Australian Government

Australian Transport Safety Bureau

In-flight break-up involving Cicaré CH-7B, VH-SWQ

43 km north-west of Barcaldine Airport, Queensland | 12 May 2014

Investigation

ATSB Transport Safety Report

Aviation Occurrence Investigation

AO-2014-086

Final – 5 February 2016

Cover photo source: Cicaré Helicopters SA, modified by ATSB

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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

Addendum

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Safety summary

What happened

On 12 May 2014, the pilot of a Cicaré CH-7B amateur-built helicopter, registered VH-SWQ, was involved in spotting operations for a cattle muster on a private station 43 km north-west of Barcaldine, Queensland. After communication with the helicopter was lost during the muster, a search party found the crashed helicopter inverted by a dry creek bed. The private pilot, who was the sole occupant, died in the accident and the helicopter was destroyed.

CH-7B helicopter example

Source: Cicaré Helicopters SA, modified by ATSB

What the ATSB found

The wreckage and its distribution pattern were consistent with an in-flight break-up.

The ATSB found that the stabiliser assembly separated from the tail boom in-flight and contacted the tail rotor blades. The resulting imbalance from the damaged tail rotor blades led to separation of the tail rotor gearbox assembly from the helicopter, and subsequent loss of control and collision with terrain.

The ATSB's technical examination found that the stabiliser assembly failed due to cracking associated with metal fatigue.

What's been done as a result

On 6 March 2015, in consideration of the potential fleet implications of the failure mechanism of the stabiliser assembly on VH-SWQ, the ATSB sent an advisory letter to all Australian registered CH-7B owners alerting them to the circumstances of the accident. The letter highlighted the importance of maintaining and operating their helicopter in accordance with the manufacturer's requirements. The letter also advised owners to discuss any serviceability concerns with the manufacturer before further flight. Owners were also reminded to seek advice from an appropriately licenced aircraft engineer and/or the Civil Aviation Safety Authority.

In addition, registered owners were notified on 6 August 2015 of an accident involving another CH-7B, which occurred on 28 July 2015. This accident is also being investigated by the ATSB (investigation AO-2015-089, available at www.atsb.gov.au) and has identified a second cracked stabiliser. The ATSB is working to establish the origin of the stabiliser failures.

Safety message

Helicopter pilots and operators should be aware of the potential dangers of abnormal vibration levels. Changes in vibration may indicate an impending failure of a component or structural part. While experience will assist a pilot to determine what vibration is normal, accurate assessment can only be made by qualified personnel using specialised equipment.

Various dynamic components need to be balanced within the manufacturer's limits during maintenance to enable the service life to be achieved and ensure the safety of the helicopter and its occupants.

Ongoing safety requires aircraft owners and maintainers to operate and maintain the aircraft in accordance with relevant regulations, including those specific to experimental aircraft. While the regulations allow for an experimental aircraft builder to be granted approval to conduct ongoing maintenance, the builder must have sufficient engineering skill and knowledge.

Contents

The occurrence

At about 0630 Eastern Standard Time[1] on 12 May 2014, a pilot flew an aeroplane from his home near Barcaldine to Longreach Airport, Queensland, arriving about 0700. The purpose of the flight was to allow the pilot to collect his Cicaré CH-7B helicopter, registered VH-SWQ (SWQ), following scheduled maintenance.

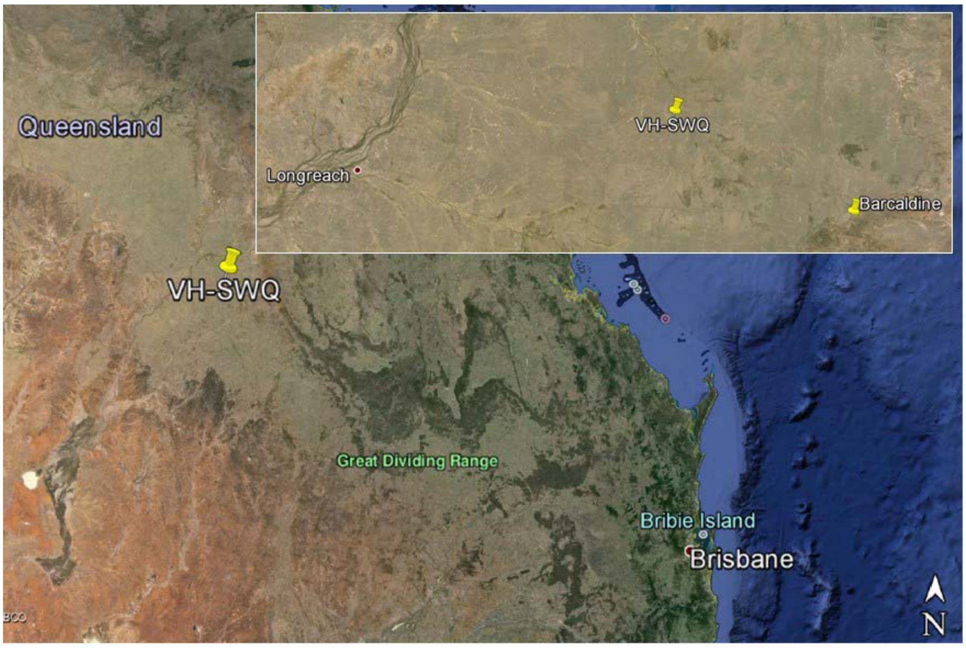
At about 0800, the pilot departed Longreach Airport in SWQ, for a property, about 43 km north-west of Barcaldine (Figure 1), arriving about 0845. The pilot was to provide aerial spotting services in support of a cattle muster while remaining in radio contact with the musterers situated on motorbikes.

At about 0900,[2] the pilot refuelled the helicopter from a 200 L drum containing premium unleaded fuel. Around this time the pilot was observed using a spanner to make an adjustment to a bolt in the tail rotor gearbox area. The pilot then started the helicopter and was observed flying to the northern side of the property to commence spotting operations. Witnesses advised that the pilot refuelled the helicopter several more times during the day. All personnel had lunch from about 1315 until 1345.

Following lunch, mustering operations continued with regular sightings of SWQ and ongoing radio communication between the pilot of the helicopter and those on the ground. The final sighting of SWQ was at about 1600. At about that time one musterer also reported hearing a ‘screeching’ noise on the radio but was uncertain of its origin. Sometime between 1630 and 1700 members of the mustering party became concerned that they had not heard from the pilot for some time. After several further attempts to re-establish radio contact failed, a search of the property was initiated.

At about 1800, with available light reducing, emergency services were contacted, and a search party was formed. At about 1955, alerted by the smell of fuel, a member of the search party located the helicopter inverted, by a dry creek bed. The pilot was fatally injured and the helicopter was destroyed. There was no fire.

Figure 1: VH-SWQ accident site location, about 43 km north-west of Barcaldine Airport



Source: Google earth, modified by the ATSB

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1 Eastern Standard Time (EST) was Co-ordinated Universal Time (UTC) + 10 hours.

2 All times relating to activities on the station are approximate.

Context

Pilot information

The pilot was issued with a Private Pilot (Aeroplane) Licence in 1999, a Private Pilot (Helicopter) Licence in 2013, and was endorsed to fly Robinson R22 and Bell 47 helicopters. As the pilot held these helicopter endorsements, in accordance with Civil Aviation Order (CAO) 40.3.0, the pilot was authorised to fly SWQ in the small single-engine helicopter class. The pilot also held a valid Class 2 Aviation Medical Certificate.

A review of the pilot's aeroplane logbook showed inconsistent recording of hours flown, with no entries between April 1999 and July 2004. The last record was on 29 August 2004, indicating a total of 399.9 hours flying experience in aeroplanes. In July 2013, the pilot indicated on his aviation medical questionnaire that he had accumulated a total of about 9,000 hours. The last entry in the pilot's helicopter logbook was on 16 October 2013 indicating that he had accrued a total of 50.5 hours helicopter flying experience.

Using the pilot's helicopter logbook, one completed maintenance release and the aircraft's hour meter,[3] it was determined the pilot had attained about 385 hours flying experience in helicopters, with 333.9 hours in SWQ. All of the experience in SWQ was gained in the last 6 months and the pilot had flown about 160 hours in the previous 90 days. Relatives reported that the pilot was well rested and had not flown in the days prior to the accident.

Post-mortem and toxicological examinations did not reveal any preconditions or substances that would have affected the pilot's ability to fly the helicopter.

Aircraft information

SWQ was a single-seat, amateur-built[4] Cicaré CH-7B helicopter, serial number 011, that was powered by a Rotax 912 ULS four-cylinder piston engine. It had a two–blade, semi-rigid main rotor system and a two-blade tail rotor system. The helicopter manufacturer is located in Argentina with the kits and product support available through an Australian distributor.

Construction and certification

The helicopter was built in Australia in 2011 from a kit supplied by the manufacturer and issued with Special Certificate of Airworthiness (SCOA) PVL/SWQ/01 on 16 December 2011 to enable the conduct of 'Initial Flight Test in Restricted Areas'. Following successful completion of 25 hours of required flight testing, SCOA PVL/SWQ/02 was issued on 13 October 2012. The helicopter was designated in the Experimental Category for the purpose of 'Operating an Amateur Built Aircraft' and was subject to conditions that were noted on the certificate, including that:

> In the event that the ownership of this helicopter should pass to anyone other than the current owner/builder, all subsequent maintenance is to be performed by a suitably licenced LAME *(Licenced Aircraft Maintenance Engineer).*

As the occurrence pilot had purchased the helicopter from the original owner/builder, he was not permitted to conduct maintenance on SWQ.

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[3] The hour meter records engine operating time and displays hours and tenths of an hour.

[4] An amateur-built aircraft is an aircraft, the major portion (more than 50 per cent) of which has been fabricated and assembled by a person who undertook the construction project solely for their own education or recreation (Civil Aviation Safety Authority definition).

Airworthiness and maintenance

The Civil Aviation Safety Authority (CASA) logbook statement indicated the helicopter was to be maintained in accordance with the manufacturer's maintenance schedule, with a periodic inspection to be conducted every 100 hours or 12 months, whichever came first.

After completion of the 25-hour flight test phase on 13 October 2012, the helicopter was not flown again until 13 December 2013 and was reported to have been stored in a hangar. The pilot purchased the helicopter from the original owner/builder in July 2013 and then commenced helicopter flying training, before taking possession of SWQ in December of the same year. Between July and December 2013, various maintenance tasks were carried out on SWQ by suitably-licenced engineers.

A 100-hourly (periodic) inspection was completed on the day of the accident at 351.4 hours time-in-service and a new maintenance release was issued. No significant maintenance items were recorded as being carried out on the airframe or engine at this time beyond replacement of clutch shoes and a tail rotor gearbox output seal. The last maintenance on the engine was recorded as a 300-hourly service that was carried out as part of the periodic inspection. During that servicing one exhaust spring was replaced and new spark plugs were fitted, as well as other general engine maintenance.

