Australian Government
Australian Transport Safety Bureau

Engine flame-out and ditching involving Bell LongRanger helicopter, VH-RHF

Cone Bay, approximately 98 km north of Derby, WA | 8 June 2013

Investigation

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Addendum

Page	Change	Date

Safety summary

VH-RHF on a previous flight

Source: Helicopter operator

What happened

On 8 June 2013, the pilot of a Bell LongRanger helicopter, registered VH-RHF, was conducting an aerial survey flight with four passengers in the Buccaneer Archipelago area north of Derby, Western Australia. The helicopter was being flown at about 1,000 ft to a planned fuel stop on an island in Cone Bay and was over water when the engine flamed out.

The pilot entered autorotation to glide towards land but was unable to reach it. During the glide the pilot deployed the helicopter's pop-out floats in preparation for an emergency ditching. Shortly after touchdown the helicopter rolled inverted. The pilot and the four passengers exited without injury. A boat crew observed the emergency landing and rescued the occupants from on top of the upturned floating helicopter.

What the ATSB found

The ATSB found that, without the pilot realising, the fuel on board was probably sufficiently low to allow momentary un-porting of the fuel boost pumps, which interrupted the flow of fuel to the engine, resulting in an engine flame-out and ditching. Contributing to the pilot's lack of awareness of the fuel state was a likely malfunction of the helicopter's fuel quantity indicating system and a faulty low fuel caution system. In addition, the operator's fuel management system was almost totally reliant on the fuel quantity indicating system and as a consequence, lacked a high level of assurance.

The ATSB also found that the guidance provided by the Civil Aviation Safety Authority in relation to pre-flight crosschecking of fuel on board allowed for a reliance on aircraft fuel quantity indicating systems without reference to independent sources of fuel quantity information.

What has been done as a result

The helicopter operator advised that as a result of this occurrence they have redesigned their fuel tracking form to improve usability. In addition, the operator is considering the fitment of a fuel totaliser to their LongRanger helicopter types.

Safety message

As shown by this and other occurrences, there is a need for operators to ensure that their fuel management policy and procedures provide for at least two independent and reliable means of establishing fuel on board. These should be supplemented by criteria for identifying, recording, and resolving any discrepancy between the amounts generated by the different methods. In situations where visual or other direct means of establishing fuel quantity are not possible, equipment that measures and totalises fuel flow can provide a valid basis for derivation of fuel on board.

Low fuel level caution systems are valuable elements in a safe fuel management framework but can fail without detection and should not be relied upon as a substitute for an independent crosscheck of fuel quantity indicating systems. Operators should consider the criticality of on-board fuel quantity measuring equipment in the context of their particular operations and manage the risk of malfunction accordingly.

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The occurrence

On the morning of 8 June 2013, the pilot of a Bell 206L-3 LongRanger helicopter, registered VH-RHF, was chartered to fly a group of four on an aerial survey flight in the Buccaneer Archipelago area to the north of Derby in Western Australia. The flight was to be conducted from Derby under the visual flight rules and was planned to include a landing for fuel before returning to Derby.

In preparation for the flight, the helicopter had been refuelled with 150 L from the airport refuelling truck to take the total fuel on board from 90 L remaining to the planned 240 L. The pilot derived the 90 L figure from the electrically-powered fuel quantity indicator, which also indicated the equivalent of 240 L fuel on board after refuelling. With 240 L of fuel and the five persons on board, the helicopter would be just under the maximum take-off weight and be able to fly for 1.6 hours at the operator's fuel consumption rate used for planning, excluding reserves (see the section titled *Operator fuel management*).

The pilot commenced work about an hour prior to the expected take-off time of 0800 Western Standard Time[1] so that he could complete the daily inspection that included fuel drains, and the paperwork for the flight. He had flown the helicopter the day prior and it was performing well with no problems or ongoing defects.

The passengers arrived around 0800 and, after some discussions, were seated in the helicopter with one passenger occupying the front left seat and the other passengers in the rear cabin. The pilot conducted a safety briefing that included operation of the doors and seatbelts, and location and use of life jackets that were stowed aboard. There was no requirement to wear life jackets as there was no plan to operate out of gliding distance of land. The pilot also advised the passengers that when the fuel state reached the equivalent of 100 L remaining on board, he would divert to an island in Cone Bay to land and refuel. He expected this to be approximately 1 hour and 10 minutes of flying time into the flight.

The pilot stated that after lifting the helicopter into a hover he checked the power available and confirmed controllability. Power indications were as expected for the helicopter's weight and conditions of the day, and all other indications such as fuel pressure were normal. The pilot transitioned into a take-off at 0840 and tracked slightly eastward of the direct track to the survey area to avoid flying over water.

A global positioning system (GPS) unit that the pilot was using as a supplemental navigation aid was mounted to the instrument panel. This unit routinely recorded time-based positional data, which was later used by the Australian Transport Safety Bureau (ATSB) for defining tracks, speeds and heights during the flight (Figure 1).

During the 35-minute transit to the survey area, the helicopter's average height was 1,000 ft and the ground speed averaged 100 kt. After arriving in the survey area, the pilot manoeuvred as directed by the passengers, maintaining ground speeds between 50 and 80 kt at heights between 800 ft and 2,200 ft above mean sea level.

