoration of the hydraulic system prevented the crew from regaining control before collision with terrain.

The ATSB also identified that**:**

- An intermittent fault in the hydraulic cut-off switch may have delayed restoration of flight control hydraulic pressure.
- A pre-flight brief was not conducted between the CFI and PUI which may have led to confusion over aircraft control and delayed restoration of the hydraulic system.

Due to a lack of available information, the influence, if any, of these two factors on the accident sequence could not be determined.

What's been done as a result

Following this accident, the operator:

- employed a trained and regulator-approved safety manager
- updated the training school operations manual with stricter controls on performing AS350 sequences as per the flight manual requirements
- installed an electronic system for tracking competencies and currencies.

The operator has also separated key roles of chief executive officer, chief flight instructor and the head of flight operations, which were previously conducted solely by the chief flight instructor.

Safety message

Compliance with the AS350 flight manual requirements following a real or simulated hydraulic failure ensures that the helicopter remains controllable during all phases of flight.

As this, and many other similar accidents illustrate, hovering an AS350 without hydraulic assistance can lead to a rapid, catastrophic loss of control even for highly experienced pilots. The Royal Australian Air Force found in evaluation of the AS350, while hovering without hydraulics, that the AS350 is subject to random perturbations, and reduction in control authority. Additionally the AS350 flight manual notes that without hydraulics the helicopter is subject to rapid changes in control direction and force.

In a training context, the rapid development of this accident, reinforces the need for a clear understanding and coordination between instructor and student when conducting hazardous activities such as simulated system failures.

Contents

The occurrence

What happened

On 6 November 2017, a commercial helicopter pilot commenced a 2-day AS350 helicopter endorsement as a pilot under instruction (PUI). The first day was spent with an instructor covering aircraft systems, and pre-flight inspection. The PUI and instructor also conducted a 1.1-hour flight that afternoon covering the initial flying components of the endorsement.

On 7 November 2017, the PUI studied the aircraft's electrical system, and theory on handling of in-flight emergencies, including hydraulic system emergencies, with the same instructor. Following the classroom session, the PUI conducted an inspection of the aircraft under the supervision of the instructor.

Flight records showed that at 1002 Eastern Daylight-saving Time,[1] the PUI and instructor commenced a training flight of 1.2 hours covering pinnacle approaches and confined areas, followed by run-on landings.[2] The PUI's next planned flight was with the chief flying instructor (CFI) at 1500 for the conduct of emergency sequences. The CFI was unable to depart at the pre-arranged time as he was attending to business matters. The PUI reported that he also took the opportunity to catch up on his own business needs during the delay. The actual takeoff was delayed by 1 hour and 22 minutes.

The instructor advised the ATSB that, prior to the accident flight, the CFI conducted a brief handover with him to ascertain the standard of the PUI's flying and the sequences briefed. At the aircraft, the PUI explained his requirement for a low-level approval and type endorsement with the CFI however, no pre-flight brief was conducted.

The PUI and CFI boarded the aircraft and began the flight at 1622. Pre-flight checks included testing of the hydraulic system and switches with no apparent faults identified. The PUI recalled that following the low-level phase of the training flight, the CFI demonstrated some upper air emergencies and had the PUI perform them. After satisfactory completion, they flew back to Hobart Airport for a continuation of practice emergencies.

The PUI recalled that upon joining the circuit at left base for approach to area X-Ray parallel to runway 12 (Figure 1),[3] the CFI announced a simulated hydraulic failure and activated the hydraulic test (HYD TEST) switch. As expected, a warning light and horn sounded. The PUI slowed from 90 kt to below 60 kt, consistent with the flight manual profile for hydraulic failure (see the sections titled *Hydraulic failure training* and *Hydraulic system*). The PUI then activated the hydraulic cut-off (HYD CUTOFF) switch. Following that, it is highly likely that the HYD TEST switch was released, though it is not known specifically when that occurred.

The PUI was to fly a run-on landing at around 10 kt without hydraulic assistance as per the requirements of the flight manual procedure. The PUI said he was comfortable to do so knowing the CFI was there to step in if anything were to go wrong. The PUI had very little further recollection, beyond the initiation of the event.

Table 1 and Figure 1 show the progression of the helicopter through the accident sequence. Paths, angles and rates are inferred from CCTV footage, air traffic control (ATC) data, and airport photographs. Due to limitations in the data available, these are approximate values only.

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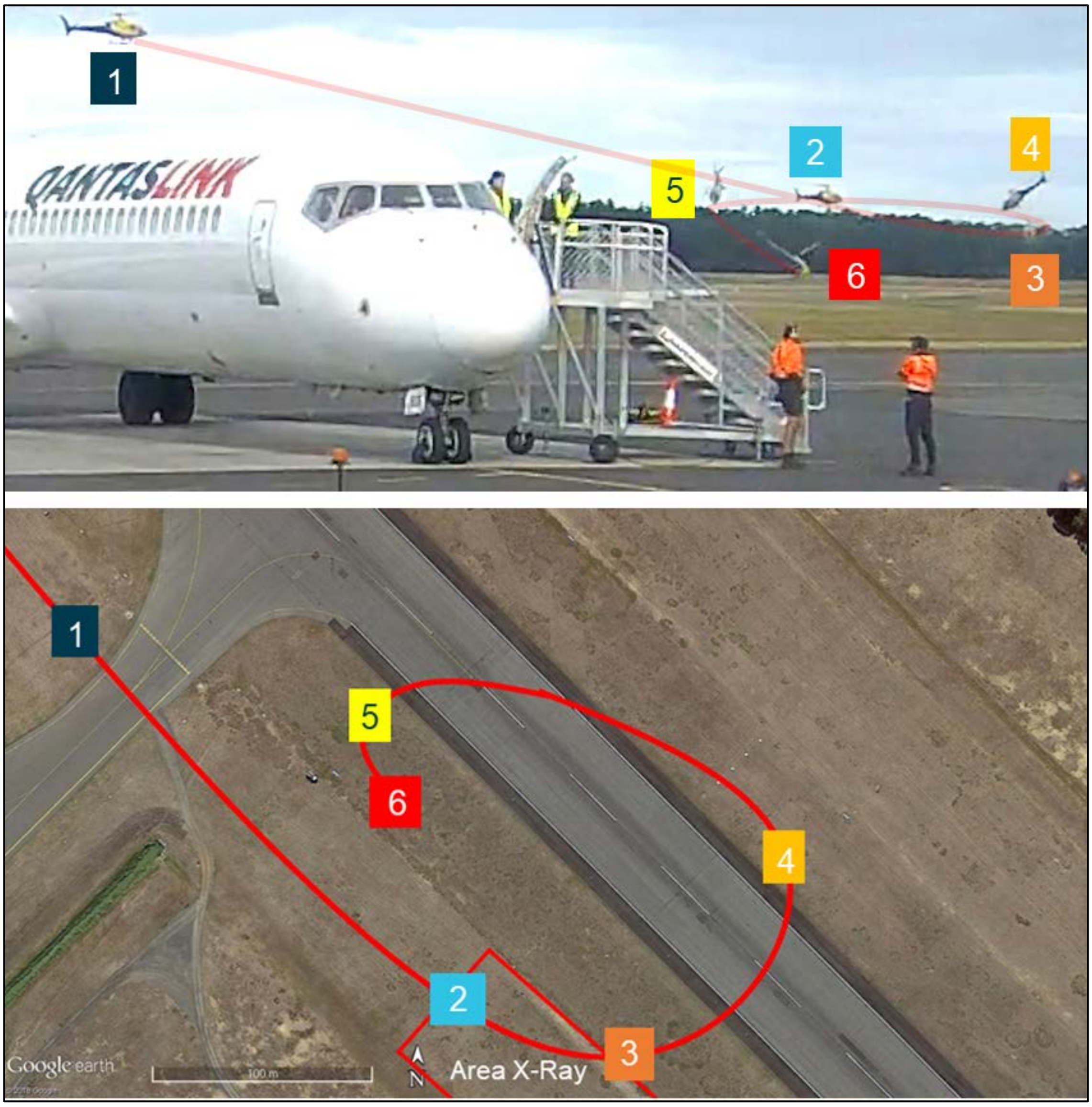
1. Eastern Daylight-saving Time (EDT): Coordinated Universal Time (UTC) + 11 hours.
2. Run-on landing: Touching down with forward speed with the skids aligned with the direction of travel of the helicopter, and slowing to a full stop while maintaining constant contact with the ground.
3. Runway number: the number represents the magnetic heading of the runway in ten degree increments.

Table 1: Accident sequence from CCTV

#	Seconds	Aircraft behaviour
1	0	Heading about 120°. VH-BAA enters frame. Travelling around 20 kt.
2	12	Variations in pitch and yaw as VH-BAA slows to about 11 kt. Approach flattens, helicopter begins to yaw left.
3	18	Change of heading to about 040° after yaw to left. Comes to hover in tail wind, slowly drifting.
4	21	The aircraft climbs, pitches forward, crossing the runway, and continues to yaw left to a heading of about 300°. Yaw continues, aircraft turns left and pitches further forward to about 50° with left roll developing. Accelerates to over 20 kt ground speed.
5	28	Heading about 240°. Slides outwards in left turn. Pitch down now around 45°, roll around 50°.
6	30	Heading about 120°. Pitch down about 40°, roll increases to about 80°, helicopter impacts terrain.

Figure 1: Approximate path of VH-BAA



Source: Hobart Airport, annotated by the ATSB

At the end of the observed flightpath, the front left side of the cabin impacted the ground first. The CFI, seated on the left, was fatally injured, and the PUI in the right seat was seriously injured. The helicopter was destroyed.

Context

Personnel

Chief flight instructor

The chief flight instructor (CFI) had 30 years of experience flying helicopters, and had accumulated 14,200 hours of aeronautical experience. His time on type for the AS350 was over 1,000 hours. He held an Air Transport Pilot License (Helicopter) and an authority to examine pilots for issuance of licences and endorsements. He had accumulated 45.3 hours flight in the previous 28 days.

The CFI was medically fit, qualified for the flight, and had demonstrated proficiency through flight checks in:

- Flight instruction on 3 August 2017
- Single Engine Helicopters on 30 June 2016
- Low level flight on 31 March 2016.

Instructor

The instructor was an experienced helicopter pilot with 4,000 hours' total aeronautical experience and 1,000 hours of AS350 experience. He had previously flown with the pilot under instruction (PUI) while working for a different operator. The PUI sought out this instructor to conduct his endorsement.

Pilot under instruction

The PUI was a commercial helicopter pilot with over 1,200 hours of rotary wing experience and he was medically fit for the flight. The PUI was also managing director of a local helicopter company. The endorsement was associated with the company's introduction of AS350 helicopters to their fleet.