Tail rotor gearbox

The tail rotor gearbox (TGB) assembly consisted of the TGB, tail rotor hub and two tail rotor blades. The TGB was supplied by the kit manufacturer already assembled and only required fitment to the tail boom. The manufacturer advised this assembly was statically and dynamically balanced at the factory before shipment with the kit. The build manual provided with the kit included the following statement:

> The critical main and tail rotor blade assemblies are supplied master balanced from the factory ready to fit on the CH-7B with little or no further balancing required.

The inspection schedule for the CH-7B did not require ongoing main or tail rotor vibration level checks.

The first record of a tail rotor balance being carried out on SWQ was during a periodic inspection on 8 March 2014 at 130.0 airframe hours. The licenced aircraft maintenance engineer (LAME) that conducted that maintenance advised that the tail rotor balance was checked and found to be about 1.5 IPS[5] before adjustment back to within limits. The tail rotor teeter bearings and TGB input shaft seal were also replaced at this time.

The TGB was replaced on 4 April 2014 at 227.2 airframe hours with a TGB from another CH-7B kit, due to output shaft movement that was observed by the pilot. A tail rotor balance was carried out at that time. It was reported that the pilot contacted the LAME about 1 week after the TGB replacement stating that the new TGB output shaft was also showing signs of movement.

An entry in the aircraft logbook on 16 April 2014 at 295.0 hours indicated a further tail rotor balance was carried out. The LAME who made this certification advised that during that maintenance the TGB pinion gear was re-tensioned; however, there was no entry on the worksheets or in the aircraft logbook certifying this maintenance action.

A periodic inspection entry in the aircraft logbook on the day of the accident, at 351.4 hours, indicated that the TGB output seal was replaced. The pilot had advised the LAME that the TGB was leaking oil and required monitoring and regular topping up. While not recorded on the worksheets, the LAME advised that a check of the tail rotor balance was again carried out at this time, with no adjustment required.

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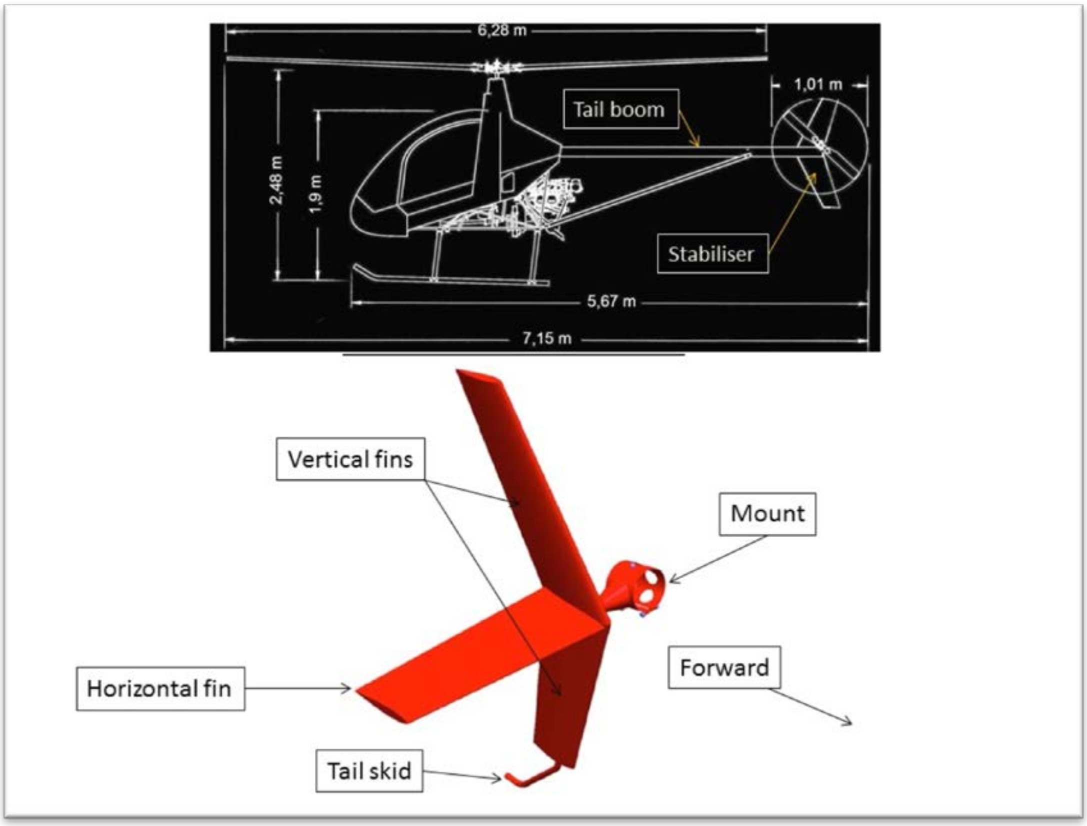
5 The measure 1.5 IPS equates 1.5 inches per second measured dynamic imbalance. Standard maximum permissible vibration level in helicopter rotor systems is generally less than 0.2 IPS.

Stabiliser assembly

The stabiliser assembly consisted of two vertical and one horizontal aerodynamic fins fitted to the rear of the helicopter tail boom. The fins generate aerodynamic forces during forward flight that keep the helicopter level and reduce the thrust required from the tail rotor. The manufacturer and Australian distributor advised that the CH-7B kits for Australia were supplied with the horizontal and vertical stabiliser assembly as a pre-fabricated component (Figure 2).

Figure 2: Stabiliser identification and location on the tail boom



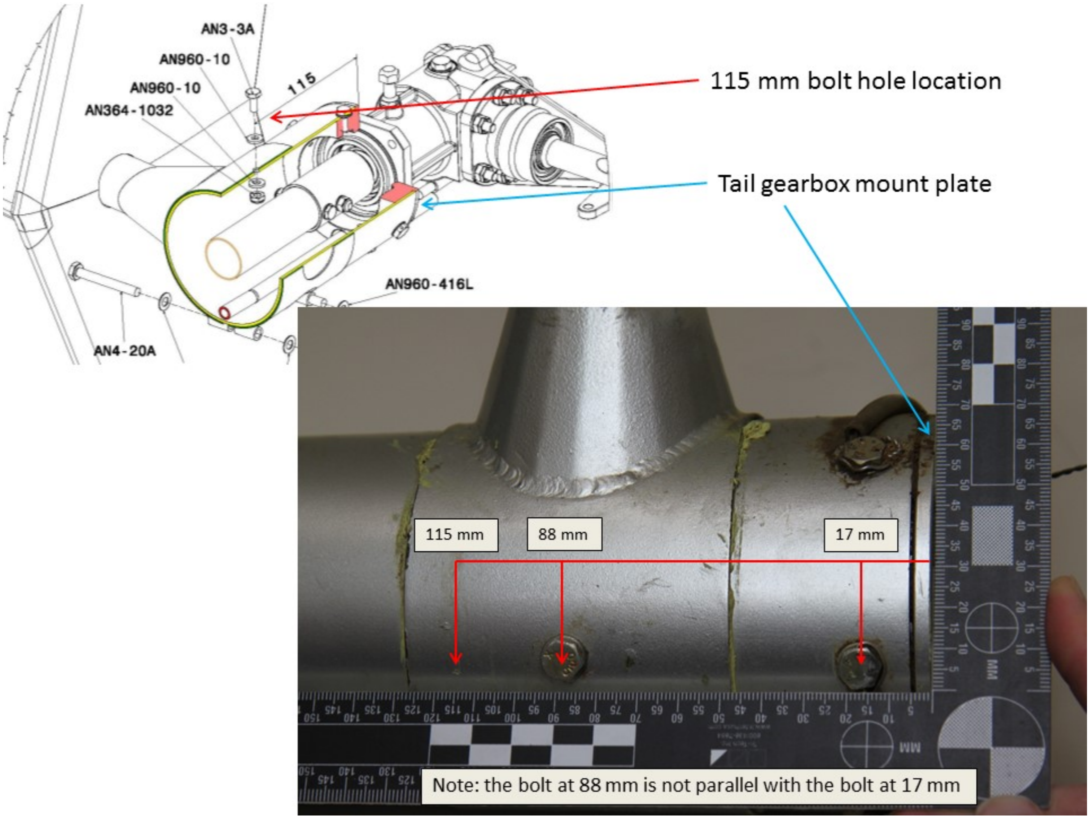
Source: ATSB and Cicaré, modified by ATSB

The CH-7B kit build manual provided instructions for locating the stabiliser on the tail boom. A factory pre-drilled 'locator hole' in the stabiliser mount was to be positioned 115 mm forward of the TGB mount and aligned with the top centre-line of the tail boom (Figure 3). A hole was then to be drilled into the boom skin, using the locator hole as a guide, and a bolt inserted through the mount and boom. Properly placed, the bolt ensured that the stabiliser assembly was always correctly positioned.

On SWQ, the position of the drilled locator hole and bolt was measured to be 88 mm from the TGB mount reference point, 27 mm further aft on the boom than its intended position (Figure 3). SWQ's builder advised that the stabiliser had been fitted as per the build manual instructions. The manufacturer advised that early versions of the CH-7B helicopter had the locator hole at 87 mm. Following modification of the tail rotor control the position of the locator hole was altered by the manufacturer to 115 mm from the reference point.

The relocation of the stabiliser assembly about 27 mm aft of design specifications had the potential to affect the aerodynamic and vibration characteristics of the helicopter. However, the manufacturer advised that 115 mm was now the fleet standard.

Figure 3: Stabiliser locator hole position dimensions



Source: ATSB and Cicaré, modified by ATSB

The pilot reportedly identified evidence of movement within the stabiliser structure and mentioned this to a LAME in early March 2014. Specifically, he was said to have identified 'working' rivets—typically a black or silver-like powder deposit on the structure surface around the rivet head.

During the next periodic inspection, the pilot removed the stabiliser and the three fins, exposing significant cracking of the stabiliser fin mount tubing (Figure 4). In response, the pilot arranged for the stabiliser mount to be weld repaired by a local welder. That welder did not hold a CASA-issued aviation welding authority. Following repair, the pilot reassembled and refitted the stabiliser to SWQ.

Figure 4: Cracks in the welded tube junction of the stabiliser mount

Source: Cicaré S.A., modified by ATSB

In April 2014, after about 295 airframe hours (Table 1), further cracking of the tubing was noted while other maintenance was being conducted on SWQ. The pilot again arranged for the stabiliser mount to be welded at the same facility. The welder advised that they had carried out a dye penetrant crack check of the welded area following each repair with both checks indicating 'a sound and satisfactory weld’. Following advice to the manufacturer of the first weld repair, images of the post-weld crack check that had been carried out by the welder were requested. The manufacturer reported that these images were not provided.

There were no procedures in the maintenance manual for the disassembly of the fins from the stabiliser mount and no authorised repair scheme for the weld repair. Removal, welding and refitment of the stabiliser was not endorsed in the aircraft logbook for either repair.