When the fuel quantity indicator reached the equivalent of 100 L (180 lb), after 39 minutes of survey, the pilot began to track to the planned refuelling location at Cone Bay. At that point the total flight time was 1 hour and 14 minutes. The pilot conducted the transit at about 1,000 ft and 100 kt.

During this sector the pilot noticed the fuel quantity indication slowly rise from 180 lb to 250 lb and then return. It did this at least twice with no other instrument indications affected and no change to helicopter operation. This fuel indication anomaly created doubt about the aircraft's fuel state so the pilot tracked direct to the Cone Bay landing site over a stretch of water. The pilot later

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

explained that his original intent was to keep in close proximity to land, but as a precaution he altered track to minimise the fuel required to complete the flight. Another consideration for the pilot was the unsuitability of the rough terrain on the overland route in case of a forced landing.

Figure 1: VH-RHF flight track as derived from data from the on-board GPS

Image source: Google Earth and Landsat, with track data overlaid by the ATSB

On approach to the Cone Bay island helipad at around 1,000 ft, the pilot positioned the helicopter for a westerly downwind leg adjacent to the island to then turn back into the easterly wind for the final approach to land.

It was 11.5 minutes into the transit and 1 hour and 25 minutes since take-off when the pilot lowered the collective control to reduce rotor lift and commence a descent. At that moment, without any prior warning, the ENGINE OUT and LOW ROTOR aural and visual alerts activated in quick succession. The pilot immediately entered autorotation to use the descent airflow to drive the main rotor and enable a glide. He steered the helicopter towards the closest part of the island and, realising they wouldn't reach it, advised the passengers to prepare for a water landing.

During the 30-second glide the pilot activated the pop-out floats[2] then flared the helicopter and touched down on the water. It was not a hard touchdown but the right skid hit a little harder than the other, detaching a float.

With the emergency flotation compromised, the helicopter rolled to the right, taking on water as it did so to become inverted and then suspended from the sea surface by the remaining floats. The main rotor contacted the water surface during the roll and stopped quickly.

One of the passengers in the rear cabin seat later stated that they initially had some trouble opening the cabin door and thought that the inflated pop-out float or outside water pressure may have been impeding the door. As the helicopter rolled right and the water level within the cabin rose, the rear passengers successfully opened the door. All four passengers and the pilot exited the helicopter unharmed through the front and rear left doors during the helicopter submersion and climbed onto the upturned fuselage. A few minutes later, they were picked up by a tender boat from a nearby barramundi farm.

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[2] An emergency system of inflatable pontoon-type floats (pop-outs) stowed within protective covers and affixed to each landing skid that are deployed by the pilot in the event of a forced water landing.

The helicopter was substantially damaged and later towed to shore (Figure 2).

Figure 2: VH-RHF after being towed ashore

Source: Helicopter operator

Context

Fuel distribution and delivery

The LongRanger was powered by a turboshaft engine that operated on aviation turbine fuel. Fuel was stored in three interconnected bladder-type fuel tanks with a maximum capacity of 424 L, including 5 L of unusable fuel (see the fuel system diagram in appendix A). Two tanks were relatively small and were located under the forward seats in the passenger cabin. The larger main fuel tank was located under and behind the rearmost seats. Fuel for the engine was supplied from the main tank only.

The two forward tanks were directly interconnected with no restriction to fuel flowing laterally between them. To be usable, fuel in the forward tanks needed to be transferred to the main tank. This transfer process used the surplus fuel flow from the two electric boost pumps and piped that fuel through a filter and flow switch to a dual-element ejector pump connected to the forward tanks. The flow of fuel through the ejector pump created suction to transfer fuel from the forward tanks to the main tank.

When the engine was operating, the inter-tank transfer process was automatic and continuous. If one of the boost pumps failed or a supply line to the ejector pump blocked, the other pump could provide sufficient fuel flow to maintain the inter-tank transfer. Any loss of flow to the ejector pump would be detected by the left or right flow switch and activate the applicable annunciator on the instrument panel. If both boost pumps failed, or both supply lines to the ejector pump blocked, as much as 87 L might remain in the forward tanks and be unusable.

Over time the helicopter manufacturer had reduced the risk of transfer line blockage by introducing a new flow switch and moving the in-line filter to upstream of the flow switch. Both modifications were incorporated into the helicopter.

After being picked up at the bottom of the main tank and passing through the two boost pumps, fuel was piped to the top of the tank. From there fuel was piped to the engine through a fuel pressure sensor, electrically-operated shut-off valve and low pressure fuel filter.

Fuel quantity indicating and alerting

The shape and arrangement of the fuel tanks precluded a visual check of fuel quantity for amounts other than full fuel. It also precluded the use of a dipstick or other direct reading means of establishing fuel quantity on board.

The LongRanger was fitted with an electrically-powered Fuel Quantity Indicating System (FQIS) as standard equipment. In this model helicopter, a probe in the left forward tank and two probes in the main tank were electrically connected to a fuel quantity transmitter incorporated into one of the probes. The transmitter processed the output of each probe and produced an electrical signal to drive the panel-mounted indicator to represent total fuel weight in pounds. Contamination of the fuel probes was known to cause false readings.