Organisational and management information

The operator had been in business for 26 years, and established in Tasmania at Hobart International Airport for 17 years. They specialised in charter, aerial work, and flight training operations.

The CFI was also the owner of the business, head of flight operations, chief executive officer, and undertook operational flying.

Flight endorsement training

General information

The Civil Aviation Safety Authority, through Civil Aviation Advisory Publication 5.14-2(0) *Flight Instructor Training (Aeroplane)*, established the need for two briefings prior to flight: a classroom brief and a pre-flight brief. These two forms of briefing prepare students for learning and performing complex sequences. A long brief in the classroom links theoretical knowledge of emergencies to practical application of those principals in the aircraft. The pre-flight brief establishes procedures and management of the aircraft between the crew. This format was not applied for the accident flight. The first instructor conducted the classroom brief, but there was no pre-flight brief between the CFI and PUI.

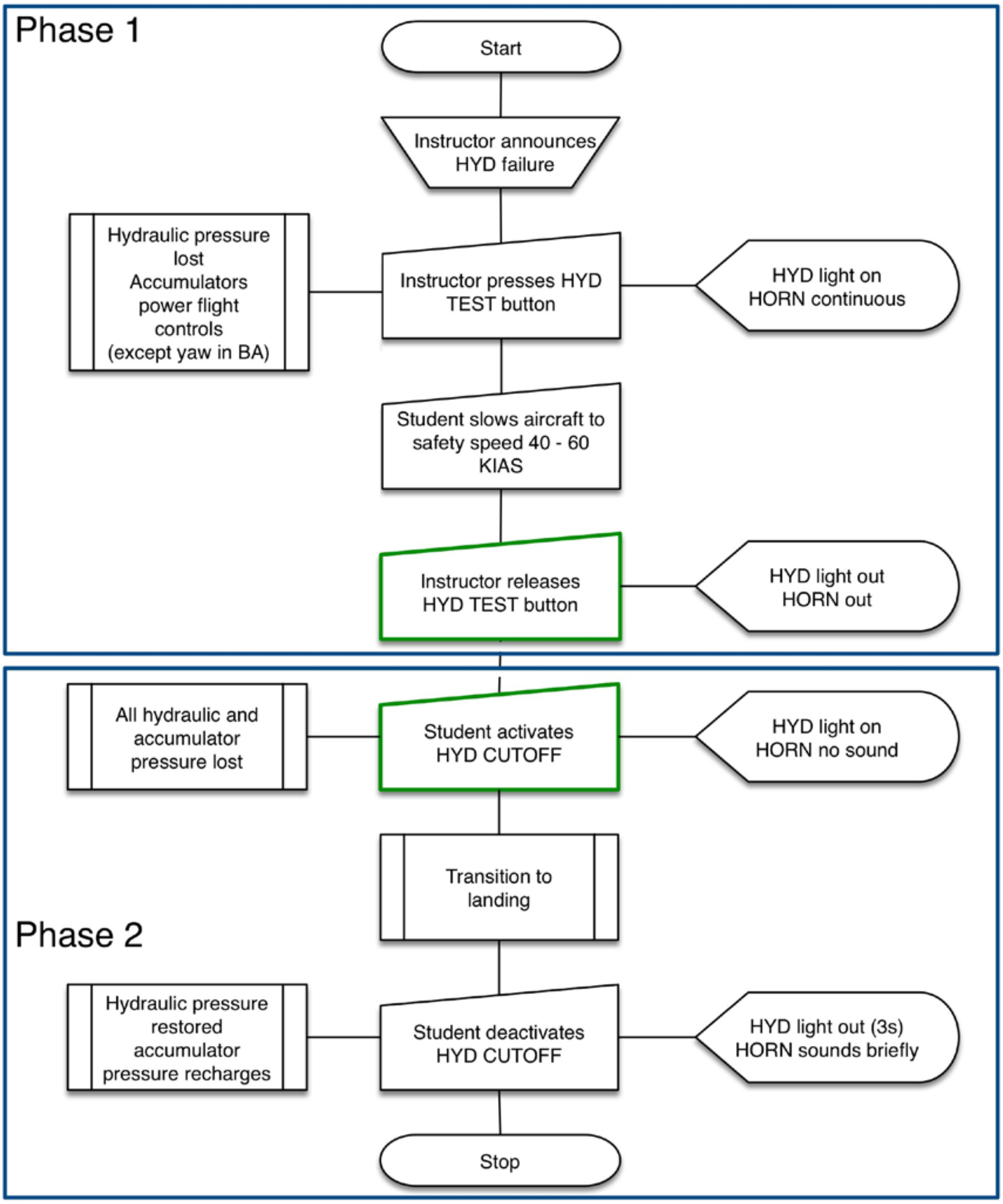
Hydraulic failure training

Training for loss of hydraulics in the AS350 required adherence to instructions in two rotorcraft flight manual (RFM) sections: Supplement 7 for the training procedure itself, and Section 3 for emergency procedures for management of the aircraft without hydraulics.

Supplement 7 training procedure

Supplement 7 of the AS350 RFM was incorporated in 2003; it carried specific instructions for hydraulic failure training. The sequence was divided into two distinct phases, and the hydraulic cut-off (HYD CUTOFF) switch and hydraulic test (HYD TEST) switch would not be engaged at the same time. This prevented depletion of tail rotor hydraulic pressure accumulators (not fitted in VH-BAA), and ensured only one switch would be required to restore hydraulics at any time. Figure 2 illustrates the two phases of the procedure.

Figure 2: AS350 Rotorcraft flight manual hydraulic failure training procedure



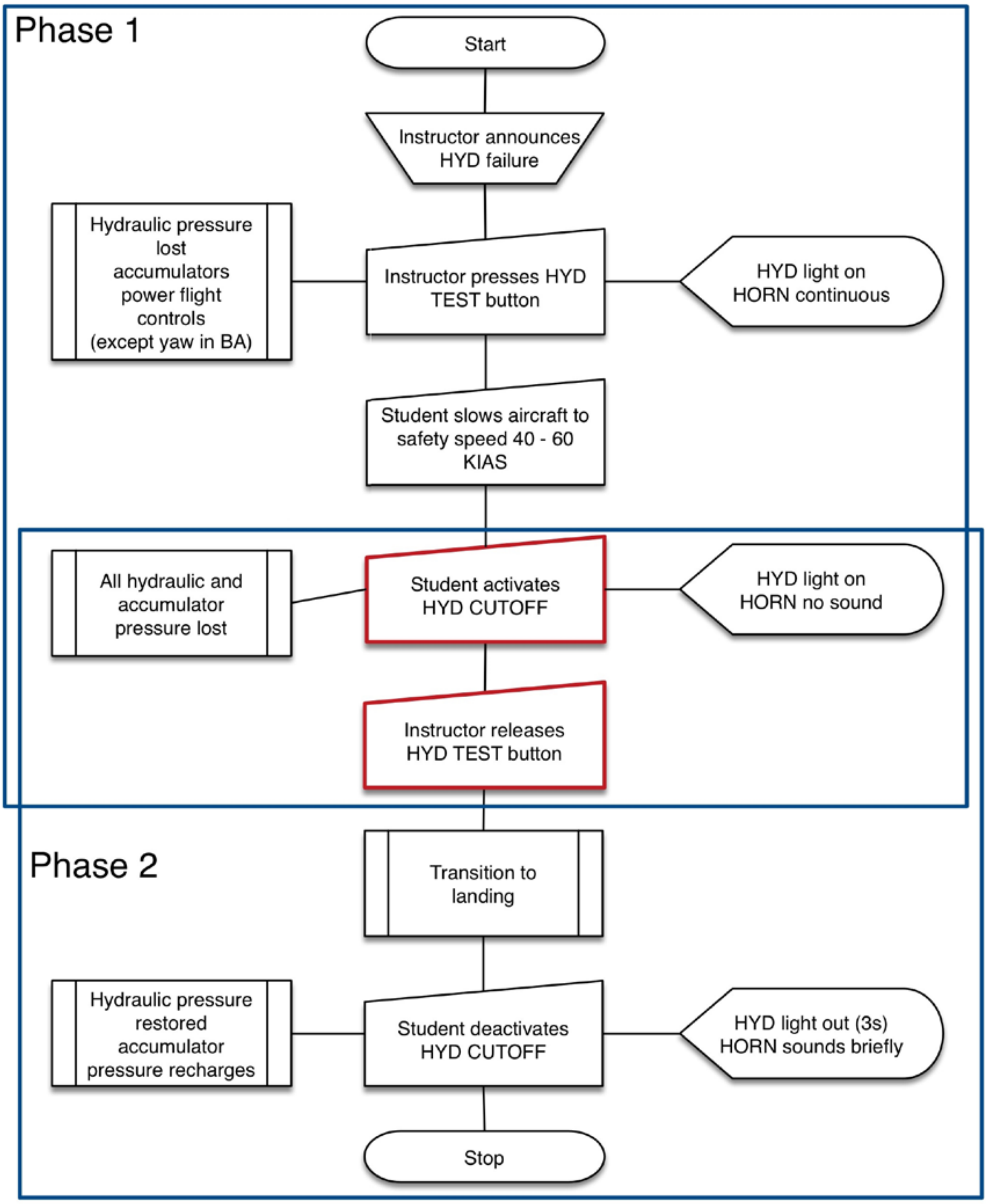
Source: ATSB. Flow chart derived from AS350 Rotorcraft Flight Manual

Incorrect sequence taught during endorsement

The instructor and the PUI advised that the flight school taught a different version of the hydraulic failure training procedure during the endorsement, and used it during the accident flight.

The procedure used had the student activate the HYD CUTOFF switch before the HYD TEST switch was released. This was a commonly-used procedure before the release of Supplement 7. An investigation into a similar accident in Canada (A13Q0021) related that flight instructors found this sequence accurately simulated a hydraulic failure. Figure 3 illustrates the procedure.

Figure 3: Hydraulic failure training procedure as taught



Source: ATSB. Flow chart derived from accounts of procedure used by flight school

VH-BAA was not fitted with a yaw load compensator. Using this procedure on an AS350 equipped with a yaw load compensator will cause total loss of tail rotor control hydraulic assistance.

Section 3 hydraulic failure emergency procedure

For completion of the transition to landing referred to in phase 2, the hydraulic failure emergency procedure from Section 3 of the RFM was to be applied. It stated:

> Keep the aircraft to a more or less level attitude. Avoid abrupt manoeuvres.