The pilot contacted the manufacturer on 7 May 2014 and informed them that a second weld repair had been conducted. In response, the manufacturer recommended to the pilot that the helicopter should not be operated until the stabiliser was replaced. Shipment of a replacement stabiliser was being organised at the time of the accident.

Table 1: Timeline between stabiliser mount weld repairs

Date	Aircraft Hours	Time between weld repairs/accident
13 Dec 2013	25.0	Current owner took possession of helicopter
8 Mar 2014	130.0	130 hours – first weld repair
16 Apr 2014	295.0	165 hours – second weld repair
12 May 2014	358.9	63.9 hours at the time of the accident

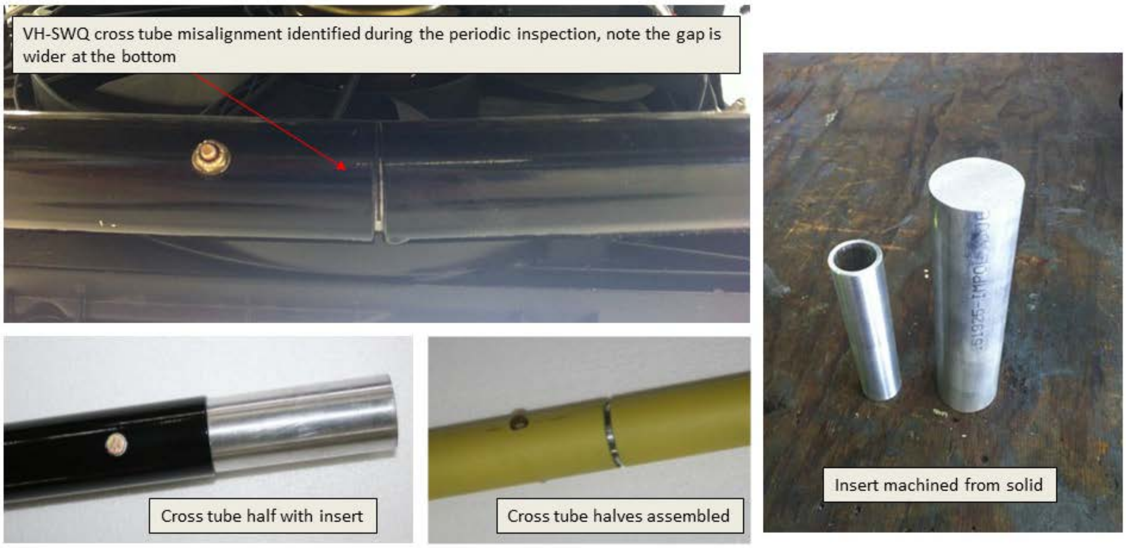
Landing gear

The CH-7B helicopter skid-landing gear was fitted with a hollow aluminium insert inside the mid-join splice of the cross-tubes (Figure 5). In the event of a hard landing, the insert was designed to distort and provide visual identification of damage by misalignment of the cross-tube halves. As a hard landing has the potential to apply excessive forces into the airframe, the manufacturer’s maintenance manual contained inspection procedures that were to be conducted following such an event.

During a periodic inspection on 4 September 2013, a LAME noticed that the rear cross-tube mid-join splice was misaligned consistent with a previous hard landing. A replacement insert was subsequently machined by the maintenance organisation using dimensions supplied by the manufacturer on 29 October 2013. No record of a hard landing inspection or the insert manufacture and replacement was identified in the aircraft’s logbook. The ATSB was provided with documented detail of the repair. However, it indicated that the repair was conducted 2 weeks prior to receiving the insert dimensions from the manufacturer. The LAME later advised that the repair certification contained a typographical error. The certification was intended by the LAME to record the repair as being carried out about 2 weeks after the dimensions were received from the manufacturer.

The circumstances of the apparent heavy landing and the reason for the apparent discrepancy in the maintenance documentation could not be determined. The original owner of SWQ advised that they had not experienced any heavy landings in the helicopter.

Figure 5: VH-SWQ cross-tube and inserts



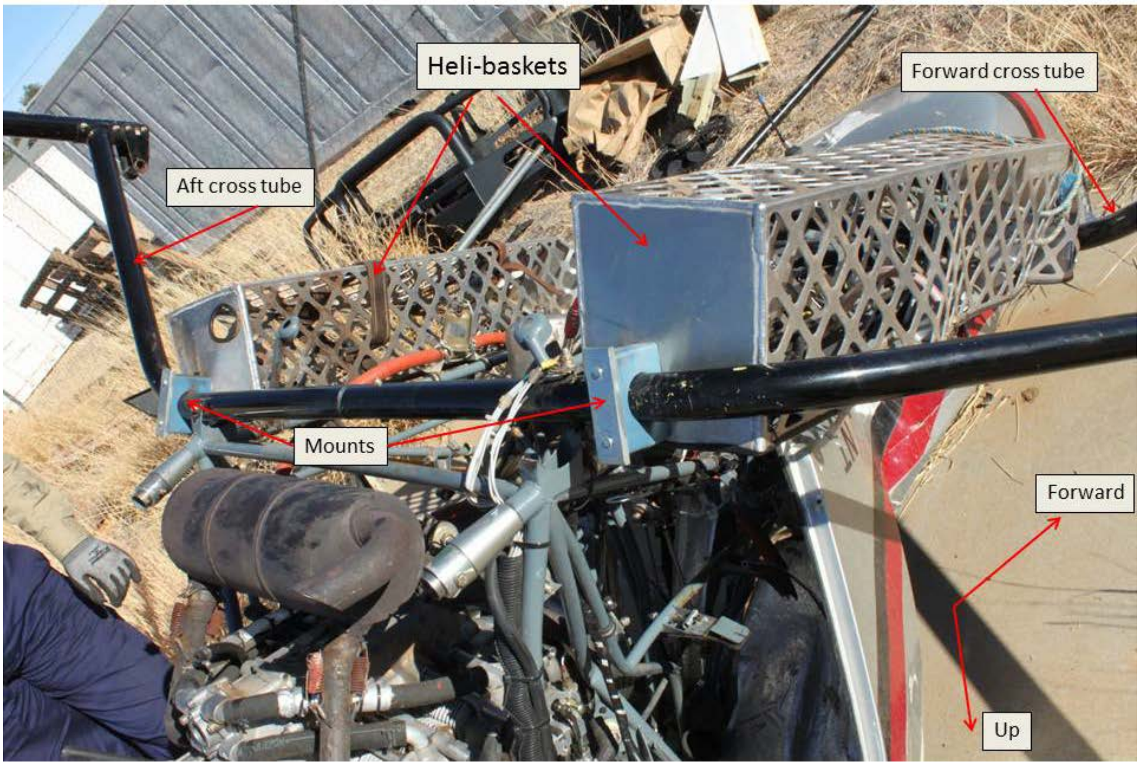
Source: SWQ maintainers and Cicaré, modified by ATSB

Heli-baskets

A pair of aluminium mesh-style baskets (heli-baskets) were locally manufactured on 5 March 2014 at the request of the pilot (Figure 6). The heli-baskets were fitted to the left and right side of the helicopter, between the fore and aft skid-landing gear cross-tubes.

The aircraft logbook contained no endorsement or information on these baskets and the ATSB could not determine who fitted the baskets.

Figure 6: Heli-baskets



Source: ATSB

Helicopter landing gear is designed to provide energy absorbing capabilities during normal or emergency landings. Fixing external loads to the landing gear can result in forces applied to the landing gear in excess of the design limit. The attachment of extra weight can also increase the in-flight dynamic loads due to increased vibration. The ATSB could not determine whether the potential effects on the in-flight loads, flight characteristics and operating weight were considered prior to the fitment of the heli-baskets.

Carburettor throttle cross shaft support

On 3 September 2014 the manufacturer released mandatory service bulletin BSC005 detailing an improvement to the carburettor throttle cross shaft support. While this service bulletin was issued after the accident, the ATSB reviewed it for potential relevance to this investigation.

The bulletin's background information suggested that 'a high frequency vibration associated with the engine crankshaft' could be transmitted to the airframes of helicopters incorporating a one-way sprag clutch[6].

The manufacturer further indicated that:

> …specific to the CH-7B helicopter is a tail rotor drive system resonance vibration which may be a combination of engine crankshaft vibration and out of balance carburettors…On the CH-7B series the resonance may cause the tail rotor to chatter and wear rod ends and teeter bearings…One of the contributing causes to this issue is when the Rotax 912/914 engine carburettors are not matched/rigged correctly.

The manufacturer offered an option to replace the carburettor supports with ones of a different design and material specification. Examination of SWQ identified that the right carburettor support was not the original one that was supplied with the kit. The pilot reportedly advised a LAME via a phone call on 7 March 2014 that he had made a new support to replace one that had cracked. This maintenance action was not documented in the aircraft logbook.

Replacement of the tail rotor teeter bearings at 130.0 hours was recorded in the aircraft logbook. Additionally, the replacement of the right carburettor support link may indicate that the engine-induced vibration, highlighted in service bulletin BSC005, was present. However as this repair was not documented it could not be ascertained if this was the case, or if the carburettors were correctly rigged and synchronised post replacement. The damage sustained to the engine and airframe in the accident prevented an assessment of whether the engine was inducing vibration into the airframe.

Other maintenance

The ATSB identified evidence of other maintenance actions having been conducted on SWQ. These included fitment of larger fuel tanks and fitment of a horn to the high/low rotor rpm indicating system. Additionally, replacement of the longitudinal throttle shaft, with a locally-manufactured shaft, and relocation of the cockpit door hinges were also noted. There were no associated certifications of these maintenance actions in the aircraft logbook.

Weight and balance information

A weight and balance check of the helicopter was carried out as part of the Special Certificate of Airworthiness process. Accurate weight and balance, and performance considerations could not be determined due to an absence of documented calculations for the installation of the larger fuel tanks, removable doors, and heli-baskets. However, based on estimated weights, the helicopter was within weight and balance and performance limitations immediately prior to the accident.

The manufacturer advised that the stabiliser assembly weighed about 2.5 kg and the TGB about 5 kg. A weight and balance calculation in the event of TGB and stabiliser separation was estimated to place the helicopter beyond the allowable forward centre of gravity limit.

[6] A type of freewheel unit that transmits torque in one direction only. In helicopters the freewheel unit transfers power from the engine to the main rotor but disengages in the event of engine failure. This allows the rotors to continue to turn without engine power (autorotation), enabling an emergency landing to be executed.

Flight characteristics

The manufacturer's flight manual included procedures to be followed in defined emergency situations. Included were procedures for loss of tail rotor effectiveness in forward flight. The flight manual also stated that the vertical stabiliser was capable of providing enough directional stability to execute an emergency landing following the loss of tail rotor directional control.