The helicopter was also fitted with an electrically-powered low fuel caution system as standard equipment that operated independently of the FQIS. When the fuel quantity in the main tank reduced to somewhere between 28 and 42 L, a float switch in the tank was designed to activate a light on the cockpit caution panel. The helicopter manufacturer warned in the flight manual that uncoordinated flight in this low fuel condition could lead to fuel starvation and sudden power loss.

Neither of the two fuel quantity indicating/caution systems was designed with built-in test capability. While the press-to-test function of the caution panel did allow testing of the low fuel caution light globe, there was no means for a pilot to directly check the integrity of either system. Any verification of system functionality relied on accurately establishing fuel quantity by other means and comparing it with the indicated amount or expected caution light operation.

For many aircraft, including the LongRanger type, a means to directly and accurately measure the amount of fuel consumed by an engine is available. It involves the installation of a fuel flow transducer in the main fuel line to the engine and installation of an instrument with the capacity to show instantaneous fuel flow as well as total fuel consumed. This helicopter was not equipped with such a system, nor was it required to be.

Maintenance history

The maintenance records for the LongRanger indicated it was maintained in accordance with the latest revisions of the helicopter manufacturer's maintenance system. This was supplemented by the engine manufacturer's maintenance system, and relevant civil aviation orders, regulations and airworthiness directives. The maintenance program for the radio, electrical and instrument systems specifically was nominated as the relevant sections of Schedule 5, a generic maintenance schedule produced by the Civil Aviation Safety Authority (CASA).

At the time of the occurrence the only maintenance requirement for the FQIS was a calibration in accordance with airworthiness directive AD/INST/8. Almost 2 years had passed since the last calibration, with the recalibration due 2 weeks after the occurrence. This pending maintenance was listed on the maintenance release.

The only maintenance requirement relating to the low fuel caution system was a functional test to be performed annually. This test involved the draining and refilling of the main fuel tank with known quantities of fuel to check that the light illuminated and extinguished within the specified range. Ten months had passed since this test was carried out, with retesting due 2 months after the occurrence. This pending maintenance was also listed on the maintenance release.

At the last scheduled maintenance, completed on 8 February 2013 at 9,468 hours total time in service, the 100-hour, 300-hour, and 600-hour periodic maintenance tasks prescribed by the helicopter manufacturer were certified as complete. A maintenance release was issued at the time, allowing 100 flying hours or 12 months (whichever came first) of operation. When the engine flame-out occurred, the helicopter had been operated for 53 flying hours over 4 calendar months since maintenance release issue. The pilot and operator were not aware of any defects or anomalies.

Helicopter recovery and on-site examination

Shortly after the ditching it was noticed that a fuel-like slick was forming in the water near the helicopter. To minimise the risk of environmental damage the helicopter was towed to a remote beach from where it was retrieved by barge on 10 June 2013. The helicopter was exposed to wave and tidal action for a period of 55 hours and incurred post-accident damage to the main rotor blades, flight control linkages, some door and access panels and the pilot's windscreen. Sea water also entered the fuel tanks at some point during this period.

The helicopter was shipped to Derby where the Australian Transport Safety Bureau (ATSB) conducted an examination of the helicopter systems. The flight controls and rotor drive trains were determined to be intact prior to impact with the water. The engine control system connections were found intact and functional. The compressor discharge air pressure system, which is used to operate engine control and governing systems, contained sea water but was intact and clear of obstructions. The ground/flight bypass valve for compressor washing was found in the flight position.

The engine compressor and turbine cores were examined in situ and found to be intact and undamaged with no evidence of foreign object ingestion or damage. There were no obstructions to the air inlet system to the engine compressor intake. Drive continuity to the respective accessory gear trains was established. Overall, there was nothing mechanical found to explain the sudden engine power loss.

The fuel control unit, engine-driven fuel pump, power section governor and fuel nozzle were removed and taken to an overhaul facility for specialist examination. That examination found nothing that might have contributed to the engine power loss.

The fuel tanks were drained and the resultant emulsion left to stand for several weeks to settle out before being measured to determine the ratio of water to fuel. A total of 137.6 L of sea water/fuel emulsion was recovered consisting of 19.6 L from the forward tanks and 118 L from the main fuel tank. The measurement of the emulsion recorded 0.4 L of fuel and 19.2 L of sea water in the forward tanks and 6.5 L of fuel and 111.5 L of sea water in the main tank. There was an additional 0.5 L of fuel and 0.5 L of water captured in a 1 L drain bottle used for the visual sediment check. A total of 7.4 L of fuel was recovered from the fuel system.

Examination of the fuel system

The two electric boost pumps were examined and found to be capable of normal operation. Examination of the under-floor fuel strainers of the ejector pump fuel transfer system found a small amount of contamination but no blockage that might have prevented normal fuel transfer (Figure 3). The two flow switches were capable of normal operation. Based on that information, there was nothing to impede the transfer of fuel from the forward tanks to the main tank.