The RFM also carried the following caution:

> DO NOT ATTEMPT TO CARRY OUT HOVER FLIGHT OR ANY LOW SPEED MANEUVER. THE INTENSITY AND DIRECTION OF THE CONTROL FEEDBACK FORCES WILL CHANGE RAPIDLY. THIS WILL RESULT IN EXCESSIVE PILOT WORKLOAD. POOR AIRCRAFT CONTROL. AND POSSBILE LOSS OF CONTROL.

RFM Instructions for approach and landing were:

> Over a clear and flat area, make a flat final approach, nose into wind.
>
> Perform a no-hover/slow run-on landing around 10 knots.
>
> Do not hover or taxi without hydraulic pressure assistance.

Helicopter details

General information

The Eurocopter AS350BA,[4] was manufactured in France in 1987 (serial number 2015). It was first registered in Australia on 4 April 2000 and at the time of the accident, had accumulated 5,612 hours total time in service. It was previously registered as VH-RLU and the registration mark was changed to VH-BAA by its current owner on 20 March 2007.

VH-BAA had seating for a pilot and five passengers and was certified for day and night charter operations under the night visual flight rules. The helicopter was powered by one Turbomeca Arriel 1B turboshaft engine.

A review of Maintenance Release entries for maintenance due, showed that a 6-month inspection was required on 7 October 2017, with an over-run tolerance of 60 hours or 18 days. With the tolerance applied, the maintenance would fall due on 25 October 2017. The maintenance related to periodic greasing of the main rotor blade retaining pins.

At the time of the accident, the maintenance had not been certified on the maintenance release as complete and was overdue. No record was found in the aircraft logbook that the maintenance had been completed. While it is a pilot responsibility to ensure that a flight does not commence unless all maintenance has been completed, it is highly unlikely that the non-lubrication of the main rotor blade pins contributed to the accident.

The operator reported that VH-BAA was on temporary hire for the purposes of the endorsement training. Between 5 November and 7 November, the helicopter was operated for about 2.5 hours in the training role. Neither the initial instructor nor the PUI reported problems with the performance of the helicopter or its operation.

Hydraulic system

The aircraft was equipped with a single hydraulic system, energised by a belt-driven hydraulic pump. The hydraulic pump was regulated to provide a constant pressure of 40 bar to four flight control servo actuators. A red warning light will light at hydraulic system pressures of less than 30 bar.

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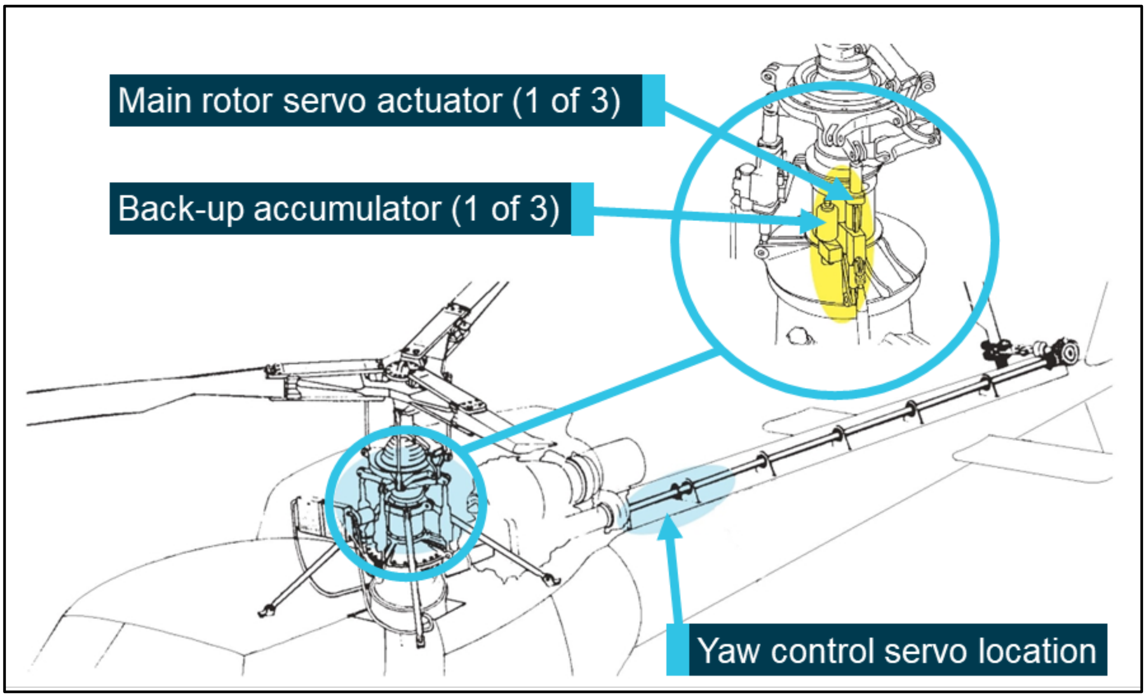
4 AS350 Squirrel: The AS350 Squirrel was originally designed and manufactured by Aérospatiale in 1975, which became Eurocopter through merger in 1992. Eurocopter was purchased and became Airbus Helicopters in 2014. At the time of writing, the AS350 was manufactured as the H125.

There were three Dunlop servo actuators for control of the main rotor and one Dunlop servo actuator for control of the tail rotor (Figure 4). With hydraulics operating, the input force required to move the rotor blades, at the cyclic,[5] is less than or equal to 0.3 kgf. For that cyclic input, at 40 bar, the system provides an output of 183.5 kgf.

Because the aircraft exhibits increasing control loads without hydraulics at high speed, and control may be lost without hydraulics in the hover, back-up accumulators are available in the hydraulic system. These accumulators store hydraulic pressure and deliver it to the servo actuators in the event of a hydraulic failure. The accumulators carry enough stored pressure for the pilot to establish the aircraft at the safety speed from cruise or from a high hover to a landing. A safety speed of 40-60 kt was stipulated in the emergency procedures section of the rotorcraft flight manual (RFM).

Figure 4: AS350 servo locations



Source: Airbus Helicopters

A yaw load compensator was fitted to later iterations of the aircraft in order to overcome excessive forces in yaw control in the absence of hydraulic assistance. VH-BAA was not fitted with a yaw load compensator, and did not have an accumulator on the yaw control. In the AS350BA, in the absence of hydraulic assistance, yaw control loads are felt directly and immediately.

Hydraulic system switches

The hydraulic system is managed via two switches. The guarded, console-mounted push-button HYD TEST switch, and the recessed, collective-mounted[6] HYD CUTOFF switch (Figure 5).

The HYD TEST switch exists to test the accumulators for the main rotor servo actuators before flight. The HYD TEST switch is OFF (out) in normal operation. Pressing the HYD TEST switch to TEST (in) creates a bypass in the hydraulic distribution block, routing pressurised fluid from the pump directly to the reservoir. This leaves the back-up accumulators to supply pressure to the main rotor servo actuators.

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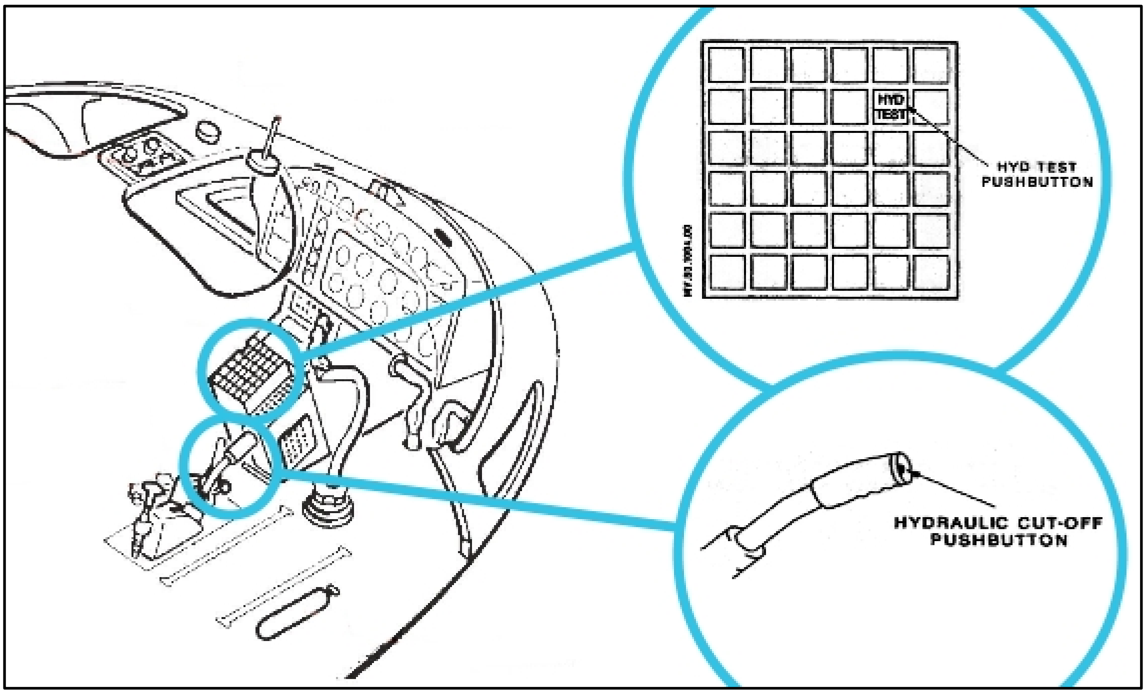
[5] Cyclic: a primary helicopter flight control that is similar to an aircraft control column. Cyclic input tilts the main rotor disc, varying the attitude of the helicopter and hence the lateral direction.

[6] Collective: a primary helicopter flight control that simultaneously affects the pitch of all blades of a lifting rotor. Collective input is the main control for vertical velocity.

The HYD CUTOFF switch is ON (out) in normal operation. Pressing the HYD CUTOFF switch OFF (in) bypasses the servos by connecting the pressure inlet and return outlet in each one. The effect is to depressurise the servos and the back-up accumulators of the main rotor servo actuators. It is used in the event of an in-flight emergency, once the safety speed of 40-60 kt has been established, to ensure that residual accumulator pressure causes no asymmetry in forces across the flight controls.

In emergency procedure training, the HYD TEST switch is used to induce hydraulic failure in flight and the HYD CUTOFF switch is used to conduct hydraulic off landings. If either switch is in, the system will not provide hydraulic pressure to the controls. As previously detailed in the section titled *Hydraulic failure training*, they should not be activated together in the AS350BA, so hydraulics can be restored with one switch.