The manufacturer advised the following with regards to their flight testing of the helicopter without the stabiliser assembly fitted:

> …proving that for hovering flight condition and low speeds, the change in controllability was verily [really] noticeable and for translational flight over 30 knots the helicopter showed a light instability in pitch and yaw that can be easily corrected by the pilot, a pilot with standard training is able to execute the emergency maneuver [sic]

With regard to the failure of the tail rotor/gearbox, the manufacturer advised:

> In case of tail rotor or tail rotor gearbox failure, due to the variety of conditions that may occur it's not possible to determine the exact behaviour of the aircraft.

Fuel

The helicopter was approved to use premium unleaded fuel or 100LL aviation gasoline. The station owner advised that 117 L of premium unleaded fuel had been purchased at a nearby fuel station and was stored in a 200 L drum that had been provided by the pilot a few days prior to the muster. Witnesses advised that the pilot refuelled the helicopter, using a hand-operated pump, several times throughout the day but the times and quantities were not recorded.

Emergency locator transmitter

The helicopter was not fitted with an automatic emergency locator transmitter (ELT), nor did the pilot carry a personal ELT. As SWQ was a single-seat aircraft, regulations[7] did not require an ELT to be carried.

Meteorological information

The police officers who attended the accident site described the weather conditions on the day as fine and clear with no wind. Those observations were consistent with a Bureau of Meteorology analysis that described local conditions at about the time of the accident to be clear with light winds, good visibility and a temperature of around 28 °C.

On 12 May 2014 sunset was recorded to be at 1750 and last light[8] at 1814. An absence of recent communication with the aircraft was noticed about 1630 and failed attempts to contact the pilot were around 1700. Based on these timings, it was considered unlikely that weather and available light conditions were a contributing factor to the accident.

Wreckage and impact information

Accident site

The ATSB did not attend the accident site before removal of the helicopter; however, an examination of the site and wreckage was carried out between 23-25 June 2014. All initial accident site detail and photography was provided by the Queensland Police Service.

The helicopter was located about 1 km north-north-west of the station's homestead, among a stand of trees that follow a seasonal creek, about 755 ft above sea level. There were no

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7 See *Civil Aviation Regulation 1988,* regulation 252A

8 Last light is the time when the centre of the sun is at an angle of 6° below the horizon following sunset. At this time large objects are not definable but may be seen and the brightest stars are visible under clear atmospheric conditions. Last light can also be referred to as the end of evening civil twilight.

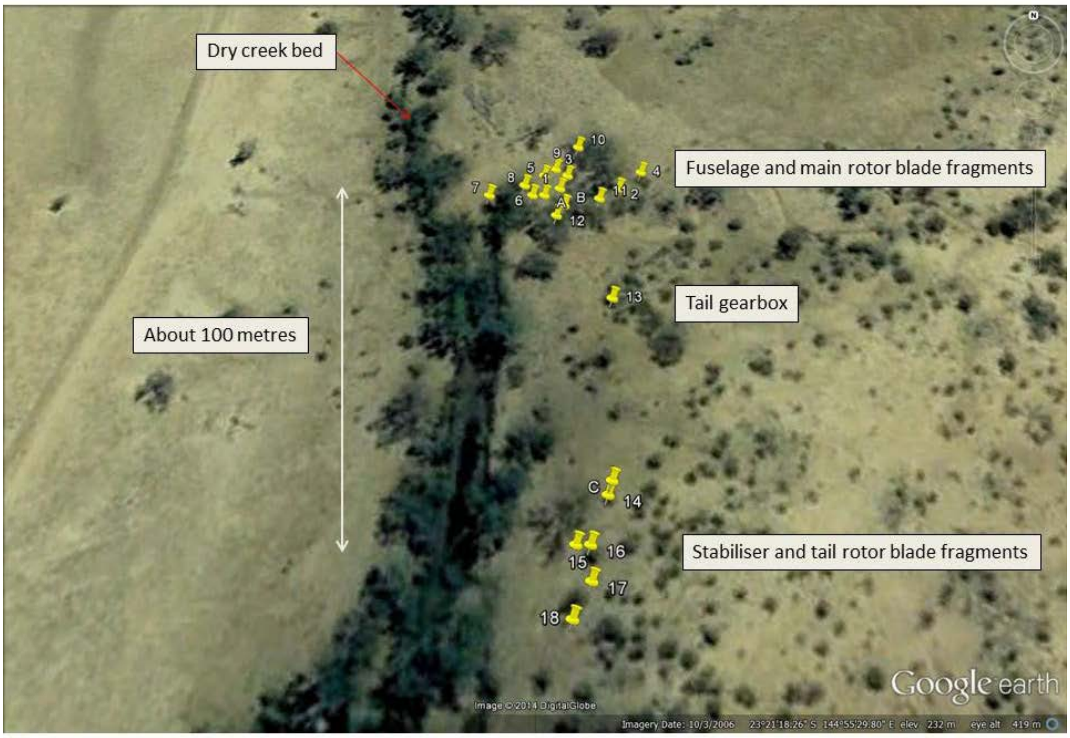
powerlines or other obstacles in the immediate area. Either side of the creek and adjacent tree line was mostly open grassland with low bushes and the occasional tree.

The stabiliser assembly and several tail rotor blade fragments were the first items found in the accident trail, in an area about 25 m to the east of the dry creek bed (Figure 7). A tree located in this area had a mark on it about 5 m above the ground and there was a large branch located near the base. The ATSB determined that the contact mark and branch were not related to the event.

The TGB was located about 63 m from the stabiliser. The main part of the helicopter with the main gearbox, engine and tail boom still attached, were located a further 40 m from the TGB, amongst trees. The fuselage was inverted. The main rotor blades had partially-fragmented and were spread out over an area of about 40 m amongst vegetation.

The accident trail and wreckage distribution was in a northerly direction over a distance of about 100 m and was consistent with an in-flight break-up.

Figure 7: VH-SWQ accident site and wreckage distribution



Source: Google earth, modified by ATSB

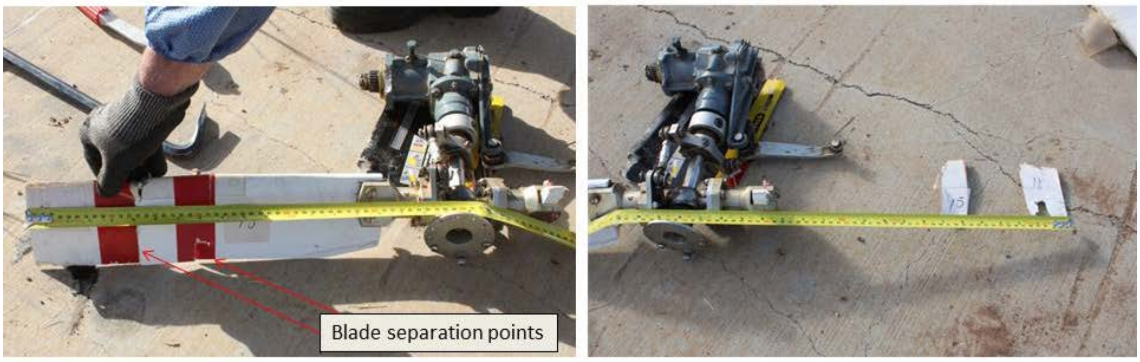
The helicopter was located by the search party primarily due to the presence of a strong fuel smell. When examined, both fuel tanks were found to be empty. However, the filler caps had detached resulting in the tank contents being open to the atmosphere. This, and the helicopter being inverted, meant that the fuel tank contents at the time of the accident could not be determined. Based on the indications of fuel at the site it was considered likely that the fuel tanks contained fuel at the time of the accident. First responders and the police reported that the electric fuel pump was still operating when they attended the site. The fuel pump was deactivated by a Queensland Fire and Rescue Service officer at 2130.

Wreckage examination

On 13 May 2014, the wreckage was relocated via truck to a storage yard in Longreach, Queensland, where the wreckage was later examined by the ATSB. Examination of the engine and its related systems did not identify any issues that would have contributed to the accident. Continuity of the flight controls was established. All damage observed was consistent with an in-flight break-up and collision with terrain.

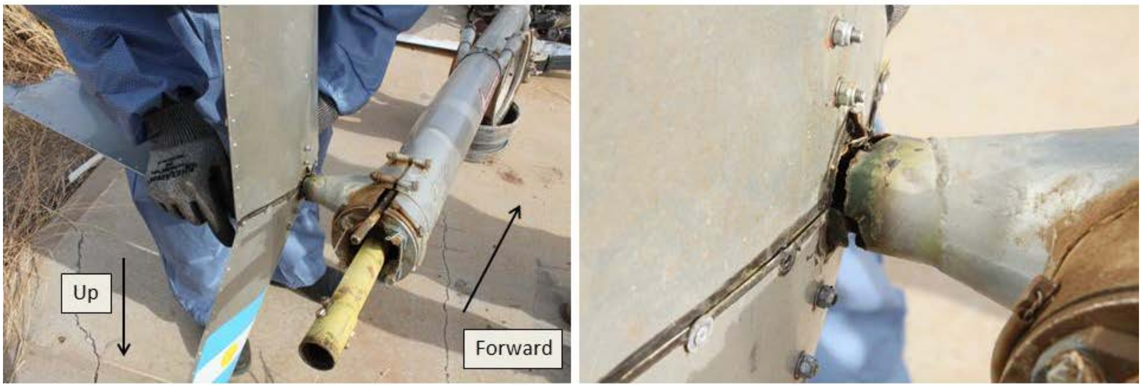
Several components from the helicopter were retained by the ATSB for further examination. This included the stabiliser assembly, tail rotor gearbox, tail rotor blade fragments and rear section of the tail boom (Figure 8 and Figure 9).