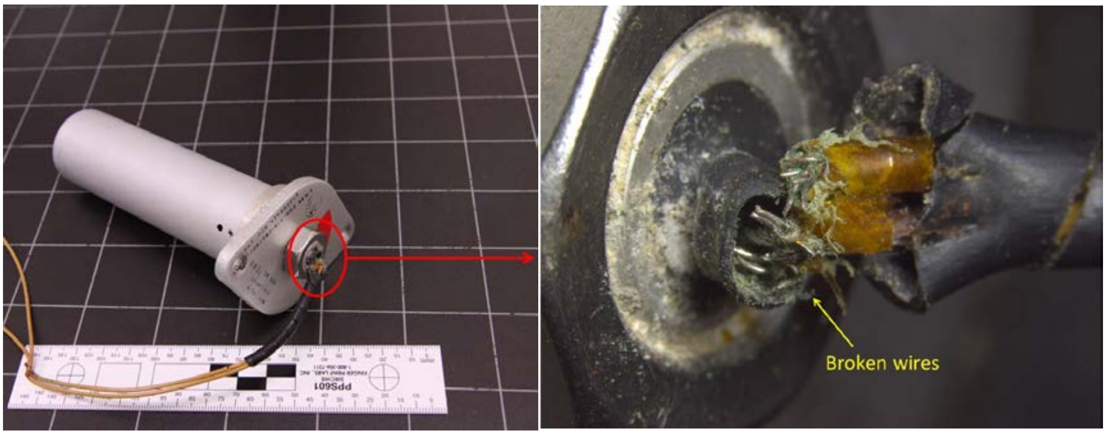
Figure 3: Underfloor fuel strainer

Source: ATSB

The fuel quantity probes and indicator along with the low fuel float switch were examined by the ATSB. The FQIS components returned readings 25 lb (14 L) lower than specified throughout the indicating range and would not indicate above 180 lb (102 L) at any input setting. This was attributed to seawater immersion and corrosion within the probes and gauge. Consequently, it was not possible to establish the accuracy of the system prior to the ditching.

The low fuel float switch was found to have a faulty electrical connection (Figure 4). This compromised the operation of the low fuel caution system such that activation of the caution light at low fuel quantities was not assured.

Figure 4: Low fuel float switch and faulty electrical connection



Source: ATSB

Operator fuel management

In relation to fuel planning for the B206L-3 type, the operator specified a normal fuel flow of 150 L/hr at an airspeed of 110 kt, and a holding fuel flow that was also 150 L/hr. For a charter flight, the operator required a fixed reserve of 20 minutes at the holding rate (equating to 50 L) and a variable reserve of 15 per cent of flight fuel. These reserve amounts were consistent with the extant regulatory guidance. It should be noted that as a flight progresses, the amount of variable fuel required to be carried diminishes proportional to the flight time remaining. For a flight without a defined route or constant fuel consumption rate, any nominal variable reserve fuel on departure can be consumed during the flight and does not have to be intact at the destination.

The operator supplied a daily flight record form for pilots to record successive flight sector details and fuel on board the helicopter at the start of the flight, fuel burn-off and fuel remaining at the end of the flight. Although not specified, the accepted practice was for pilots to derive the start and stop fuel-on-board amounts from the fuel quantity indicator, and then to calculate the fuel consumed from the difference between the two indications. No provision was made for a fuel consumption rate calculation after each flight.

The operator's procedures required that, after refuelling, a pilot was to confirm that the amount of fuel recorded by the refueller agreed with the amount dispensed into the helicopter. This figure was to be recorded on the daily flight record. Furthermore, before commencing each flight a pilot was to check the amount of fuel dispensed and verify by means of gauges (and visually if possible) that total fuel on board was sufficient.

The active daily flight record recorded the details of nine previous flights dating back to 13 May 2013, which was the last time the helicopter was refuelled to full tanks. A review of that flight record identified some anomalies in the fuel figures that were corrected after the accident by the operator, adding three refuelling figures and two flights.

The daily flight record was used by the chief pilot as the basis for the average fuel consumption calculations, as required by the operator at least six times per year.

Fuel on board calculations

The ATSB sought to calculate the fuel on board at the time of the engine flame-out. For this type of flight, with variations to speed/power, height and weight (as fuel was consumed), this presented some difficulty. Three different methods were used to establish a range of possibilities.

First, the specified planning rate of 150 L/hr was applied to the total flight time of 1 hour and 25 minutes. This produced a fuel consumed figure of 212 L. Based on a nominated start figure of 240 L that equals 28 L remaining at the time of the occurrence.

Second, the average fuel consumption rate calculated by the operator from the daily flight record was applied. This rate of 141 L/hr was derived from the sum of the fuel consumed on each flight (based on fuel quantity indications) divided by the sum of the flight times. When that average rate is applied to the 1 hour 25 minute flight, the result is 200 L consumed. Based on a nominated start figure of 240 L, that equals 40 L remaining at the time of the occurrence.