Figure 5: HYD TEST switch and HYD CUTOFF switch locations

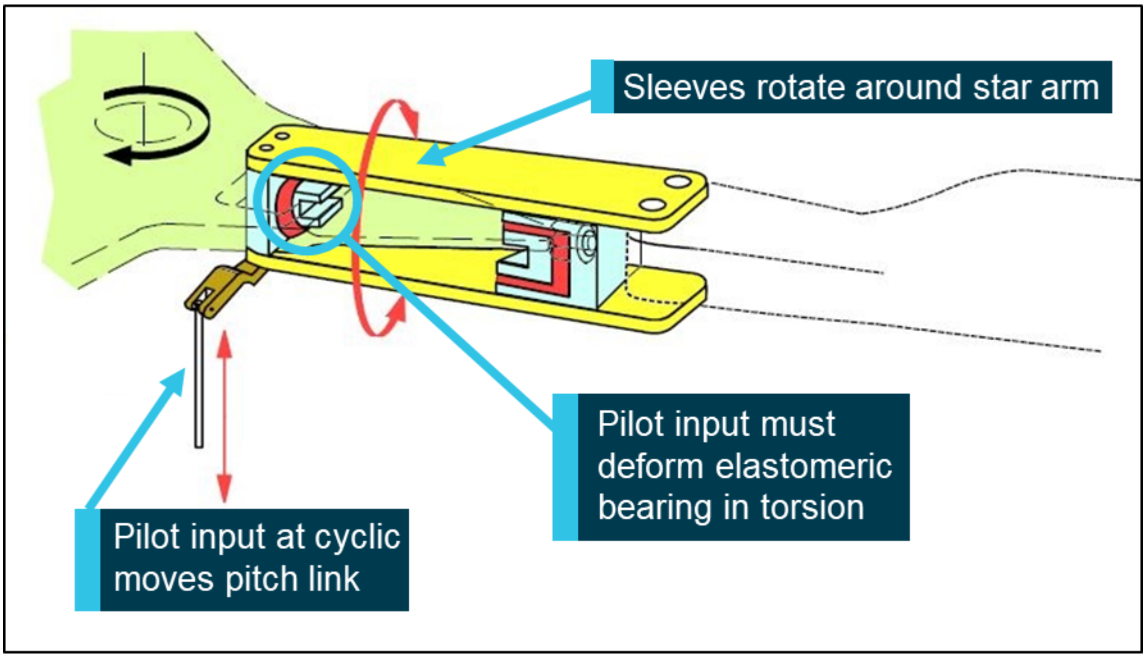


Source: Airbus Helicopters

Main rotor system

The AS350 was fitted with a starflex hub (Figure 6). This design replaced hinges with elastomeric (rubber type) bearings. Without hydraulic assistance, the pilot must exert significant effort to push or pull the flight controls to deform the elastomeric bearings, change the pitch of the blades, and control the helicopter.

Figure 6: AS350 main rotor pitch change mechanism



Source: Airbus Helicopters

The RFM states in section 3.2 that the *expected* control input forces without hydraulic pressure are:

- Left-hand cyclic load 4 to 7 kgf
- Forward cyclic load 2 to 4 kgf
- Collective 20 kgf.

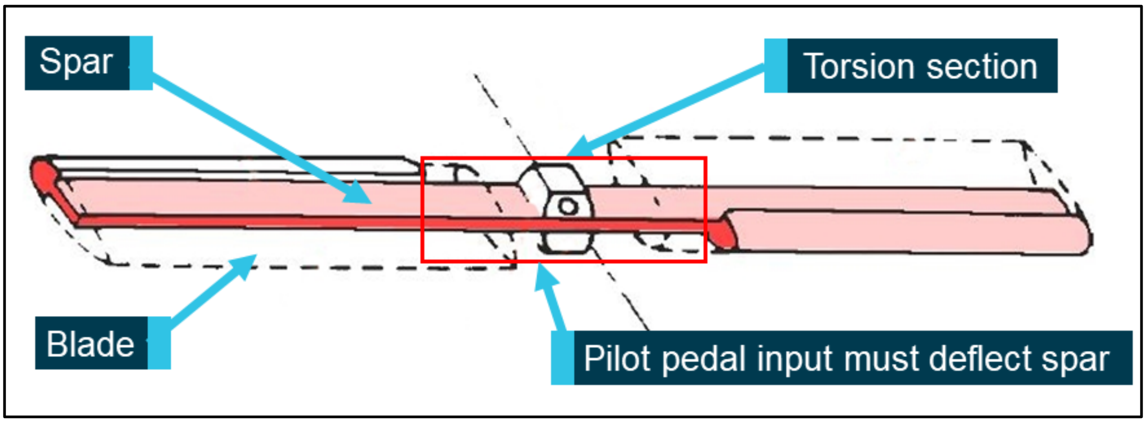
The RFM states in section 7.7 that the *maximum* forces a pilot should have to exert are:

- Lateral cyclic 15.3 kgf
- Longitudinal cyclic 17.3 kgf
- Collective forces were not stated.

Tail rotor system

The AS350 tail rotor is built on one continuous composite spar (Figure 7). Without hydraulic assistance, the pilot must push the pedals and twist the spar to change the pitch of the tail rotor blades. While helicopter weight and speed affect pedal force, the Royal Australian Air Force (RAAF) Aircraft Research and Development Unit (ARDU) (see section titled *Research*) found that a tail rotor pitch change requires a force of up to 50 kgf. Airbus Helicopters advised they were able to demonstrate significantly lower required forces in flight tests while observing flight manual limitations.

Figure 7: AS350 Tail rotor



Source: Airbus Helicopters

Automatic pilot

The aircraft was fitted with a two-axis automatic pilot system. The installation included two servos in line with the cyclic control's pitch and roll control rods. The optional collective-to-yaw linkage, that can accompany this equipment, was not a part of this installation. The automatic pilot system was not a component of the endorsement, nor was it used during the endorsement. When the automatic pilot is disengaged, the servos of the automatic pilot system act in the same way as a push/pull rod. There was no evidence to indicate that the automatic pilot system was a factor in the occurrence.

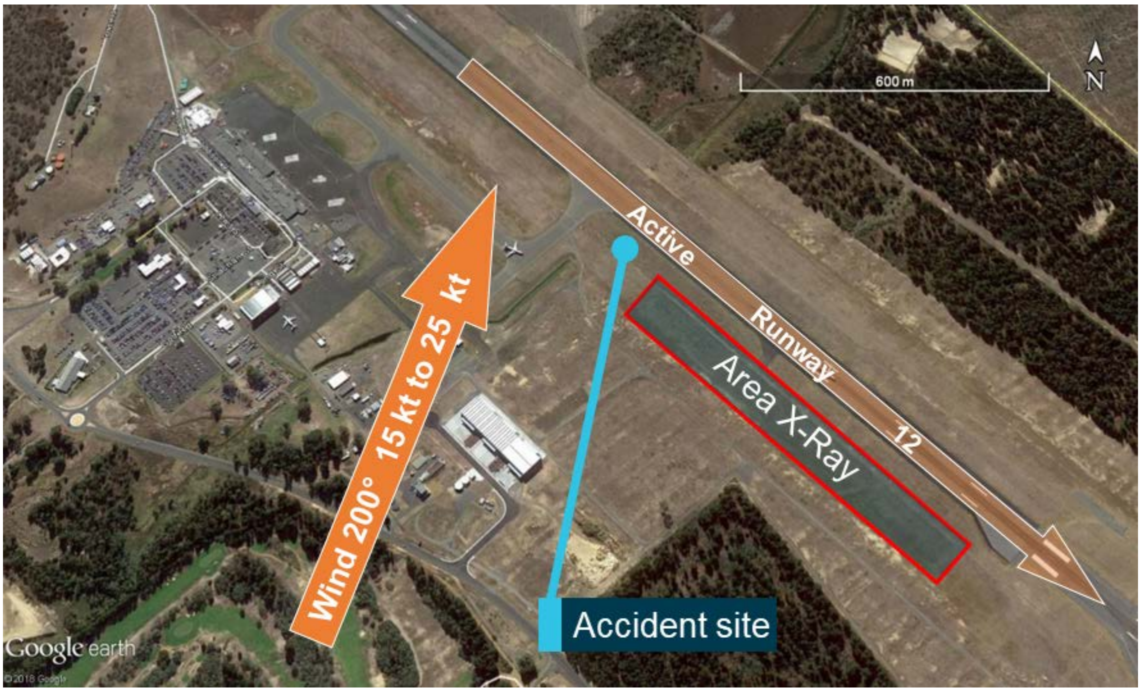
Site and wreckage inspection

Aerodrome information

Hobart Airport is on the south-east coast of Tasmania, and has a single north-west/south-east runway (Figure 8). Helicopter training area X-Ray was used on the day of the accident.

Area X-Ray was on the western side of, and 60m outside of, the runway. It was under the control of air traffic control (ATC), who provided clearances for all aircraft movements on and around the airport. A clearance was required for helicopters to overfly active taxiways and cross the runway.

Figure 8: Helicopter training area X-ray at Hobart International Airport



Source: Google earth, annotated by the ATSB

Site inspection

As the accident closed the only runway, Tasmania Police assisted the ATSB by documenting the site prior to the arrival of the on-site investigators. This allowed the wreckage to be removed, and the airport to be reopened, without jeopardising important physical evidence such as ground contact marks. ATSB investigators examined the wreckage in a secure location nearby.

There was evidence that the engine was running for a period of time after the helicopter impacted with terrain, as indicated by burnt grass in the area of the engine exhaust, though there was no fire on site. Figure 9 shows the aircraft before removal.

Figure 9: Accident site image

Source: Tasmania Police

Survivability

Immediately after the accident, ATC activated the emergency response and closed the runway. The aviation rescue and firefighting services (ARFF) stationed at the airport responded immediately to the event, reaching the accident site in 1 minute 40 seconds. The ARFF recovered the CFI from the left seat and assisted the PUI from the right seat.

Damage was indicative of significant impact on the front left side. The flexible steel legs of the skid gear, four-point harnesses, crash-resistant seats and light alloy frame of the cabin floor, all offer protection to occupants during accidents if the helicopter contacts the ground in a level attitude. The polycarbonate construction of the cabin offers very little protection to occupants if the collision involves contact with the canopy.

Investigation of previous AS350 hydraulic failure accidents identified that on initiation of the loss of control event the aircraft often rolled to the left, and initial impact with ground was on the left hand side. Consequently, the left seat occupant is likely to experience the highest impact forces during a collision. In this accident, the helicopter impacted the ground nose down while rolling to the left. As a result, there was significant disruption to the survivable space on the left side of the helicopter’s cabin.

Both pilots were wearing seatbelts with upper torso restraints, and the seatbelts and seats held during the accident sequence. This kept the right-seat pilot within a disrupted but liveable space within the cabin, contributing to his survival.