Figure 8: Tail rotor components retained for further examination



Source: ATSB

Figure 9: Stabiliser point of fracture



Source: ATSB

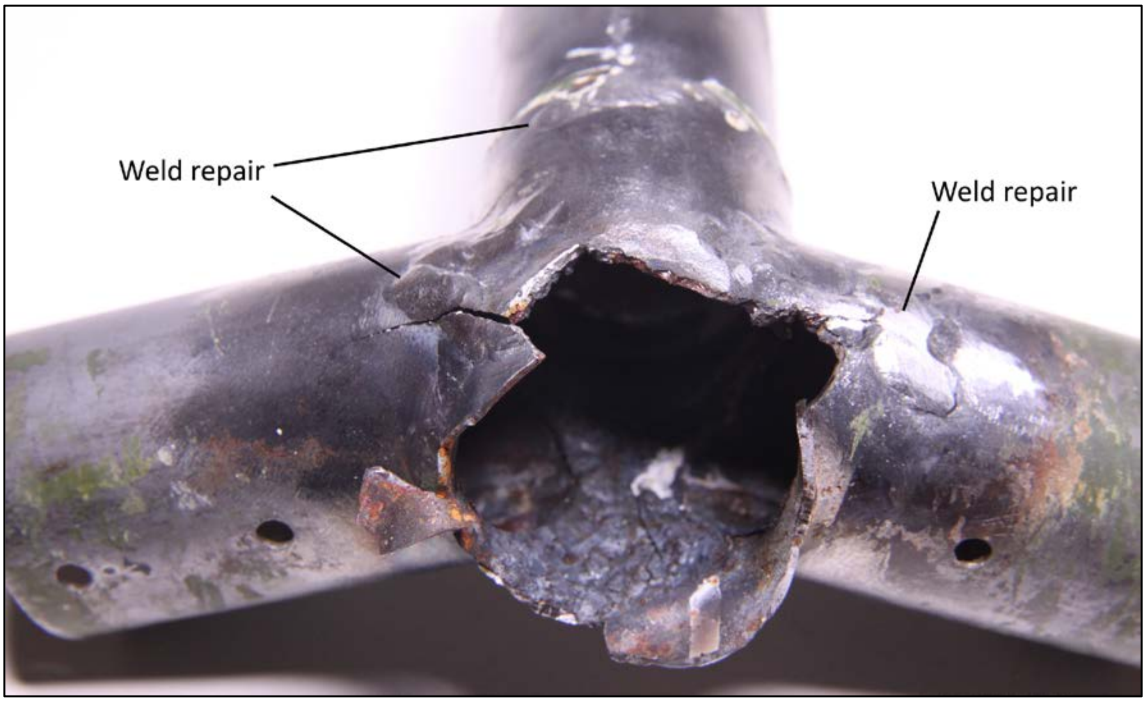
Technical examination of the tail rotor assembly

Detailed examination of the retained tail components was conducted at the ATSB's technical facilities in Canberra. The examination found that the TGB had separated from the rear of the tail boom. The fracture surfaces of the TGB exhibited features associated with gross overstress.

The recovered sections of blade from the tail rotor presented damage signatures that were consistent with having struck the aerofoil sections of the stabiliser. Matching contact marks were identified on the lower vertical and horizontal fin surfaces.

Examination of the fractured stabiliser mount showed evidence that it had been welded on at least two occasions post manufacture (Figure 10). Detailed microscopic examination of the stabiliser mount fracture revealed metal fatigue cracking that primarily followed the welded portions of the tube junction. The fatigue crack had progressed around 40 to 50 per cent of the tube circumference.

Figure 10: Fracture surface detail of the stabiliser mount (view looking outboard) with the locations of previous weld repairs identified



Source: ATSB

Refer to appendix A for further detail of the technical examination of the tail components.

Survival aspects

The damage to the helicopter and surrounding vegetation indicated an inverted, almost vertical descent. The windshield, which was a one piece Perspex moulded dome with side pillars, had shattered on impact and reduced the available survivable space.

The pilot was wearing a four-point harness and a flight helmet at the time of the accident. However, the orientation of the wreckage and the pilot's post-mortem report indicated the accident was not survivable.

Operational aspects

Aerial stock mustering and spotting

Operations involving stock mustering and spotting can involve significant manoeuvring requiring the application of multiple control inputs. Abrupt control inputs can produce high stresses on the helicopter, which may in turn contribute to premature and/or catastrophic failure of critical components.

CASA Airworthiness Bulletin (AWB) 02-15 *Helicopter – Effects on fatigue on life limited components* (available at www.casa.gov.au) explained the potential effects on components by different types of operation. Similar advice was contained in a safety notice (SN) produced by the Robinson Helicopter Company, who manufactures the R22 helicopter. This helicopter is also used extensively in mustering operations. SN-37 -*Exceeding approved limitations can be fatal* (available at www.robinsonheli.com) explained how exceeding approved flight and power limitations can induce stresses to the helicopter that can reduce service life, with possible fatal results.

Ground handling

The flight manual contained the procedures for ground handling the helicopter using the wheels provided, which attach to the landing gear. These procedures stipulated that the helicopter is to be pushed or pulled by holding the tail rotor gearbox. Additionally, the flight manual included the following caution:

> Do not move [the] Cicaré CH-7B by holding either the horizontal or vertical stabiliser, or from the tail rotor, or the tail rotor controls, or tail skid[9].

Of note, manoeuvring the helicopter via the tail skid, especially over rough terrain, can induce unintended forces on the stabiliser mount.

Operation and maintenance regulations

Commercial flying

In order to conduct commercial operations, including aerial spotting and aerial stock mustering, the pilot was required to hold a commercial pilot licence. Additionally, Civil Aviation Regulations 1988 (CAR) regulation 206 [10] stated that an Air Operators Certificate (AOC) was also required to conduct commercial operations. The pilot did not hold a commercial pilot licence for aeroplanes or helicopters, and did not hold an AOC. As the pilot was conducting aerial work in an experimental helicopter, as per CAR 262AP, they were required to hold an appropriate AOC. The special airworthiness certificate that was issued for SWQ also detailed a condition that the helicopter was not to be flown for commercial operations, and the aircraft logbook statement listed the operational category for the aircraft as private/experimental.

Despite not holding the appropriate licences or certificates, the pilot had regularly conducted commercial flying operations in both aeroplanes and helicopters, including at the time of the accident.

Low flying

Witnesses advised that the pilot was regularly engaged by station owners for aerial spotting and/or mustering operations. One witness stated during their last sighting of SWQ on the day of the accident, the pilot was observed to be operating at about 300 ft above ground level (AGL).

Flight below 500 ft AGL requires a specific approval as detailed in CAR 157. This includes specific low-level endorsements for aerial mustering. In addition, *Civil Aviation Order* (CAO) 29.10 defined the requirements for mustering operations. A review of the pilot's current licence and log books did not identify any low-level or mustering endorsements.

Pilot maintenance

CASA Instrument 33/13 detailed that, in some circumstances, a person who builds or has previously built an amateur-built aircraft of a similar type, may be authorised to conduct maintenance on that aircraft. The authorisation only applied to the builder and did not pass to any subsequent owner of the amateur-built aircraft. As such, the authorisation did not extend to the occurrence pilot.

As the holder of a private pilot licence that was valid for Class B aircraft, the pilot was authorised to conduct only the maintenance specified in CAR 1988, Schedule 8. All maintenance conducted by the pilot under this authorisation was to be certified for on the maintenance release and/or aircraft logbook.

It was reported that the pilot conducted maintenance on at least two occasions that he was not authorised to conduct. The first was where the pilot advised a LAME that he had replaced the right carburettor throttle shaft support mount with one that he had manufactured. This non-standard component was identified during the wreckage examination. Additionally, on the day of the accident a witness observed the pilot making an adjustment to a bolt on the tail rotor pitch change

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9 Refer to Figure 2 for the location of the tail skid.

10 Flight crew licencing regulations noted in this report were current at time of the accident and may have since been superseded through the Civil Aviation Safety Authority's 'Regulation Reform' process. See www.casa.gov.au.

system.[11] There was no certification for this maintenance in either the logbook or maintenance release. There was also no evidence of an independent inspection of this work, which was required when any part of the flight control system had been disturbed, as detailed in CAR 42G.

Training

The builder of a VH-registered amateur-built aircraft had to undergo training from the Sport Aircraft Association of Australia (SAAA) or other authorised training provider before being granted an authorisation to maintain their aircraft. Training topics included the regulations regarding maintenance and operations, covering general regulations and those specific to amateur-built aircraft. The training also provided information in topics such as human factors, safety in the aircraft workplace and safety management systems.

There is no requirement for a subsequent owner of an amateur-built aircraft to undergo this training. While the second owner may not be authorised to conduct maintenance on their aircraft, many of the topics were relevant to the pilot of SWQ. Similar training may also benefit other purchasers of amateur-built aircraft.

Dynamic balancing of helicopter rotor systems uses specialised and calibrated equipment. An owner/builder with a maintenance authorisation would have to purchase or have access to this equipment and have received training on its use. Builders of amateur-built helicopters should also consider whether they have suitable experience with which to apply such training, or maintain rotary wing aircraft and their associated critical components.

Maintenance release

When an authorised person signs a maintenance release, they are confirming that all the required maintenance has been performed and certified for, as required by CAR 43. This certification also indicates that the maintenance has been carried out in accordance with approved procedures.

With the exception of the maintenance release valid at the time the pilot purchased SWQ, all subsequent maintenance releases contained no pilot entries, either for hours flown or clearing maintenance-due items. The requirement to record the hours flown at the end of each day was detailed in CAR 43B. In addition, CAR 47 stated that a maintenance release would cease to be in force if the aircraft continued to be flown past a due maintenance requirement.

The maintenance release issued on the day of the accident was considered invalid. This was due to the required independent inspection after disturbing the flight controls during the scheduled maintenance not having been endorsed by either the pilot or another licenced engineer. This endorsement is required by CAR 42ZE and CAR 42G.

Maintenance regulations

The ATSB identified multiple maintenance actions that were not recorded in the aircraft logbook. These records were required by CAR 42ZE and CAR Schedule 6. Under CAR 42ZC, it was the responsibility of the holder of the Certificate of Registration and the pilot in command to ensure all required maintenance was carried out by a person authorised to do so.

Although required by CAR 41 (*Maintenance schedule and maintenance instructions*), the maintenance schedule for the CH-7B did not include inspection schedules for main and tail rotor balancing or for the calibration of instruments.

Amateur-built experimental aircraft maintenance regulations

CASA allows the manufacture of components for amateur-built experimental aircraft in some circumstances. Instrument number CASA EX180/12 *Exemption - maintenance on limited category and experimental aircraft* applies to the person carrying out the maintenance and the registered operator of the aircraft. Schedule 1, paragraph 2 stated:

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[11] The witness identified the bolt from an image of a CH-7B tail rotor assembly.

> In relation to replacement of aircraft components, the exemption only has application if no replacement component is available to the registered operator.

The manufacturer advised that replacement parts were available from the factory. A selection of parts was also available from the distributor in Australia to reduce aircraft unserviceability time.

Any part manufactured in the course of maintenance needs to be identical with the replaced component. The requirements covering this manufacture were detailed in CAR 42W(2)(b)(i) and airworthiness bulletin AWB 02-047. The engine's longitudinal throttle shaft was replaced with a locally-manufactured shaft on 8 March 2013. It was reported that the replacement shaft was of a different material specification to the original part.

In relation to modifications and repairs, CASA EX180/12 Schedule 2 stated that an authorised person (AP) must approve a modification or repair that is considered to be a major design change before further flight. CASA defined a major design change as that which has a significant effect on:

> (a) the weight and balance of the aircraft; or
>
> (b) the structural strength of the aircraft; or
>
> (c) the performance of the aircraft; or
>
> (d) the operational characteristics of the aircraft; or
>
> (e) other characteristics that may affect the validity of the special certificate of airworthiness for the aircraft.

This instrument required the heli-basket fitment and stabiliser mount repair to have been assessed and approved by an AP. The ATSB could find no evidence that either occurred.

Approval to conduct welding on amateur-built aircraft is contained within CASA Instrument 33/13 *Authorisation of persons to carry out maintenance on certain amateur-built, kit-built and light sport aircraft with a special certificate of airworthiness*. Schedule 1 of that instrument stated a person must not carry out manual welding unless the welding is carried out:

> (a) by the person who performed the welding during the fabrication of the aircraft; or
>
> (b) by a person who is the sole owner of the aircraft and performed the welding during fabrication of an aircraft that is essentially similar to the aircraft; or
>
> *(c)* in accordance with an aircraft welding authority granted under regulation 33D of CAR 1988.