Third, the fuel consumption data supplied by the helicopter manufacturer for an equivalent LongRanger at the same weight and in the same environmental conditions was applied. Given the average ground speed for the flight was 81 kt, the ATSB considered the most representative data was for an airspeed of 85 kt. When the manufacturer's rate of 123 L/hr is applied to the total flight time, the result is 174 L consumed. Based on a nominated start figure of 240 L, that equals 66 L remaining at the time of the occurrence.

Fuel management guidelines

In the guidance given to operators and pilots in Civil Aviation Advisory Publication (CAAP) 234-1(1) *GUIDELINES FOR AIRCRAFT FUEL REQUIREMENTS*, CASA advised that 'Fuel gauges, particularly on smaller aircraft, may occasionally be unreliable.' In regard to the need for a fuel quantity crosscheck, CASA recognised that the design of some aircraft fuel tanks precluded a visual or other direct reading means of establishing fuel quantity at less than full tanks. Nevertheless, CASA recommended that a pilot try to use the best available fuel quantity crosscheck prior to starting, and that the crosscheck should consist of establishing the fuel on board by at least two different methods.

The CAAP listed four ways of achieving this type of crosscheck, including item (c) as follows:

> After refuelling, and having regard to previous readings, a check of electrical gauge or visual readings against the refuelling installation readings.

No documented guidance was given in the CAAP as to what an acceptable variation between readings might be. In its response to the draft report, CASA advised that the issue of tolerable variation should be the subject of the operator's fuel policy for the aircraft type, and the maximum allowable variation would need to be based on the acceptable accuracy calibration of the fuel gauge system of the aircraft.

Safety analysis

Introduction

The reported circumstances and subsequent aircraft examinations clearly implicated a complete and sustained engine power loss as the reason for the forced ditching. At the time of the power loss, the helicopter was operating at an altitude from which a restart was not practicable. The pilot initiated an autorotation and altered his approach towards nearest land, then deployed the pop-out floats prior to touching down on the water. Although one of the floats detached during the landing, there was sufficient buoyancy to keep the submerged helicopter near the water surface.

The analysis following will examine the factors in the engine power loss and consider the operational aspects of the occurrence.

Engine power loss

The Australian Transport Safety Bureau (ATSB) considered mechanical failure, fuel contamination and air induction blockage but determined that these potential factors did not exist and therefore could not have influenced the outcome. The other possibility, of inadequate fuel supply to the engine, will then be examined in detail.

Determination of the amount of fuel on board the helicopter post-accident, and of its distribution within the three tanks, was rendered inconclusive due to the flooding of the fuel system with sea water. However, the fuel-like slick on the sea surface immediately following the ditching indicates there was probably fuel on board in excess of the unusable fuel amount recovered from the tanks. In that case, fuel exhaustion (no usable fuel) was less likely than fuel starvation (interruption to engine fuel supply).

In the LongRanger, there is a well-documented scenario in which the total fuel on board can be sufficient but some is isolated in the forward tanks. Consequently, this fuel is not available to the outlet in the main tank and the engine is eventually starved of fuel. Without the optional forward tank quantity indication being fitted to this helicopter, the pilot was not able to identify which portion of the total fuel quantity was in the forward tanks. That said, the components that work together to transfer fuel from the forward tanks to the main tank were found to be capable of normal operation. In addition, there was no fuel boost pump failure indication that is usually associated with this failure mode. On that basis, the isolating of otherwise usable fuel in the forward tanks is not a feasible explanation of this occurrence.

The only other mechanism for interrupting fuel flow to the engine in this case was an un-porting of the electric boost pumps due to a critically low fuel state. If this had occurred, it was inconsistent with the pilot’s report of at least 180 lb (100 L) fuel indication when diverting towards the refuelling point. It was also inconsistent with the range of calculated fuel quantities (30 to 66 L) that might be expected after departing with the nominated fuel on board and flying for 1 hour and 25 minutes.

For a boost pump un-porting condition to occur, the Fuel Quantity Indicating System (FQIS) would have to be inaccurate and the fuel on board to be at the lower end of the calculated fuel quantities, if not lower. Although the results of the post-accident FQIS testing were inconclusive, there was sufficient doubt about the operation of the system to establish in the context of the occurrence that the FQIS was probably giving erroneous indications. The last time the FQIS was calibrated was nearly 2 years prior to the occurrence, which was sufficient time for its accuracy to drift. The operator’s use of the FQIS in the determination of aircraft fuel loads is discussed in the section following.

In the case of a FQIS malfunction, the low fuel caution was an independent system designed to activate at between 28 and 42 L to alert a pilot to a critical fuel state. Given the fuel quantity at the time of the engine power loss was probably in this range or below, the low fuel caution should have illuminated prior to the engine power loss. However, this system was compromised by a faulty electrical connection and had been in this condition for an indeterminate time. As a result, the pilot had nothing other than the FQIS intermittency in the last stages of the flight to indicate that the FQIS might have been inaccurate.

The ATSB concluded that, without the pilot realising it, the fuel on board was probably sufficiently low to allow momentary un-porting of the fuel boost pumps, which interrupted the flow of fuel to the engine and resulted in engine flame-out and a forced ditching.