Wreckage inspection

The aircraft was inspected at a facility in Hobart.

Engine controls were found connected and secured with all attaching hardware present. The engine oil system was inspected, the oil filter, chip detector and oil were free from debris and discoloration. Fuel was tested for presence of water with no positive indication. The fuel had a clear appearance, the fuel filter was clean and the bypass indicator was indicating normal operation.

The main rotor transmission had clean oil, the casing was intact and the chip detector was free of debris. The tail rotor gearbox rotated freely with no binding, and the chip detector and gearbox oil was free of debris. The oil quantity was at the correct level.

Flight control linkages to the main rotor and tail rotor were connected, and securing hardware was in place. The hose supplying the tail rotor servo with pressure was found fractured; detailed examination concluded that was a result of impact damage.

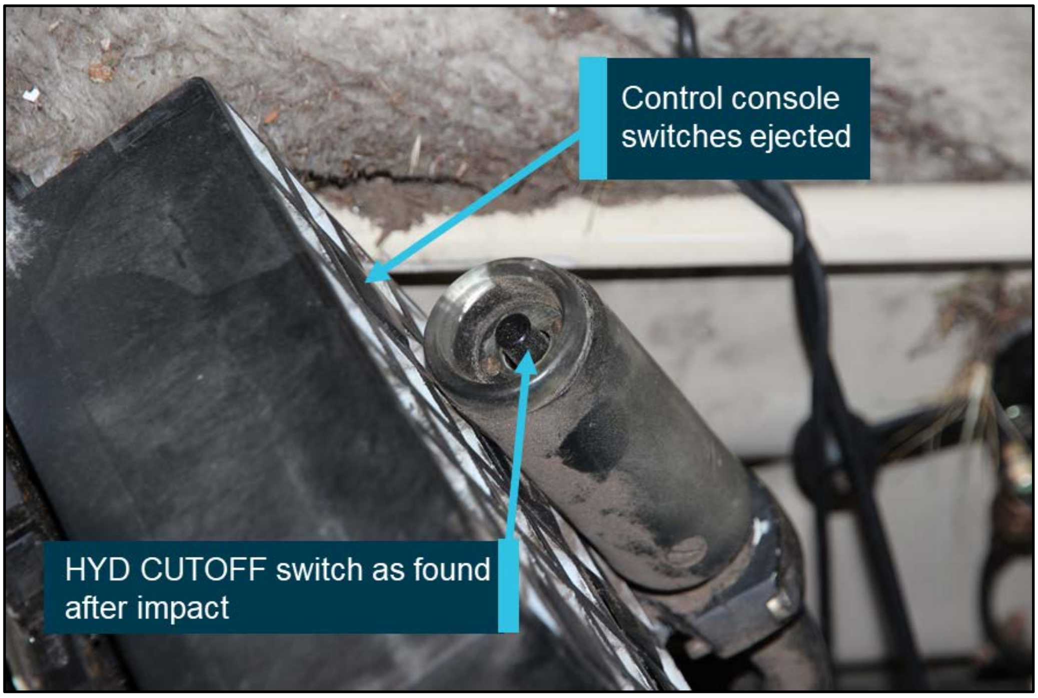
The hydraulic system lines were mounted and connected correctly, and the hydraulic pump and drive belt were intact. The hydraulic fluid had a clear appearance and the oil, chip-detector and filter were free of debris.

The back-up accumulators fitted to main rotor servos were checked for nitrogen charge and found to be serviceable. All hydraulic system shutoff valves (main and servo-mounted) were present and in place, with the wiring connected. Servo actuators were securely mounted with all electrical plugs and control rods securely in place.

Hydraulic system configuration

The HYD CUTOFF switch and the HYD TEST switch were found in the correct position for restoration of hydraulic pressure at the time of impact (Figure 10). It is possible that one or both switches moved during the impact sequence. The HYD TEST switch unit was found outside of the aircraft, in the off (normal operation) position.

Figure 10: HYD CUTOFF switch and control console as found



Source: ATSB

No pre-existing defects were identified. All damage noted was consistent with impact forces during the accident sequence.

The following items were collected for further assessment:

- Pilot's collective lever HYD CUTOFF switch
- HYD TEST switch
- Caution and Warning panel.

Hydraulic cut-off switch examination

The HYD CUTOFF switch is an 'on condition'[7] component which is tested during pre-takeoff checks, prior to every flight. Neither the initial instructor nor the PUI reported any anomaly with the switch prior to the accident flight.

Laboratory examination and comparative analysis of the HYD CUTOFF switch from VH-BAA was conducted with a new switch. They found that the switch fitted to VH-BAA at the time of the accident was susceptible to intermittent operation. The switch had a level of wear, corrosion, contamination and internal damage (Figure 11). Consequently, the mechanical latching and unlatching which cycled the internal contacts to ON or OFF could stick, and require additional effort to latch or unlatch.

Therefore, it was possible to action the HYD CUTOFF switch without restoring hydraulics, inducing a genuine emergency. The system's normal 3-second activation period could delay diagnosis of a fault.

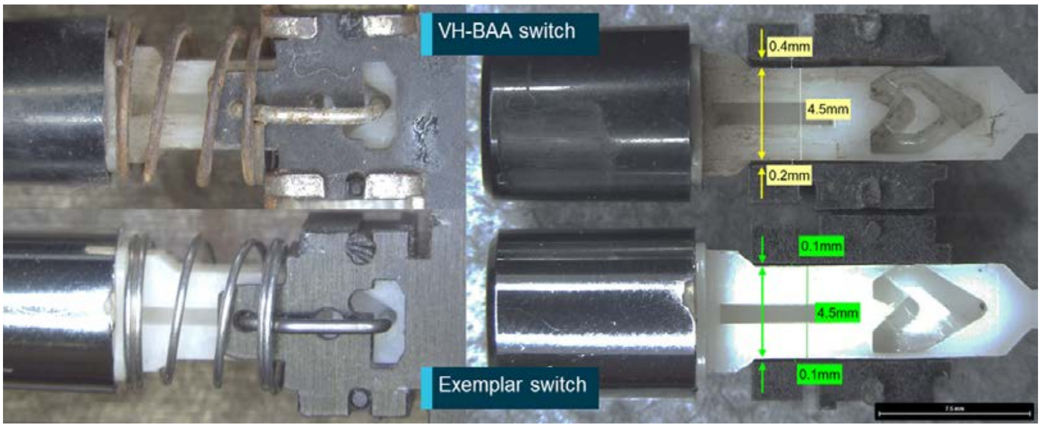
Additionally, Part 4.3 of section 7.7 of the RFM describes abnormal operations of the hydraulic system. It discusses the possibility that the switch may fail to dump hydraulic pressure from the accumulators in the event of an emergency.

> The HYD CUTOFF switch may not be effective in opening all the electro-valves, and dumping all the pressure in the accumulators simultaneously…if the hydraulic cut-off switch is rendered ineffective due to the loss of electrical power, broken wires, or a faulty switch.

The manual made no comment on the opposite case of the switch failing while restoring hydraulics after hydraulic failure training.

It could not be determined if the intermittent operation was due in part to impact-induced damage.

Figure 11: Corrosion, contamination, and wear in VH-BAA switch



Source: ATSB

Hydraulic warning system light bulb analysis

When the hydraulic system is inoperative, two incandescent bulbs light the red HYD warning light (Figure 12). Both of these bulbs were inspected for impact damage (Figure 13). The left bulb was intact and the right bulb exhibited pole whip damage (Carver, 1987). The pole whip created a brittle fracture between the terminal and the support post. There was some observed filament sag, which is consistent with an aged bulb exposed to high-impact forces. If the bulbs were illuminated at impact, provided the impact forces were sufficient, it is likely that the filaments would show evidence of stretch-type deformation damage. Therefore, it is considered probable that the HYD warning light was not illuminated at the time of impact.

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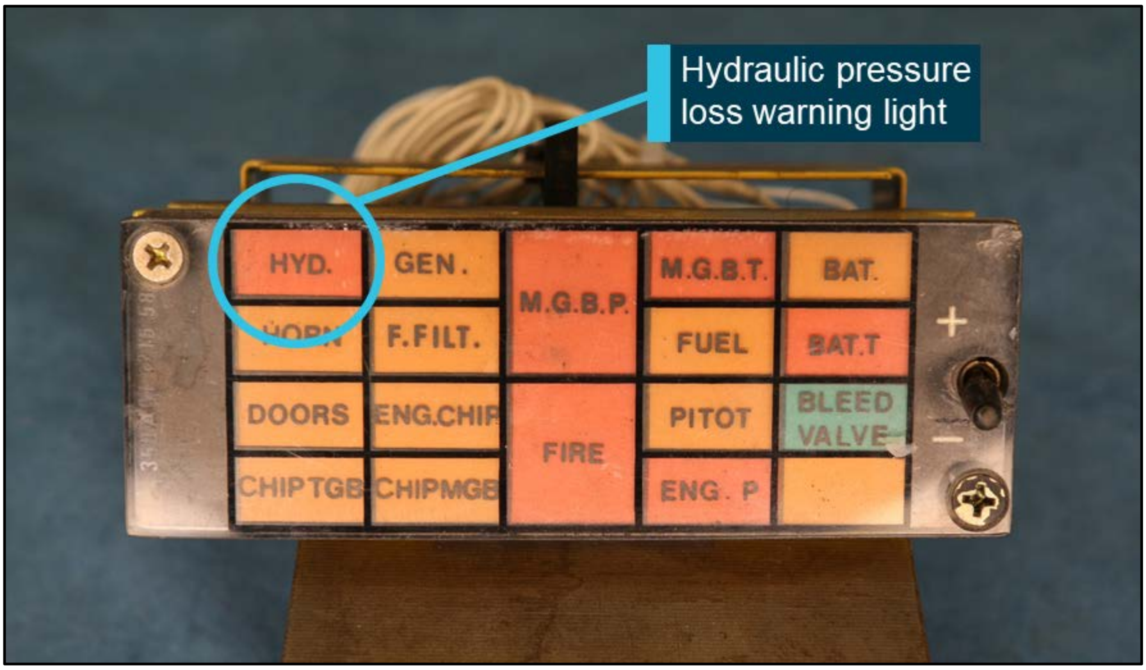
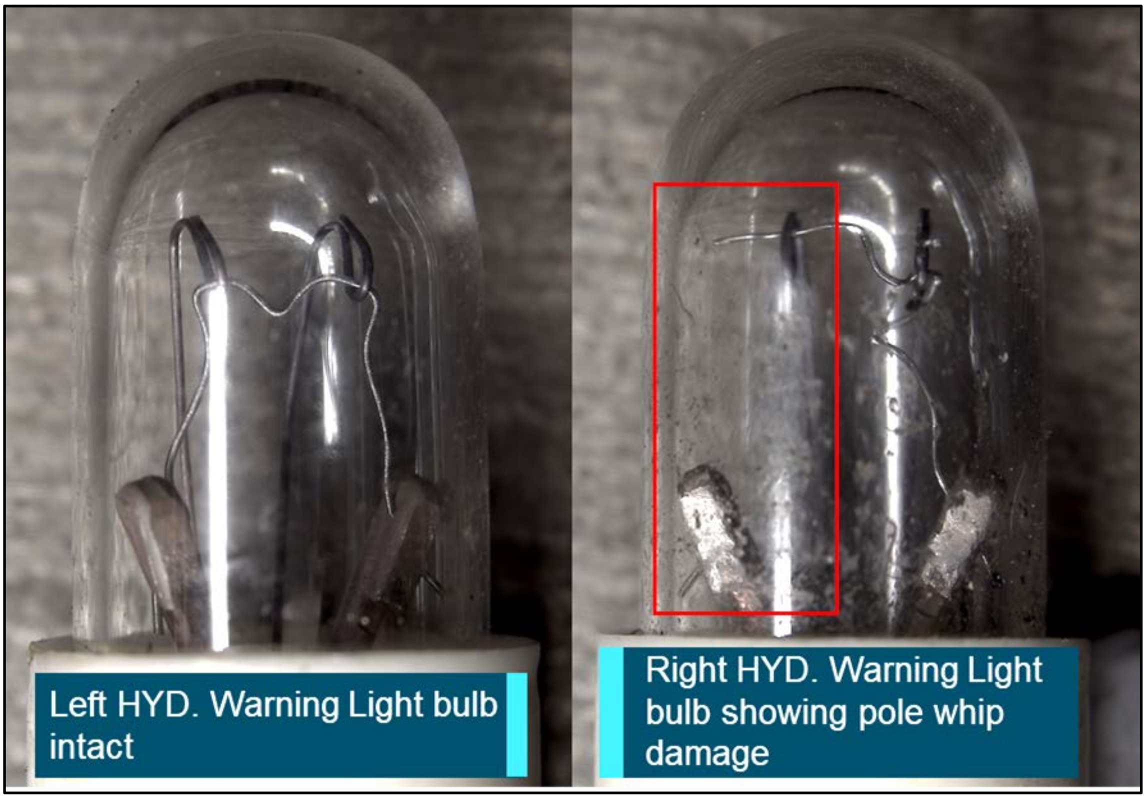
[7] On condition: an on condition item has no designated service or replacement schedule. These items would only be replaced when found to be unserviceable.