The builder of SWQ advised they had not carried out any welding during the assembly of the helicopter. The two weld repairs to the stabiliser mount were carried out by a person who was not authorised by CASA to do so.

In addition to the above requirements, special certificate of airworthiness (SCOA) PVL/SWQ/02 included the following condition:

> Any repairs, alterations or modifications are to be inspected by an SAAA approved person prior to being returned to service

The ATSB could find no record of any such inspections following the stabiliser weld repairs, fitment of larger fuel tanks, fitment of heli-baskets or the manufacture of the skid-landing gear cross-tube insert.

During the investigation, several LAMEs reported that they were advised by an AP that certification for the completion of maintenance on an aircraft in the experimental category must be done under the engineer's own licence number and not 'for and on behalf of' an approved maintenance organisation'.

CASA advised that a LAME may individually certify for an experimental aircraft if that aircraft is within the scope of their licence. Alternately there are no restrictions to a LAME certifying on behalf of a maintenance organisation if the aircraft is within the scope of the maintenance approval for that organisation. CASA also advised that there is the opportunity to ensure authorised persons have an understanding of the current regulations through annual refresher training and auditing.

Reporting of defects

The ATSB administers a voluntary aviation confidential reporting scheme (REPCON) that allows any person who has an aviation safety concern such as:

> …a procedure, practice or condition that a reasonable person would consider endangers, or, if not corrected, would endanger, the safety of air navigation or aircraft operations...

to report the matter (see www.atsb.gov.au).

In addition, the reporting of defects to CASA through the Service Difficulty Reporting (SDR) scheme can permit timely airworthiness and safety oversight of Australian-registered aircraft. Civil Aviation Advisory Publication (CAAP) 51-1(2) *Defect reporting* provides guidance on determining what needs to be reported and how it should be reported.

Defect reporting helps identify and treat potential safety issues and enables dissemination of these issues and their resolution to manufacturers, maintainers and aircraft owners. As an example, through collected data, inspections can be developed on components with emerging issues, thereby capturing and preventing defects resulting in incidents or accidents.

Related occurrences

AO-2015-089 Collision with terrain involving Cicaré CH-7BT, VH-JEW

At the time of writing, the ATSB is investigating another fatal accident involving another Cicaré CH-7 series helicopter that occurred on 28 July 2015, near Roy Hill Station, Western Australia. Preliminary technical examination indicated that the stabiliser failed due to cracking associated with metal fatigue in a similar manner to the stabiliser of SWQ.

While the ATSB is working to establish the factors that led to the failures, Australian Cicaré owners are advised to exercise extreme caution in the operation of their helicopters. Additionally a news item on the failure of these Cicaré CH-7 series helicopter stabilisers is available on the ATSB website at www.atsb.gov.au.

AO-2013-193 Collision with terrain involving Lancair Legacy, VH-ICZ

On 25 October 2013 an amateur-built Lancair Legacy, registered VH-ICZ, collided with terrain alongside Shepparton Airport, Victoria. Both occupants were fatally injured and the aircraft was destroyed. The ATSB found that shortly after take-off, and for reasons that could not be determined, the aircraft entered a steep climb, likely entered an aerodynamic stall, and began a descending right turn that continued until the aircraft collided with terrain.

The ATSB found a number of instances where the regulatory requirements relating to the maintenance and operation of the aircraft had not been appropriately complied with. While the ATSB found no evidence that those non-conformances had brought about, or directly contributed to the accident, they did individually and collectively increase the risk associated with the aircraft's operation.

While amateur-built experimental aircraft are not required to comply with the full range of safety regulations that are applicable to commercially-manufactured aircraft, the regulations that do apply are fundamentally important and have been introduced to control and reduce (as much as possible) the risks associated with the operation of this category of aircraft.

Research

Two ATSB research investigations have identified that amateur-built aircraft are over-represented in aviation accidents and incidents in Australia.[12]. While these investigations did not include amateur-built helicopters due to the small numbers in operation at that time, much of the data and outcomes of the reports are relevant to aeroplanes and helicopters. The prevalence of amateur-built helicopters in Australia is also increasing.

[12] See AR-2007-043(1*) Amateur-built and experimental aircraft - Part 1: A survey of owners and builders of VH- registered non-factory aircraft* and AR-2007-043(2) *Amateur-built aircraft Part 2: Analysis of accidents involving VH-registered non-factory-built aeroplanes 1988-2010* at www.atsb.gov.au.

Safety analysis

Introduction

Examination of the site and wreckage determined that an in-flight break-up of the stabiliser assembly initiated the accident sequence. The pattern and length of the debris trail indicated the helicopter was above tree height at the time of the break-up and the engine was providing power to the rotor systems. Available information indicated that it was unlikely that the pilot became incapacitated during the flight, and pilot fatigue and weather were not considered factors.

This analysis will examine the potential factors that may have led to the in-flight break-up, and discuss a number of issues concerning maintenance of amateur-built aircraft.

In-flight break-up

Technical analysis of the tail components identified that the stabiliser assembly mount was significantly weakened by cracking associated with metal fatigue. While ultimate failure of the mount was due to overstress, the fatigue crack was found to have propagated around approximately half of the mount's circumference. Failure of the mount led to contact between the stabiliser aerofoils and the tail rotor blades that caused imbalance and subsequent separation of the tail rotor gearbox.

The aircraft flight manual provided separate procedures for managing detachment of the stabiliser assembly and loss of tail rotor effectiveness. While recognising that the failure of the stabiliser should be controllable, the manufacturer advised that, if this took place in combination with separation of the tail rotor gearbox, it was difficult to determine if the helicopter would remain controllable.

Loss of either the stabiliser assembly or tail rotor effectiveness requires prompt and effective control input from the pilot to overcome the resulting altered flight characteristics and centre of gravity change. The operating altitude and airspeed at the time of the break-up may also have impacted the successful management of the malfunction. Emergency procedures training and overall flying experience would also influence the ability of a pilot to identify the malfunction and respond effectively within the time available.

Considering the likely short period between the loss of the stabiliser and the tail rotor gearbox, and the advice from the manufacturer, it is not possible to conclude that the helicopter would have been controllable.

Stabiliser mount cracking

The investigation considered the potential factors that contributed to the cyclical loading that resulted in fatigue cracking of the stabiliser mount. These included:

- alteration of the location of the stabiliser assembly along the tail boom
- possible engine vibration, as indicated by replacement of the cracked carburettor support
- fitment of the heli-baskets and larger fuel tanks
- continued operation of the helicopter with abnormal vibration
- possible operations exceeding the manufacturer's limitations.

The effect of altering the location of the stabiliser on the loading applied to the helicopter structure could not be determined. The extent to which the possible engine vibration, relating to the replacement of the cracked carburettor support, may have affected the airframe vibration characteristics was also not possible to quantify. As the fitment of the larger fuel tanks and heli-baskets were unauthorised, the ATSB was unable to determine their effect, if any, on the development of the fatigue cracking.

A statement in the build manual advised that the main and tail rotor assemblies were supplied 'master balanced from the factory ready to fit on the CH-7B with little or no further balancing required'. This could have led to confusion as to whether post-build balancing of the rotors was required. Shipment and handling of components during the build had the potential to affect the tail rotor balance. The updated maintenance manual advised that if there was any doubt, it was to be balanced again. However, this statement about re-balancing the rotor was not included in the maintenance manual that was current at the time of the accident.

The pilot appeared to have been concerned about airframe vibration in SWQ from the time of purchasing the helicopter. Several components associated with the tail rotor drive system were replaced, including the complete tail rotor gearbox assembly. It was reported that after each rectification, the pilot was initially satisfied with the 'smoothness' of the helicopter; however, the vibration issue reportedly returned. While balancing the tail rotor to within defined limitations will reduce vibration levels, it is important to find and eliminate the source of any recurring vibration.

A number of systems in a helicopter may induce a high frequency vibration[13] into the airframe, including the engine, drive train, and main and tail rotor systems. Ongoing vibrations, if not maintained within manufacturer-prescribed limits, can affect the wear of rotating and stationary components and can lead to failure of components on the helicopter well before the expected service life limits. Operating a helicopter outside the manufacturer's limitations also has the potential to induce stresses on the airframe and components, leading to premature wear and possible failure.

Helicopter maintenance

Limited maintenance documentation and information was available to examine any maintenance-related events that may have contributed to the commencement and propagation of the stabiliser mount fatigue cracking. While the initiation point of the crack could not be determined, there were several missed opportunities to identify, and thereby prevent, propagation of the crack.

Recognising that cracking of the stabiliser mount occurred prior to the initial weld repair, the unauthorised welding carried out on the mount did not prevent further in-service metal fatigue cracking. An authorised aviation welder has been trained to identify and understand the consequences of welding on critical components. If both of the weld repairs had been carried out by an authorised welder, it is likely they would have been done in accordance with an approved repair scheme. Such a scheme would either be supplied by the helicopter manufacturer or approved by an authorised person before the welding took place. The ATSB did not identify any approved stabiliser repair schemes for the welding conducted on SWQ.

There was no maintenance certification detailing the removal, disassembly or reassembly and fitment of the stabiliser assembly relating to either weld repair. This indicated that the helicopter was not maintained in accordance with the applicable maintenance and inspection documentation. In addition, the repairs carried out on SWQ were not approved by a Sport Aircraft Association of Australia (SAAA) authorised person, as was required by the special certificate of airworthiness.

There was a requirement for any Licenced Aircraft Maintenance Engineer (LAME) who undertook work on SWQ to ensure that all maintenance was carried out correctly and certified. However, the ultimate person responsible for the airworthiness of the aircraft was the owner of SWQ.

The lack of documentation of numerous maintenance actions prevented an accurate airworthiness record being maintained. However, the ATSB identified a number of modifications and repairs that were not conducted within the scope of the regulations. These known maintenance issues were not reported to either the Civil Aviation Safety Authority (CASA), via the Service Difficulty

[13] A high frequency vibration is in the range of 2,000 cycles per minute and above.

Reporting scheme, or if appropriate to the ATSB via the aviation confidential reporting scheme (REPCON). This non-reporting by either the pilot or the LAMEs that worked on SWQ resulted in a missed opportunity to ensure its ongoing airworthiness.

During a phone call 5 days before the accident, and after the pilot had advised them of the second weld repair, the manufacturer recommended not to fly the helicopter until the stabiliser had been replaced. Pilot correspondence with the manufacturer and witness statements indicated that the pilot was reluctant to ground the helicopter while waiting for the replacement stabiliser assembly. The in-flight break-up of the stabiliser assembly occurred on the first day of flight after this recommendation.