Fuel management considerations

The development of a critically low fuel state without pilot awareness is an outcome that an operator's fuel management system is intended to prevent. Given the pilot complied with the operator's procedures, the focus of this section will be on the efficacy of those procedures.

The procedures adopted by the operator for pilots to establish the fuel on board the LongRanger were almost totally reliant on the FQIS. This was because the design of the helicopter fuel tanks precluded a visual or other direct check of fuel quantity (such as a dipstick), and the on-board instrumentation did not have the capability to totalise fuel consumption. Also, the FQIS was considered by the operator to be reliable and accurate with no history of problems.

However, apart from filling or draining the tanks, the pilot had no way of regularly and independently establishing the actual quantity of fuel on board as a way of crosschecking the accuracy of the FQIS. And, even if the tanks were filled or drained, that only achieved a crosscheck of the FQIS at those extremities. Although the FQIS was calibrated throughout the range of indication at 2-year intervals, this did not and could not provide assurance that the system would be accurate between calibrations.

Operator procedures required pilots to correlate the amount added to the tanks after refuelling with the amount dispensed into the helicopter. While it is unclear how the amount dispensed into the helicopter was to be established, the apparent intent of this provision was consistent with crosscheck option (c) of Civil Aviation Advisory Publication 234-1(1) *GUIDELINES FOR AIRCRAFT FUEL REQUIREMENTS*. This was basically a correlation of the amount added during refuelling, with the difference between the before and after FQIS readings.

The pilot was essentially employing this crosscheck option the day before the flight when he noted the FQIS reading before refuelling (90 L) and used it to calculate the amount needed (150 L) to increase the fuel on board up to the target amount (240 L). Once the nominated amount of fuel was added to the tanks the FQIS would be expected to indicate 240 L, which it did at the time and on the day of the flight. Understandably, the pilot did not suspect that the FQIS was inaccurate and he proceeded on the basis of having 240 L on board at the time of departure and 100 L on board at the time he tracked for the refuelling site. As it turned out, there was probably less fuel on board than the FQIS was indicating at any time during the flight.

It is apparent, then, that the means offered by the Civil Aviation Safety Authority as a valid fuel quantity crosscheck did not provide a high level of assurance that the FQIS would be correct. For certain types of operation, the absence of any independent means of establishing fuel quantity can be a critical weakness in the fuel management framework. Helicopter survey operations are particularly vulnerable in that the fuel consumption rate can vary significantly throughout a flight for any number of reasons. As a result, pre-flight fuel planning, in-flight fuel remaining calculations and post-flight calculation of an aircraft's fuel consumption rate can be made problematic. As well as being demonstrated in this occurrence, it was identified as a factor in several other occurrences.

One of these involved a Bell 206B JetRanger being operated on scenic flights at Coomera, Queensland on 10 June 2009. On approach to land the engine lost power and the helicopter landed heavily with serious injuries to some occupants. The investigation found that helicopter had insufficient fuel on board for the flight and that the engine was probably starved of fuel.

Contributing to this situation was the lack of an operator procedure to ensure independent crosschecking of the helicopter's fuel quantity.

Fuel starvation events of this nature are not limited to helicopters and have been identified in various ATSB investigations of engine power losses involving a Metro III aeroplane (investigation 200504768), Cessna 404 aeroplane (investigation AO-2007-049) and a Brasilia aeroplane (investigation AO-2007-017). Copies of these investigation reports are available at www.atsb.gov.au.

As shown by this and other occurrences, there is a need for operators to ensure that their fuel management policy and procedures provide for at least two independent and reliable means of establishing fuel on board. These should be supplemented by criteria for identifying, recording, and resolving any discrepancy between the amounts generated by the different methods. In situations where visual or other direct means of establishing fuel quantity are not possible, equipment that measures and totalises fuel flow can provide a valid basis for derivation of fuel-on-board amounts.

The operator's daily flight record was intended to allow the tracking of fuel quantities and consumption rates but that data was derived in one way or another from the FQIS. In addition, recent pilot use of the daily flight record was inconsistent and imprecise, and in combination with the design of the form did not provide an effective means of monitoring fuel on board.

Irrespective of the FQIS indications, the low fuel caution system could be expected to alert the pilot of a critically low fuel state in time for the pilot to land before the engine flamed out. On this occasion a wiring fault prevented any activation of the caution light so the pilot was unaware of the likely low fuel state. This was a latent failure because the system had been compromised for a period of time without pilot awareness. As was common for the type of system, pre-flight testing verified operation of the globe but was not capable of detecting whole-of-system integrity. The only scheduled check of the system was the annual functional check.

Low fuel caution systems are valuable elements in a safe fuel management framework but can fail without detection and as such should not be relied upon as a substitute for an independent crosscheck of fuel quantity indicating systems. Operators should consider the criticality of on-board fuel quantity measuring equipment in the context of their particular operations and manage the risk of malfunction accordingly.

The ATSB concluded that the operator's procedures for a pilot to determine the fuel on board the helicopter before, during, and after a flight, was almost totally reliant on the electrically-powered fuel quantity indicating system, and as a consequence lacked a high level of assurance.