Figure 12: VH-BAA Warning – Caution – Advisory Panel



Source: ATSB

Figure 13: HYD. Warning Light bulbs



Source: ATSB

Meteorological information

The automated weather information service[8] for Hobart Airport at the time of the accident on 7 November 2017 recorded the following conditions:

- wind from 200°, minimum 15 kt maximum 25 kt
- visibility greater than 10 km
- cloud scattered[9] at 5,000 ft.
- temperature 15° C
- barometric pressure (QNH) 1019 hPa

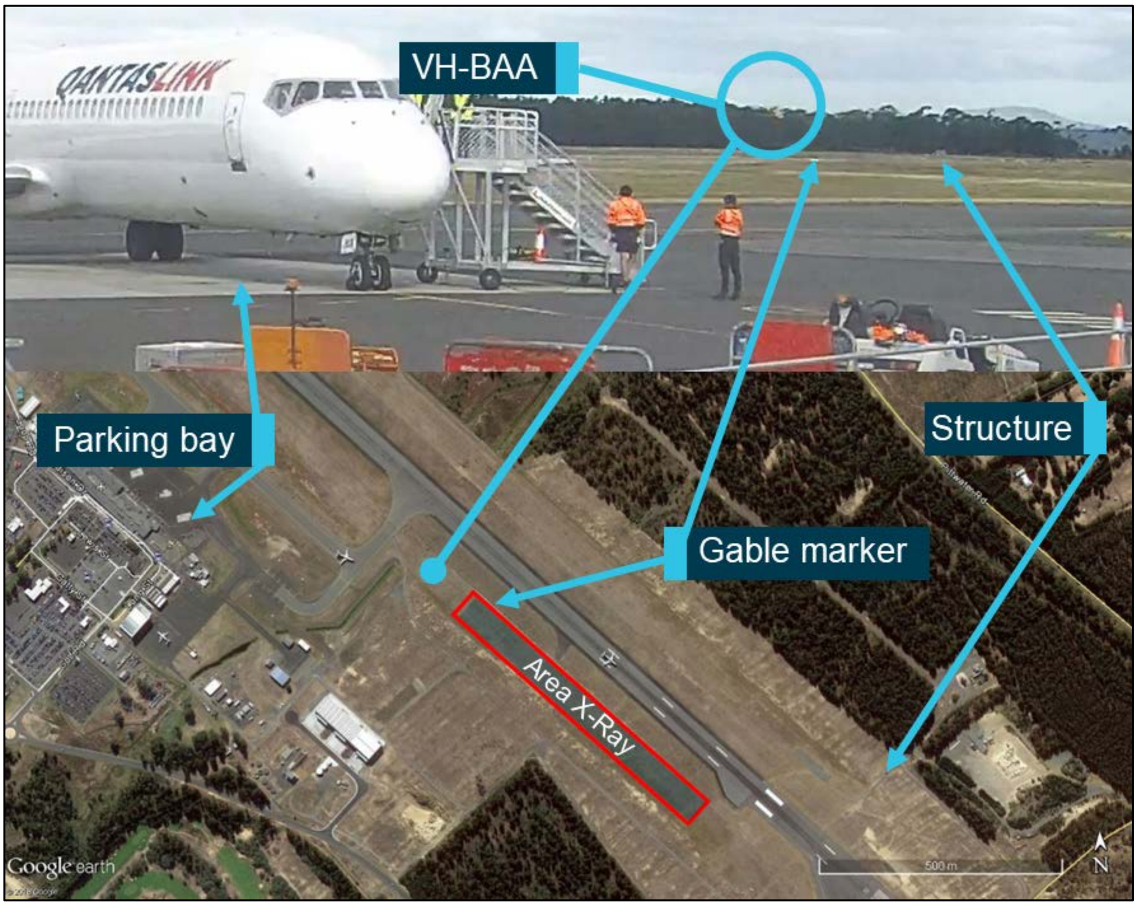
Recorded information

The aircraft did not carry any recording devices, nor was it required to.

Closed circuit television

Closed circuit television (CCTV) from the regular public transport apron of the Hobart Airport captured VH-BAA during approach, loss of control and impact. Figure 14 shows the point of view from the apron CCTV.

Figure 14: Apron CCTV point of view



Source: Hobart Airport, Google Earth, annotated by the ATSB

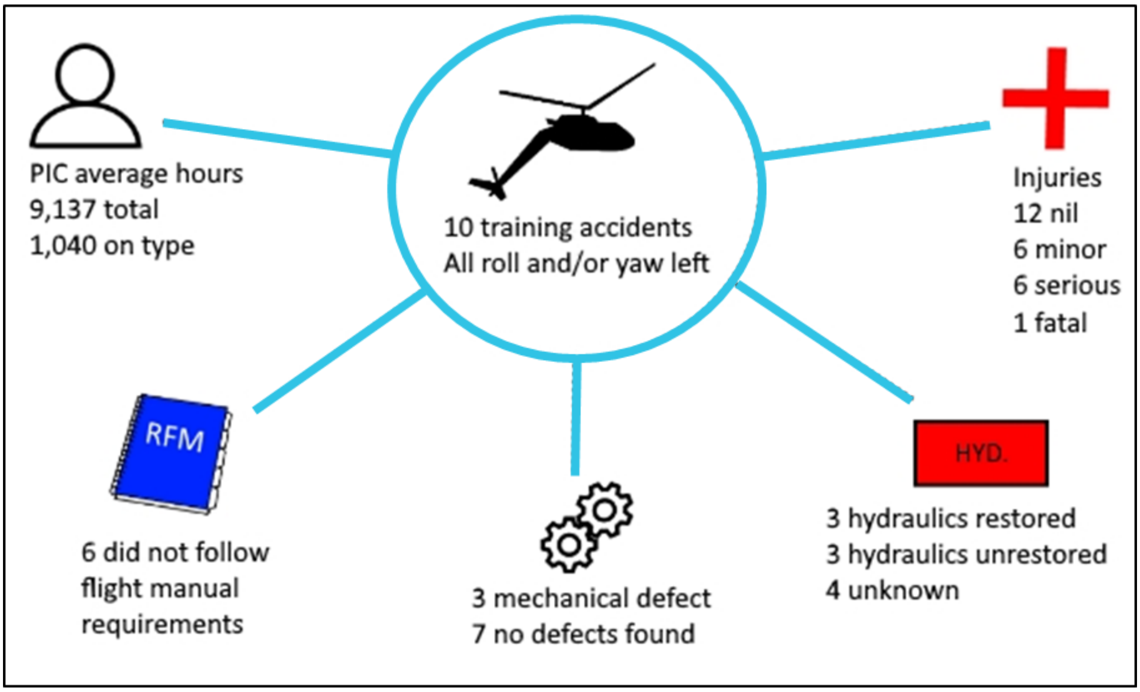
[8] Aerodrome weather information service (AWIS): actual weather conditions, provided via telephone or radio broadcast, from Bureau of Meteorology (BoM) automatic weather stations, or weather stations approved for that purpose by the BoM.

[9] Cloud cover: in aviation, cloud cover is reported using words that denote the extent of the cover – 'scattered' indicates that cloud is covering between a quarter and a half of the sky.

Related occurrences

The ATSB reviewed 34 investigations of accidents involving AS350 series helicopter's hydraulic systems worldwide. Figure 15 collates the data from ten of the accidents that occurred prior to the accident in VH-BAA, involving simulated hydraulic failure during flight training. It indicates that loss of control accidents during training do happen to highly experienced pilots. Refer to Appendix A for a synopsis of the reports and the Transport Safety Board of Canada's report A05F0025 for a list of AS350 loss of control events.

Figure 15: Overview of related hydraulic failure training accidents.



Source: ATSB

Reports of unmovable controls have been a feature of a number of accidents following commanded/uncommanded hydraulic failures in AS350 helicopters. First-hand accounts relate that, as well as the rapid and intense changes in direction and magnitude of control forces described in the flight manual, the controls can become immobile.