Aircraft documentation and regulatory aspects

Compliance with operational and maintenance regulations is necessary to ensure aviation activities are conducted safely. Specifically, appropriate authorisation for the aerial work being undertaken in SWQ would have required the pilot to receive further training in commercial flying, and meet various organisational aspects associated with operating under an air operators certificate (AOC), including the management of fatigue. Further flight training would have included areas such as flying at low level and safe mustering manoeuvres. Operating under an AOC, as required for commercial operations, may have provided more oversight from CASA. This may have helped to identify any possible issues with the operation, pilot or aircraft, and allowed CASA to work with the pilot to remedy any identified issues.

It was the responsibility of the owner of the aircraft, and the LAMEs who maintained the helicopter, to familiarise themselves with the specific regulations that cover operations and maintenance of amateur-built experimental aircraft. While the pilot’s decision not to follow certain regulations may not have directly influenced the in-flight break-up of the stabiliser assembly, it did increase risk to the pilot and those working around the helicopter during the flying operations.

Findings

From the evidence available, the following findings are made with respect to the in-flight break-up of a Cicaré CH-7B helicopter, registered VH-SWQ, which occurred 43 km north-west of Barcaldine Airport, Queensland on 12 May 2014. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing factors

- The stabiliser mount failed due to overstress following propagation of a fatigue crack, leading to in-flight break-up.
- Following failure of the stabiliser mount, the stabiliser aerofoils contacted and damaged the tail rotor blades, causing an imbalance which lead to the tail gearbox assembly separating from the tail boom and loss of control of the helicopter.

Other factors that increased risk

- The helicopter had undergone repairs and modifications that were not approved by the Civil Aviation Safety Authority and/or the kit manufacturer, which could have affected helicopter serviceability and flight characteristics.
- The pilot was conducting low-level commercial flying operations and aircraft maintenance without the required Civil Aviation Safety Authority authorisations, which increased the safety risk.

Safety issues and actions

Whether or not the ATSB identifies safety issues in the course of an investigation, relevant organisations may proactively initiate safety action in order to reduce their safety risk. The ATSB conducted the following proactive safety action in response to this occurrence.

Advisory letter sent to registered Cicaré CH-7B owners

On 6 March 2015, in consideration of the potential fleet implications of the failure mechanism of the stabiliser assembly on VH-SWQ, the ATSB wrote to all registered owners of the CH-7B. The content of that letter follows.

Australian Government
Australian Transport Safety Bureau

The Australian Transport Safety Bureau (ATSB) is investigating a fatal accident that occurred on 12 May 2014 near Barcaldine, Queensland involving a Cicaré CH-7B helicopter. The ATSB has identified that the helicopter experienced an in-flight separation of the stabiliser and subsequent collision with terrain.

Technical examination at the ATSB's facilities in Canberra, Australian Capital Territory indicates that the stabiliser failed due to cracking associated with metal fatigue (Figure 1). While the ATSB cannot determine the origin of the crack, its initiation and propagation may have been associated with on-going operation of the helicopter with vibration that was reported as being above defined limitations.

Figure 1: Stabiliser, showing fatigue crack location

The initial crack occurred within the stabiliser and thus was unlikely to be visible during inspection. However, it was reported that the fatigued area was identified earlier by unanticipated movement of the stabiliser and evidence of loose or working fasteners. An example of evidence of working fasteners (rivets) is shown at Figure 2.

62 Northbourne Ave
Canberra ACT 2601
Australia

PO Box 967
Civic Square
ACT 2608 Australia

Telephone 02 6257 4150
24 hours 1800 020 616
Fax 02 6247 3117

Web www.atsb.gov.au
Email atsbinfo@atsb.gov.au
Twitter @ATSBinfo

Figure 2: Typical indication of working rivets (photograph not of a CH-7B helicopter)

Owners are reminded of the importance to operate and maintain their helicopter in accordance with the Cicaré publications, including the flight and maintenance manuals. The maintenance manual provides the maintenance schedule, inspection criteria and vibration level limits for continued safe operation and includes the following:

> During inspection, check the general condition of the components and observe if there is evidence of damage, colour change due to high temperatures, dents, scratches, notches, corrosion and specially cracks. Also check for any sign of friction in the parts that are near one another. Usually, friction on aluminium parts produces a fine black powder, whereas in the steel parts rust red or black residues are evident.
>
> Check the whole surface of the stabilizers. Verify there are no scratches or cracks.
>
> In case any doubt may arise concerning the inspection or maintenance of any part, piece or component of the CICARE CH7B, the Technical Department of CICARE S.A. shall be immediately consulted.

In addition to contacting Cicaré, owners may also wish to discuss any concerns with an appropriately-licenced aircraft maintenance engineer or with the Civil Aviation Safety Authority before further flight.

The ATSB intends providing all owners with a copy of the final investigation report for their information.

Provision of the final investigation report to all registered CH-7B owners

The ATSB intends providing all registered Cicaré CH-7B owners with a copy of the final investigation report for their information.

General details

Occurrence details

Date and time:	12 May 2014 – about 1630 EST	
Occurrence category:	Accident	
Primary occurrence type:	In-flight break-up	
Location:	43 km north-west of Barcaldine Airport, Queensland	
	Latitude: 23° 21.274' S	Longitude: 144° 55.501' E

Aircraft details

Manufacturer and model:	Cicaré Helicopters CH-7B	
Year of manufacture:	2011	
Registration:	VH-SWQ	
Serial number:	011	
Total Time In Service	358.9 hours	
Type of operation:	Experimental - private	
Persons on board:	Crew – 1	Passengers – 0
Injuries:	Crew – 1 (Fatal)	Passengers – 0
Damage:	Destroyed	

Sources and submissions

Sources of information

The sources of information during the investigation included the:

- data recovered from the pilot's personal global positioning system (GPS)
- Civil Aviation Safety Authority (CASA)
- Queensland Police and Coroner
- helicopter manufacturer and Australian kit importer
- Bureau of Meteorology
- manufacturer of the heli-baskets
- maintainers of VH-SWQ.

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 CASA, the helicopter manufacturer, Australian kit importer and the maintainers and welder who conducted repairs on VH-SWQ.

Submissions were received from CASA, the helicopter manufacturer, the Australian kit importer and the maintainers of VH-SWQ. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

Appendices

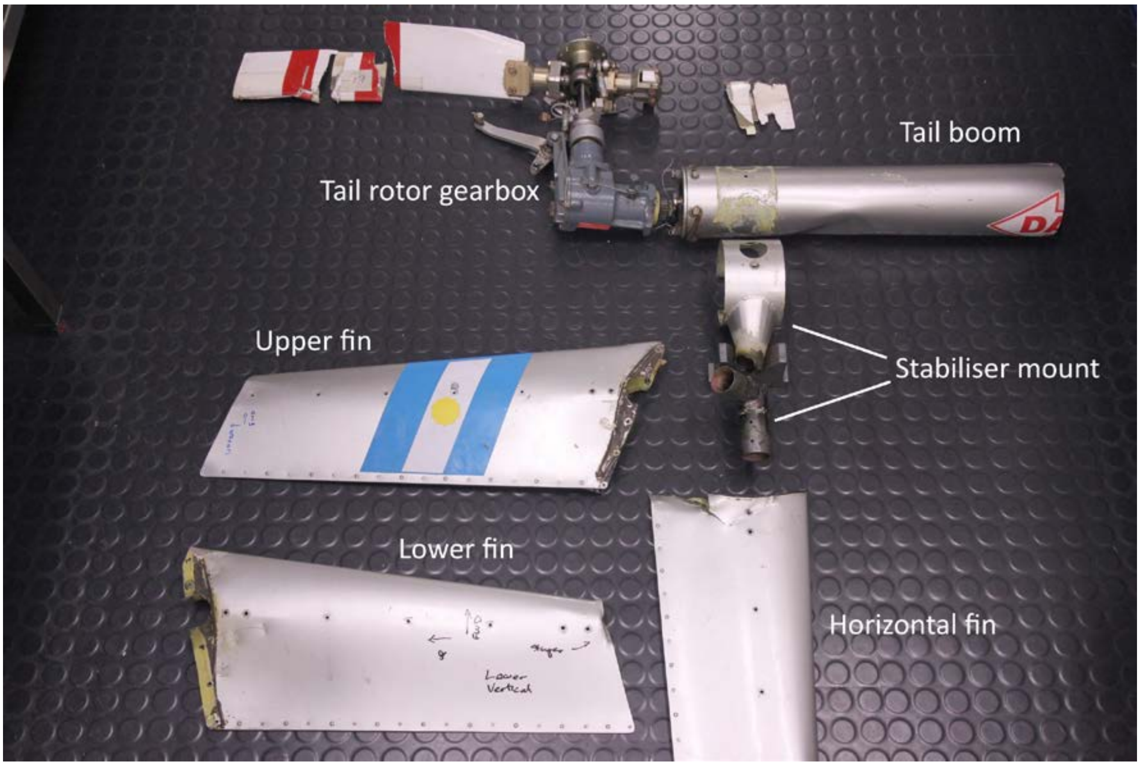
Appendix A –Technical Analysis Report

Technical examination of the tail rotor assembly

General examination

A detailed examination of the fins, tail rotor, aft tail boom section, and tail rotor gearbox (TGB) was conducted at the ATSB's technical facilities in Canberra (Figure A1). The examination indicated that the TGB had separated from its installed position at the rear of the tail boom. The fracture surfaces of the TGB only exhibited features associated with gross overstress. The recovered sections of blade from the tail rotor presented damage signatures that were consistent with having struck the aerofoil sections of the stabiliser. Matching contact marks were identified on the lower vertical and horizontal fin surfaces (Figure A2).