Flight over water and use of life jackets

During the transit to the refuelling site, the single-engine helicopter was operated below 2,000 ft over water and out of gliding range of land without the occupants wearing life jackets as required by regulation. The pilot's decision to track direct to the landing site over water reduced the anticipated flight time but exposed the passengers to a ditching. Without life jackets being worn there was increased drowning risk, but this was mitigated by the pop-out floats which maintained sufficient buoyancy to keep the helicopter afloat. Fortuitously, when the engine flamed out the helicopter was in the vicinity of the landing site and the ditching was observed by people with the capability to rescue the occupants.

The difference in water pressure on the doors or impingement by a float as the helicopter settled probably contributed to the initial difficulty the rear passengers experienced in opening the passenger door. When the water level rose within the cabin and or the cabin attitude changed, the door could be opened. The passengers had the presence of mind not to panic, but wait for the water level to rise.

Findings

From the evidence available, the following findings are made with respect to the engine flame-out and ditching involving a Bell Helicopter 206L-3 LongRanger, registered VH-RHF, that occurred 98 km north of Derby, Western Australia on 8 June 2013. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing factors

- Unbeknown to the pilot, the fuel on board was probably sufficiently low to allow momentary un-porting of the fuel boost pumps, which interrupted the flow of fuel to the engine, resulting in engine flame-out and ditching.
- The fuel quantity indicating system was probably malfunctioning and providing higher than actual quantity indications at the time of departure as well as the time of diversion to the fuelling site, contributing to the pilot’s lack of awareness of the low fuel state.
- A faulty electrical connection on the low fuel caution sender switch prevented a low fuel caution being indicated to the pilot, contributing to his lack of his awareness of the low fuel state.
- The operator's procedures for a pilot to determine the fuel on board the helicopter before, during, and after a flight, was almost totally reliant on the electrically-powered fuel quantity indicating system, and as a consequence lacked a high level of assurance.

Other factors that increased risk

- The guidance provided by the Civil Aviation Safety Authority in relation to pre-flight crosschecking of fuel on board allowed for a reliance on an aircraft fuel quantity indicating system without reference to an independent source of fuel on board information.

Other findings

- The pilot conducted an autorotation to the water surface and successfully deployed the pop-out floats.

Safety issues and actions

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

Proactive safety action

Operator

The helicopter operator advised that as a result of this occurrence they have redesigned the fuel tracking form to improve usability and are considering the fitment of a fuel totaliser in their LongRanger helicopter types.

Ongoing safety action

Civil Aviation Safety Authority

Although not specifically in response to this occurrence, the Civil Aviation Safety Authority (CASA) advised that it is reviewing the existing fuel and alternate requirements generally via Project OS 09/13, which was commenced on 21 August 2009. CASA indicated that this project had relevance to the operator's fuel management policy and its implementation by the pilot; in particular, Phases 2 and 3 of the 4-stage project stated:

> Phase 2: This review will include the methods, by which pilots and operators calculate fuel required and fuel on-board, and
>
> Phase 3: The pilot in command or the operator must take reasonable steps to ensure sufficient fuel and oil shall be carried to undertake and continue the flight in safety.

In addition, CASA advised that:

> The project to amend CAAP [Civil Aviation Advisory Publication] 234-1(1) is ongoing, noting that ICAO [International Civil Aviation Organization] amendment 36 to Annex 6, State Letter AN 11/1.32-12/10, details the new SARPs [Standards and Recommended Practices] for fuel planning, inflight fuel management, selection of alternates and EDTO [Extended Diversion Times Operations]. This amendment represents a culmination of over ten years of ICAO work to develop and refine the EDTO provisions based on best practices and lessons learned, along with the need to update the fuel and alternate selection provisions. The ICAO Fuel and Flight Planning Manual (FFPM) are reflected in this SARP to Annex 6. Inclusion of the provisions of the Amendment 36 SARPs will be captured throughout this project.
>
> The ICAO SARP became effective from November 2012; however ICAO is still finalising the fuel manual and CASA is participating in this process. CASA is already incorporating the new ICAO fuel requirements into the new proposed Operational CASRs [Civil Aviation Safety Regulations]. Once this is done, a flow down to the relevant guidance material will occur, where the CAAP 234-1(1) may become a supporting AC [Advisory Circular] along with the ICAO fuel manual. This is work in progress.

General details

Occurrence details

Date and time:	08 June 2013 – 1005 WST	
Occurrence category:	Accident	
Primary occurrence type:	Engine flame-out	
Location:	98 km north of Derby, Western Australia	
	Latitude: S 16° 28.7’	Longitude: E 123° 32.37’

Pilot details

Licence details:	Commercial Pilot (Helicopter) Licence, issued April 2007
Helicopter Endorsements:	Robinson R22 and R44, Hughes 269, Bell 206 series
Ratings:	Command Instrument Rating (Multiengine aeroplane)
Medical Certificate:	Class 1, valid to August 2013
Aeronautical experience:	Helicopter 950 hours, Bell 206 JetRanger 500 hours (40 hours LongRanger) Aeroplane 6,000 hours
Last flight review:	August 2012

Aircraft details

Manufacturer and model:	Bell Helicopter 206L-3	
Registration:	VH-RHF	
Serial number:	51115	
Type of operation:	Charter	
Persons on board:	Crew - 1	Passengers - 4
Injuries:	Crew – Nil	Passengers –Nil
Damage:	Substantial	

Sources and submissions

Sources of information

The sources of information during the investigation included the helicopter:

- manufacturer
- operator and pilot in command
- passengers.