The manufacturer is clear on avoidance of loss of control, yet the concern of unmovable controls, which is still reported in contemporary production models of the AS350 (see AAIB report EW/C2017/05/01 page 5), is not accepted by the manufacturer. Airbus Helicopters contends that pilots are surprised by the forces required and that prevents pilots from applying sufficient force to the flight controls.

Research

AS350BA controllability research and recommendations

In 1997, the RAAF ARDU conducted an evaluation of the handling characteristics of the AS350BA, in flight without hydraulic assistance.

ARDU found lateral forces with a 30 kt wind from 30° to the front right (a 15 kt crosswind component) caused lateral cyclic forces to vary continuously and 'satisfactory lateral control could not be achieved'.

The forces required at the controls without hydraulics recorded during that evaluation were:

- longitudinal cyclic 14.8 kgf forwards at 1,700 kg all up weight while established in a hover

- lateral cyclic 6.8 kgf with a crosswind component of 15 kt
- collective (lifting) 16.2 kgf at 1,950 kg all up weight into wind at 15 kt.

Furthermore, ARDU found that at low speed with hydraulics out, pedal authority was reduced by up to 27 per cent, and that passage through free play in the pedals was required to effect a change in heading. These conditions made control difficult to retain and harder to recover. Right pedal force of 50 kgf was required to maintain a heading into wind at 15 kt.

The ARDU report concluded that with hydraulics out:

- reduced authority, free play, and excessive control forces in primary flight controls were unacceptable
- controllability below 15 kt airspeed was not reliable, and hover flight could lead to loss of control.

Following the evaluation, ARDU recommended that when conducting hydraulic failure training:

- use only one hydraulic switch at a time to simulate failure of the hydraulic system
- maintain over 15 kt during the run-on landing
- do not use over 30° angle of bank
- conduct run-on landings into wind.

Safety analysis

Introduction

The pilot under instruction (PUI) was unable to recall the majority of the practice hydraulic failure exercise after the accident. As such, there was no firsthand account of the final stages of the accident flight and the sequence of events was largely assembled from closed circuit television (CCTV) footage and wreckage examination.

This analysis will examine the observed aircraft behavior associated with the simulated hydraulic system failure, instructor intervention, and crew coordination.

Flight manual requirements

In order to safely conclude a practice hydraulic failure sequence, the rotorcraft flight manual (RFM) requires a flat final approach into wind and a no-hover/slow run-on landing around 10 kt. This is a compromise to keep the helicopter in ground effect and avoid hovering while maintaining a manageable run-on landing speed for potentially unprepared surfaces. Additionally, the requirement to conduct the run-on landing into wind provides a level of consistency in the direction of airflow across the main rotor. This simplifies the pilot’s task by minimising changes to direction and magnitude of cyclic input.

Assurance of control does not require restoration of hydraulics if the helicopter is accelerated into forward flight before the aircraft slows too much. The aircraft becomes easier to control as it is accelerated from 10 kt to the RFM safety speed of 40-60 kt. If restoration of hydraulics fails at the safety speed, the pilot in command has ample controllability to manage the genuine emergency.

Loss of control

Approaching crosswind

While the RFM requires an into wind approach, the sequence in VH-BAA was planned for approach and landing in a right crosswind of 15-25 kt. Crosswind changes the airflow across the main rotor as the aircraft slows and the crosswind becomes the dominant flow. As detailed in the Royal Australian Air Force Aircraft Research and Development Unit (ARDU) research report, this creates unpredictable changes in direction and magnitude of cyclic input, which are more pronounced when the crosswind is variable, as it was on the day. This significantly increased the pilot’s workload and can render the helicopter uncontrollable.

Analysis of the flight path of VH-BAA from the CCTV footage showed the helicopter to be controlled during the early stages of the approach. As the aircraft slowed, and the crosswind became the dominant airflow the helicopter was observed to drift and vary in pitch and yaw, consistent with the ARDU flight test observations.

Hovering without hydraulic assistance

The PUI recalled feeling a need to prevent the helicopter’s airspeed from decaying late in the approach; CCTV shows he was unable to do so. For a 3-second period, as the helicopter slowed to a hover, there appeared to be no positive control on the aircraft. Despite that, there was no apparent intervention to prevent the helicopter slowing to an out of ground effect (OGE) hover, and the sequence progressed past the boundary of assured control.

The helicopter yawed left, putting the wind behind the helicopter, and facing into an active runway. It is unlikely that this situation was commanded by choice. Instead, it is indicative of the tail rotor returning to a neutral pitch in the absence of hydraulic assistance and reduced, or ineffective, control inputs.

The OGE hover increased the magnitude of control inputs required, and induced rapid random changes in intensity and direction of control feedback forces. Due to aerodynamic couplings between controls and lag in control input and response, pilots must anticipate control inputs, and make them before they are required. However, a pilot cannot anticipate the inputs required for an aircraft subject to random perturbations in flight controls.

CCTV showed that after the aircraft came to a hover and yawed left, a positive collective input was made and the aircraft climbed. It is not known who made that input. Shortly thereafter, control of the aircraft appeared to be lost as it crossed the active runway, with excessive pitch nose down, and left roll developing. Given the nature of the helicopter movement and proximity to the ground, there was little opportunity at that point to restore control.

It is extremely unlikely that the chief flying instructor (CFI) would have entered an active runway without clearance in normal operations. An air traffic controller stated that the CFI had never previously departed area x-ray without announcing his intentions and gaining a clearance. It is therefore virtually certain that entering the runway must have been unavoidable once the aircraft departed controlled flight, or considered necessary to regain control of the aircraft.

Deviation from standard operating procedures decrease safety margins and increase opportunity for an accident (Sumwalt and Lemos, 2010). Both the flight manual and the ARDU research paper identified that operating outside of the prescribed procedure would probably result in a loss of control.

Control not restored

Hydraulic system restoration

Light bulb analysis of the hydraulic system fault warning lights indicated that it was probable that the HYD fault light was not illuminated at the time of impact with terrain. Further, both the HYD TEST and the HYD CUTOFF switches were in the normal flight (hydraulic system on) configuration during post-accident examination. While the switch position is less reliable than the light bulb analysis, in combination the ATSB concluded that it was likely that the switches were moved to restore hydraulics prior to impact.

The collective input immediately prior to crossing the runway was 9 seconds prior to collision with terrain. The hydraulic system was likely restored at a point between 9 seconds and 4 seconds before impact. As identified during the investigation of past similar accidents, delays in restoration of the hydraulic system can prevent control recovery.

Restoration of the hydraulic system was potentially delayed due to:

- use of an incorrect hydraulic failure training procedure
- lack of a pre-flight brief to develop common understanding between crew
- a potential intermittent failure of the HYD CUTOFF switch.

The level of contribution, if any, of each factor could not be determined, though each increased risk in the operation.

Incorrect hydraulic failure training procedure

The procedure used to simulate failure of the hydraulic system did not match the requirements of the RFM, and overlapped the two phases of the procedure. It released the hydraulic test (HYD TEST) switch after activation of the hydraulic cut-off (HYD CUTOFF) switch. This introduced a hazard into the operation.

Distraction could lead to the HYD TEST switch being forgotten and remaining in. In this configuration, a pilot must activate two switches to restore hydraulics. This would lead to a failure to restore hydraulics when commanded via the HYD CUTOFF switch. Such an event would lead to delayed restoration, due to time taken to diagnose the problem and release the HYD TEST switch. Although as detailed in the section above, it is probable that the HYD TEST switch was released during the occurrence flight, it could not be determined at what point that occurred.

Crew coordination and pre-flight preparation

Instructing is a complex task and instructors must balance the benefit to the student's learning and experience with safe margins of operation in a dynamic environment. Instructor intervention is a critical control in flight training. It is often the final opportunity to retain control of the aircraft.

In intervention, an instructor has three time-sensitive options:

- adjust – fix the issue and allow student to continue
- restore – return to normal flight
- complete – take over and complete the sequence.

Intervention is supported by clear assessment, communication, and planning. The PUI received a classroom briefing on emergencies from the original instructor and the CFI received a briefing on the status of the PUI from the same instructor. However, possibly due to the delayed departure, the CFI and PUI did not conduct a pre-flight briefing.

The requirement for a pre-flight brief, especially where non-normal operations are conducted is well-established. Such a briefing reaffirms standard operating procedures, promotes predictable behaviour, and sets expectations among crew (Sumwalt and Lemos, 2010). In this case, the absence of a brief was a missed opportunity to establish correct procedure, and generate a common understanding of how the practice emergencies would be conducted.

Once in the aircraft, the CFI advised he would announce practice emergencies and expected the PUI to fly and manage the aircraft. Any unannounced emergencies were to be considered real and the PUI should take immediate essential actions; the CFI would take over if necessary. This is a commonly relied upon arrangement in flight training yet, as an unsafe condition can develop rapidly during the simulation of emergencies, it often requires further definition and understanding between the pilots to be effective.

Additionally, during emergency training, the transition from practice emergency to a genuine emergency is not always clear. Ordinarily available cues for an emergency are defeated, warning lights may already be illuminated, and alarms may or may not sound. The PUI has, by definition, little working knowledge of the aircraft to support diagnosis. Not knowing the aircraft state creates ambiguity, which is known to delay decision-making (Orasanu, and others, 2001).

On this occasion, the absence of a shared mental model of when or how to terminate the sequence may have led to:

- no one controlling the aircraft
- both pilots controlling the aircraft
- a late intervention to prevent hovering
- a delay in restoration of hydraulics

Due to a lack of available information however, it was not possible to determine to what extent the lack of pre-flight brief contributed to the accident.

Findings

From the evidence available, the following findings are made with respect to the fatal loss of control accident involving Eurocopter AS350BA, registered VH-BAA at Hobart Airport on 7 November 2017. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing factors

- The rotorcraft flight manual hydraulic failure emergency procedures were not followed. Specifically, the final approach was flown with a significant right crosswind and the helicopter was allowed to slow to a high hover.
- The hydraulic failure training sequence was allowed to progress to a point where control was no longer assured.
- Hover flight without hydraulic assistance led to loss of control of the aircraft.
- The hydraulic system was restored too late in the sequence to recover control of the aircraft. The reason for late restoration could not be determined.

Other factors that increased risk

- The operator did not follow the hydraulic failure simulation procedure required by the manufacturer. This introduced a hazardous condition with potential to delay restoration of hydraulic assistance.
- The collective mounted hydraulic cut off switch showed signs of excessive wear and intermittent operation. The switch may have required multiple actions to return hydraulic assistance when activated, potentially delaying restoration of the hydraulic system.
- The chief flying instructor and pilot under instruction did not conduct a pre-flight brief, to develop a shared understanding of how the hydraulic failure sequence would be conducted. This may have led to confusion over aircraft control and delayed restoration of the hydraulic system.