Figure A1: Dismantled tail rotor assembly components



Source: ATSB

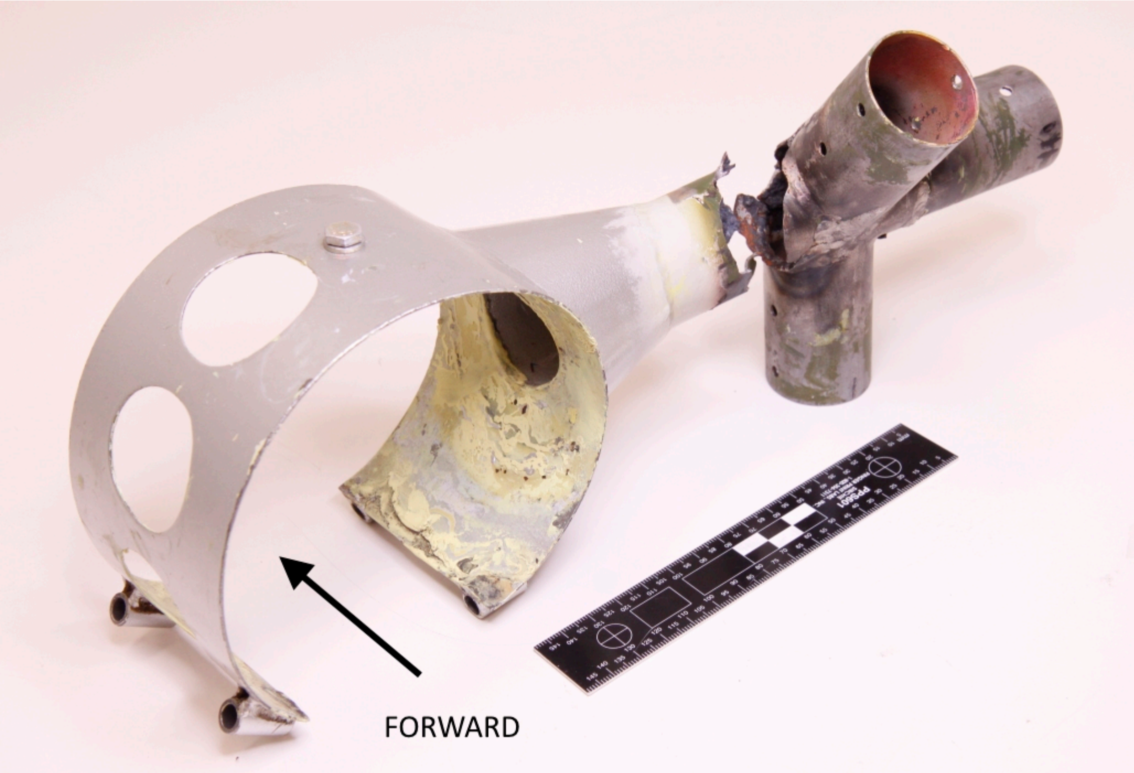
Figure A2: Matching witness marks indicate that a tail rotor blade contacted the lower fin

Source: ATSB

Stabiliser mount

The fins were removed from the stabiliser assembly in order to completely expose both portions of the fractured stabiliser mount (Figure A3).

Figure A3: Fractured stabiliser mount with fins removed

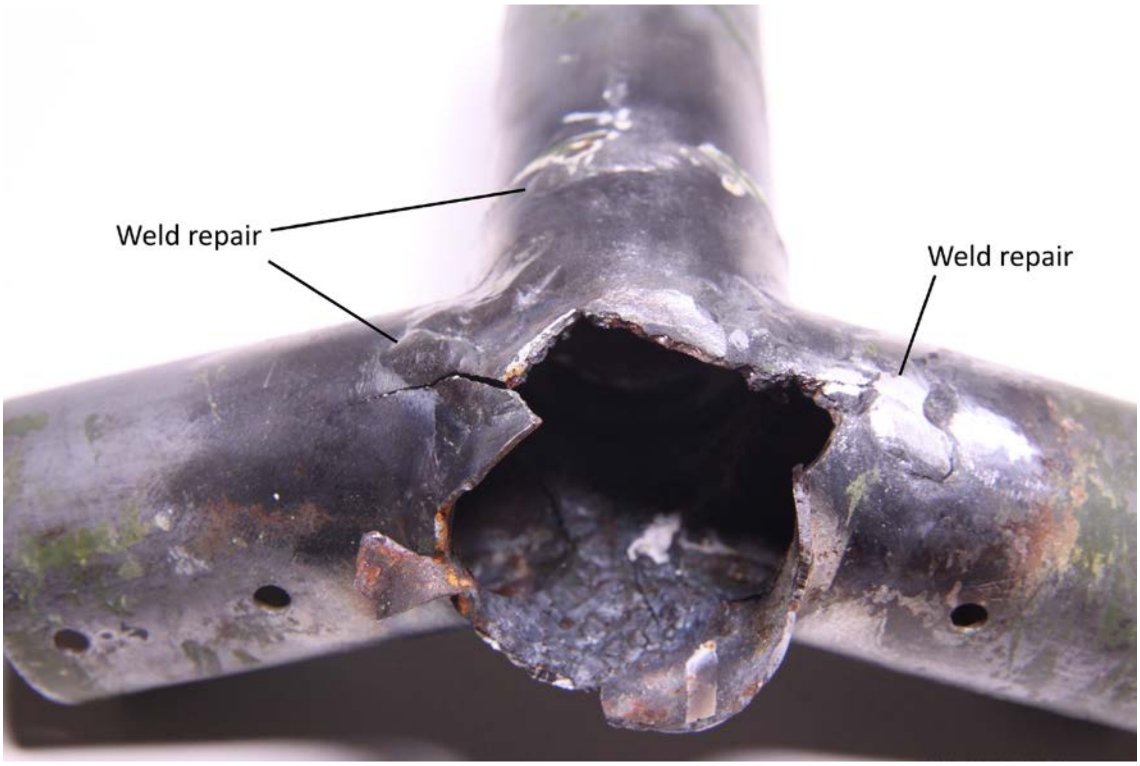


Source: ATSB

The stabiliser mount was comprised of three main sections; a clamp for attaching to the tail boom, a conical support and three oval-shaped, thin-walled metal tubes that were used to locate and secure the fins into position. During manufacture at the factory the three tubes had been cut to fit and then welded together at the apex of the support cone. The appearance of the weld beads indicated that a tungsten inert gas welding method had been used to join the tubes during fabrication. Some surfaces surrounding the welded tube junction displayed evidence of having been bead blasted.

It was noted that the tube junction contained four areas that had been weld repaired. The surface of three of the weld repairs had been bead blasted, while one of the repairs had been ground flat. This was indicative that the welding was conducted subsequent to the other repair. The presence of the weld repairs was consistent with the reported service history of the helicopter, where the owner discovered that the stabiliser mount was cracked at a number of locations surrounding the tube junction. The owner had those cracks welded on two separate occasions (Figure A4).

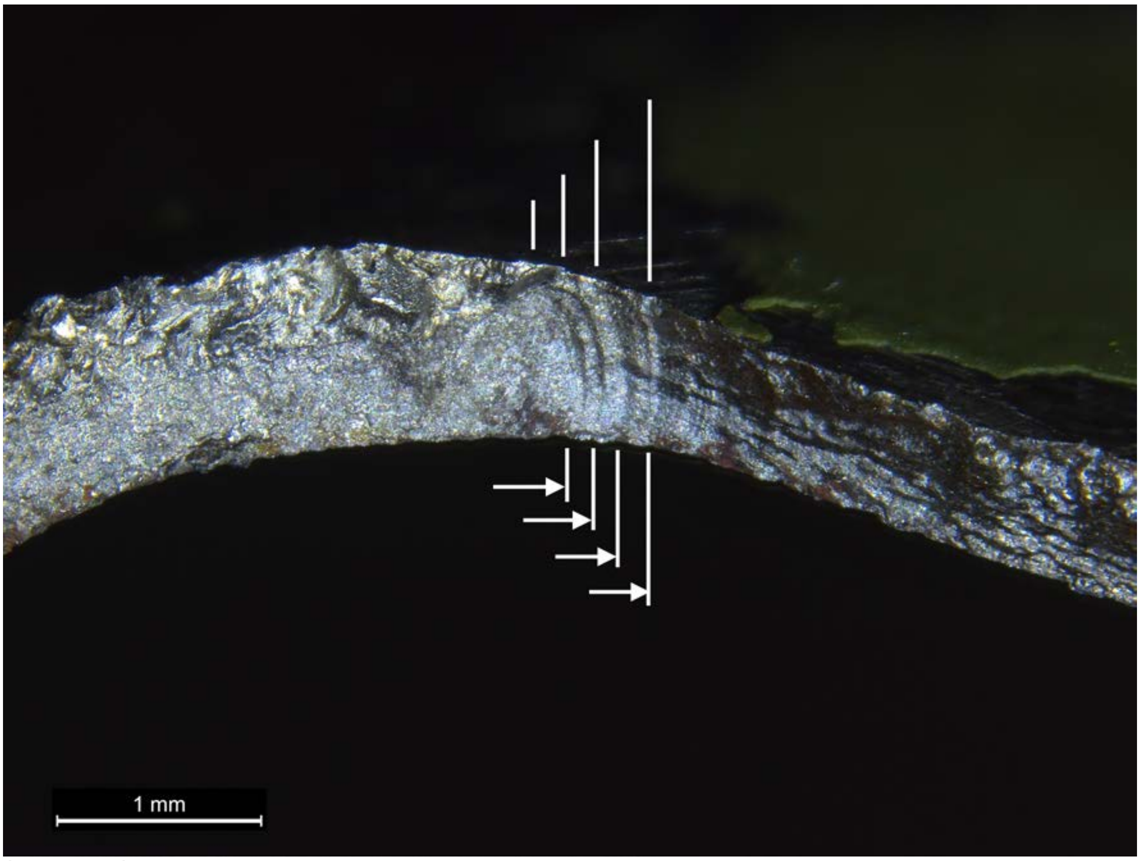
Figure A4: Fracture surface detail of the stabiliser mount (view looking outboard) with locations of previous weld repair identified



Source: ATSB

Detailed microscopic examination of the stabiliser mount fracture surfaces was accomplished using a binocular microscope. The examination revealed that the fracture path primarily followed the welded portions of the tube junction. One half of the fractured component revealed the presence of a finely spaced series of continuous progression marks (Figure A5). Such features are entirely consistent with a fatigue crack growth mechanism that was propagated due to cyclic loading of the tail rotor components. Fatigue cracking was identified to have progressed around 40 to 50 per cent of the tube circumference. The origin of the fatigue cracking could not be clearly identified due to post-accident damage from metal-to-metal contact that had smeared some of the finer fracture surface details. No obvious defects or anomalies were observed in the welded regions that might have otherwise contributed to the growth of the fatigue cracking.

Figure A5: High magnification view of a portion of the stabiliser mount fracture surface with clearly defined fatigue progression bands (arrowed)



Source: ATSB

In-flight failure sequence

It can be concluded that, moments prior to the accident, fatigue cracking of the stabiliser mount reached a critical length, which then led to overstress and fracture of the welded tube structure. Based on the positions of the recovered debris in combination with witness marks identified during the examination, the attached lower and outboard fins then contacted the tail rotor blades causing the blades to fragment. The resulting rotor blade imbalance led to the overstress fracture and separation of the tail rotor gearbox from the helicopter.

Australian Transport Safety Bureau

The ATSB is an independent Commonwealth Government statutory agency. The ATSB is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; fostering safety awareness, knowledge and action.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

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

Purpose of safety investigations

The object of a safety investigation is to identify and reduce safety-related risk. ATSB investigations determine and communicate the factors related to the transport safety matter being investigated.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes it appropriate. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

Australian Transport Safety Bureau

Enquiries 1800 020 616
Notifications 1800 011 034
REPCON 1800 011 034
Web www.atsb. gov.au
Twitter @ATSBinfo
Email atsbinfo@atsb.gov.au
Facebook atsbgovau

Investigation

ATSB Transport Safety Report
Aviation Occurrence Investigation

In-flight break-up involving Cicaré CH-7B, VH-SWQ
43 km north-west of Barcaldine Airport Queensland, on 12 May 2014

AO-2014-086
Final – 5 February 2016