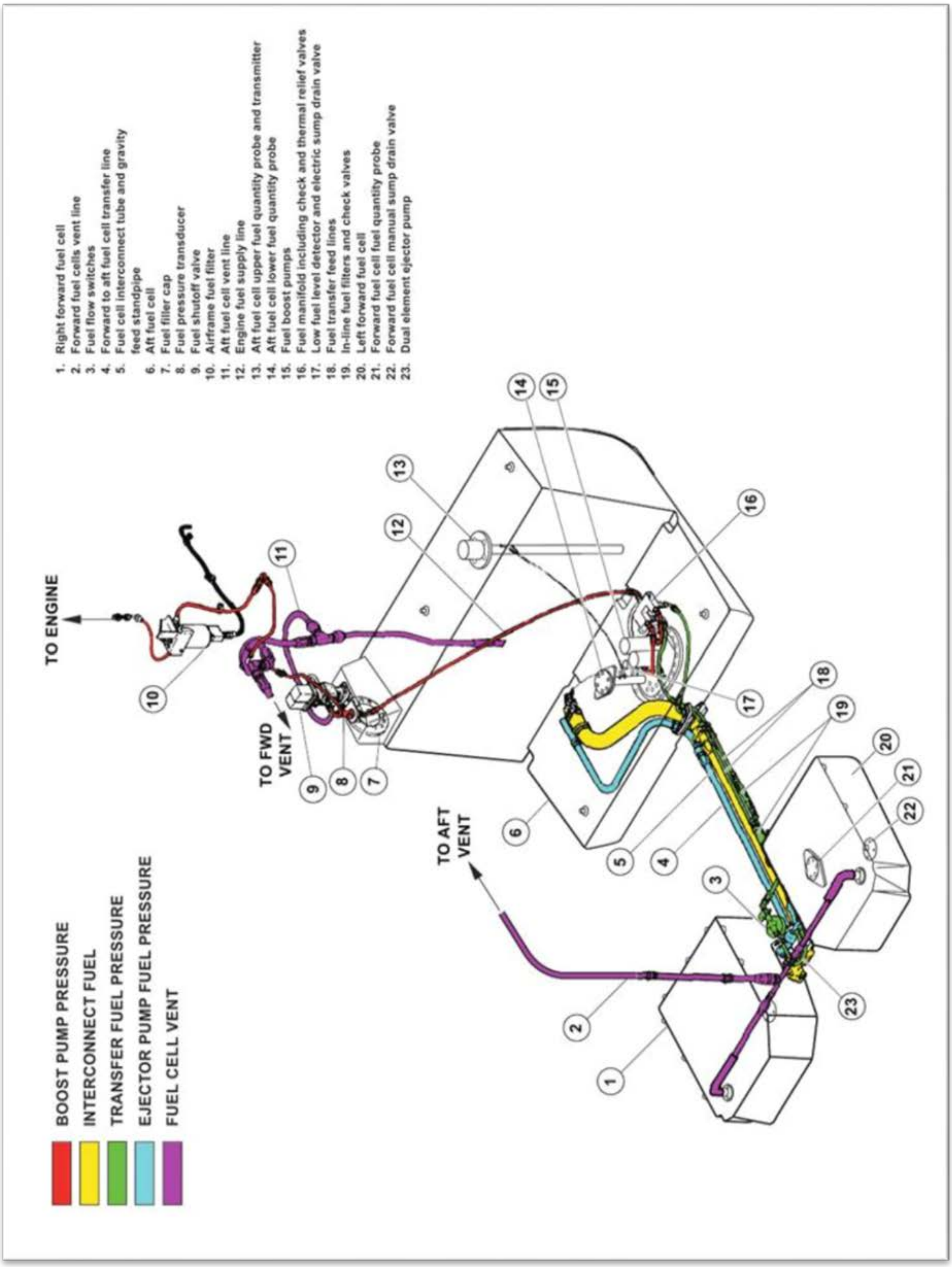
Submissions

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

A draft of this report was provided to the Civil Aviation Safety Authority (CASA), the pilot, the helicopter operator, the helicopter manufacturer, the engine manufacturer and the respective States of Design/Manufacture. Submissions were received from CASA, the helicopter manufacturer, the engine manufacturer, Transport Canada and the pilot. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

Appendix

A - Bell 206L3 LongRanger fuel system



Source: Bell Helicopter

Australian Transport Safety Bureau

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

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

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

Purpose of safety investigations

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

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

Developing safety action

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

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

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

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

Australian Transport Safety Bureau

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Investigation

ATSB Transport Safety Report
Aviation Occurrence Investigation

Engine flame-out and ditching involving Bell LongRanger helicopter VH-RHF , Cone Bay, approximately 98 km north of Derby, WA
8 June 2013

AO-2013-097
Final – 11 December 2013