General details

Occurrence details

Date and time:	7 November 2017 – 1722 EDT	
Occurrence category:	Accident	
Primary occurrence type:	Loss of control	
Location:	Hobart Airport	
	42º 50’ 10” S	147º 30’ 37” E

Aircraft details

Manufacturer and model:	Eurocopter AS350BA	
Registration:	VH-BAA	
Operator:	Rotorlift Aviation	
Serial number:	2015	
Type of operation:	Flight training	
Departure:	Hobart Airport	
Destination:	Hobart Airport	
Persons on board:	Crew – 2	Passengers – nil
Injuries:	Crew – 1 fatal, 1 serious	
Aircraft damage:	Destroyed	

Sources and submissions

Sources of information

The sources of information during the investigation included the:

- aircraft operator
- pilot under instruction
- instructor
- Airservices Australia
- Civil Aviation Safety Authority
- previous accident investigation reports
- ATSB aviation occurrence data
- Airbus Helicopters

References

Civil Aviation Safety Authority 2012, Civil Aviation Advisory Publication 5.14-2, Flight Instructor Training, on-line, www.casa.gov.au/rules-and-regulations/current-rules/civil-aviation-advisory-publications

Kouabenan, D.R., Ngueutsa, R., Mbaye, S. 2015, Safety climate, perceived risk, and involvement in safety management, *Safety Science*, 77, 72-29.

Orasanu, J, Martin, L, & Davison, J. (2001). Cognitive and contextual factors in aviation accidents, in E Salas and G Klein (Eds.) *Linking expertise and naturalistic decision making*, Lawrence Erlbaum Mahwah NJ. 209–226.

Sumwalt, R.L., Lemos, K.A. 2010, *The Accident Investigator's Perspective*, Crew Resource Management, pp. 399-423.

Weber, E.U., Milliman R.A. 1997, Perceived risk attitudes: Relating risk perception to risky choice, *Management Science*, 43(2), 123-144.

Submissions

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

A draft of this report was provided to the flight-training organisation, pilot under instruction, instructor, Airservices Australia, the Civil Aviation Safety Authority, the Bureau of Meteorology, and the aircraft manufacturer.

Submissions were received from the flight-training organisation, the Civil Aviation Safety Authority, the instructor and the aircraft manufacturer. The submissions were reviewed and, where considered appropriate, the text of the report was amended accordingly.

Appendix A

Synopsis of related occurrences

National Transportation Safety Board (US) LAX92FA025 - 1991

> At an airspeed of about 2 knots and a skid height of about 1 foot, the helicopter began an uncommanded turn to the left. The pilot attempted to counter the turn but was unable to move the flight controls**.** The helicopter's left bank angle, nose down attitude and left turn continued until the main rotor blades struck the ground.

National Transportation Safety Board (US) IAD99GA056 - 1999

The aircraft developed an uncontrollable roll to the left while hovering without hydraulic assistance.

> …the helicopter began an uncontrollable roll to the left while at the hover…I tried to level the helicopter by using both hands to attempt to pull the cyclic control to the neutral/level position**.** The helicopter continued to roll left and and subsequently the main rotor blades hit the ground.

Excessive flow rates were detected in all servos and two were rejected in a speed test.

National Transportation Safety Board (US) LAX00LA195 - 2000

The student struggled to control the aircraft towards the end of an approach with hydraulics off. The instructor took over and requested return of hydraulics. The student switched on the hydraulic system. Controls remained stiff and the helicopter impacted terrain.

> He reported that just prior to touchdown, the aircraft controls became very stiff. At that point, the flight instructor directed the pilot trainee to re-engage the hydraulics isolation switch on the collective control. The student re-engaged the hydraulics but reported that the controls remained stiff and he was having difficulty applying forward cyclic. As the instructor got on the controls it started a slow turn to the left. As the instructor attempted to counteract the turn rate increased. The helicopter impacted the ground in a left turn with rear lateral movement.

National Transportation Safety Board (US) ATL02LA097 - 2002

The training and checking captain was unable to control the aircraft while hovering without hydraulic assistance.

> The check airman then stated that he would demonstrate the handling characteristics of the helicopter in the hydraulics off configuration. The check airman brought the helicopter to a hover approximately three feet above the ground. At that time the helicopters nose appeared to pitch up dramatically. This attitude was followed by a simultaneous rotation about the yaw axis. As the spin accelerated the check airman instructed the airline transport rated pilot to restore the hydraulics, which was done by depressing the switch on the collective. The rotation of the helicopter continued, and the helicopter impacted the ground coming to rest on the right side of the fuselage.

National Transportation Safety Board (US) ANC02FA029 - 2002

> He brought the helicopter to a hover about four feet above the road. According to the pilot, the cyclic was frozen in the full aft left position when he lost control**.** The helicopter rolled left, and struck the ground inverted.

Air Accidents Investigation Branch (UK) EW/C2004/10/05 - 2004

The AAIB found that the instructor did not follow flight manual procedure for hydraulic failure training, leading to the HYD TEST switch being activated at the same time as the HYD CUTOFF switch. The instructor did not attempt to restore hydraulics and was unable to recover the aircraft.

Transportation Safety Board of Canada A05F0025 - 2005

> As the pilot gradually descended, and at a height of about 10 feet above ground level, he experienced significant binding in the flight controls**.** The pilot was unable to rectify the control binding and had considerable difficulty maintaining attitude and altitude control of the helicopter.

It should be noted that the pilot had not received any of the conventional alerts of hydraulic malfunction, such as the klaxon or the warning light.

National Transportation Safety Board (US) LAX07GA217 - 2007

While attempting to regain control at the bottom of a failed hydraulics off approach, the student did not restore hydraulics when requested by the instructor. The student stated that they were told it was dangerous to do so as it could induce over control. The instructor was unable to recover the aircraft.

> The CFI [chief flying instructor] noted that the slowest airspeed the helicopter ever reached was a minimum of 8 kts. He added that he was not sure if the cyclic was immobile in any additional direction**,** aside from the forward-right position, as he did not move it into another direction to prevent possible further loss of control of the helicopter. The CFI estimated that he performs hydraulics-off simulated emergency procedures on a regular basis; he has never experienced any problems or difficulty controlling the helicopter.

A lateral servo was found to be rigged out of limits and mushroom deformation existed on the longitudinal servo.

National Transportation Safety Board (US) LAX08IA042 - 2007

Unlocking pressure on one hydraulic servo was too high and created a control lock. The instructor landed the helicopter by following the emergency procedure from the flight manual.

The CFI immediately noticed that an abnormal force was required on the cyclic control to prevent the helicopter's nose from pitching up and to the left.

> The CFI elected to continue the landing with the hydraulics off …. He managed to complete a run-on landing without mishap by maintaining an airspeed of about 10 kts. When the helicopter came to rest, the pressure was released on the cyclic and the second pilot restored the hydraulics via the collective switch. Immediately thereafter, the cyclic began a hard over and displaced to the left against the CFI's leg. He attempted to center the cyclic with both hands, but he was unable to move the control.

National Transportation Safety Board (US) WPR10LA046 - 2009

The student lost control during hydraulic failure training. The instructor’s delayed input and a lack of positive exchange of control contributed to accident.

> The instructor told the PUI [pilot under instruction] to turn the hydraulics back on. The helicopter continued in a nose low attitude and in a left bank of about 15-30 degrees. The pilots both stated that they could not move the cyclic in the lateral axis. The helicopter continued the rotation with the nose low attitude until ground impact.

Transportation Safety Board of Canada A13Q0021 - 2013

The TSB found that the instructor did not follow flight manual procedures for flight without hydraulic assistance. The instructor encountered heavy unpredictable control forces and could not recover from a steep left roll.

> The flight instructor took off in manual mode and again flew a tight left pattern at low speed and low altitude. At the end of the base leg, at the beginning of the final approach, the helicopter momentarily reached a level attitude. Just before the flight instructor handed the controls to the pilot in training, the helicopter banked slightly to the left and then quickly rolled to the left in a nose-down attitude, and the main rotor struck the runway.

Air Accidents Investigation Branch (UK) EW/C2017/05/01 - 2017

The instructor lost control while flying a tight low-level left-hand circuit without hydraulic assistance and at a high angle of bank.

> When interviewed**,** the instructor stated that he had been unable to move the cyclic control to the right to arrest the roll to the left**.**

Appendix B

For a full copy of the safety information notice click the hyperlink

[Airbus Helicopters Safety Information Notice 3246-S-29 Rev1 2019]

AIRBUS HELICOPTERS

No. 3246-S-29

SAFETY INFORMATION NOTICE

SUBJECT: HYDRAULIC POWER

HELICOPTER WITH SINGLE HYDRAULIC POWER SYSTEM - Hydraulic failure training

For the attention of	

AIRCRAFT CONCERNED	Version(s)	
	Civil	Military
AS350	B, BA, BB, B1, B2, B3, D	L1
AS550		A2, C2, C3, U2
AS355	E	

The purpose of the revision of this "Safety Information Notice" is to inform the customers and operators that the video describing the good practices related to the hydraulic failure training procedure has been completed with a quiz to check for good understanding of this procedure.

The analysis of various incidents and accidents that have occurred during the hydraulic failure training phases on helicopters equipped with a single hydraulic power system has shown that the majority of these incidents and accidents were the result of a loss of control at low speeds due to a lack of understanding or a lack of compliance with the training procedure described in Supplement 7 of the Flight Manual.
The following errors are the most frequent:
- simulation of a failure in hover flight or at low speed,
- flight maneuvers at low speed without hydraulic power,
- landings performed from a hover flight phase instead of a running landing,
- etc.

In order to provide a practical tool to better understand and comply with the hydraulic failure training procedure, Airbus Helicopters has created a training video. The procedure was filmed from the cockpit of an AS350 B3e (AS350 B3 with Arriel 2D engine) equipped with a single hydraulic power system. The video shows the different phases and steps in the procedure, and also points out the errors to be avoided. The various training phases and instructions described in the video are applicable to all versions of the Ecureuil equipped with a single hydraulic power system**.

The flight crew for this training exercise is an instructor pilot and a trainee pilot. The video is mainly intended for instructor pilots.

In addition to this video, Airbus Helicopters has introduced a questionnaire to check your understanding of the hydraulic failure training procedure.

Revision 0 2018-07-09
Revision 1 2019-12-10

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This document is available on the Internet: www.airbushelicopters.com/techpub/

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 the ATSB's 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.

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 factor: a 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 factor would probably not have occurred or existed.

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

Other findings: 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.