Aviation Safety Investigation Report 199601505

Bell Helicopter Co Longranger

07 May 1996

NOTE: All air safety occurrences reported to the ATSB are categorised and recorded. For a detailed explanation on Category definitions please refer to the ATSB website at www.atsb.gov.au.

Aviation Safety Investigation Report

199601505

Occurrence Number:	199601505	**Occurrence Type:**	Accident
Location:	6km E Dauan Island, (ALA)		
State:	QLD	**Inv Category:**	3
Date:	Tuesday 07 May 1996		
Time:	0947 hours	**Time Zone**	EST
Highest Injury Level:	Fatal		

Injuries:

	Fatal	Serious	Minor	None	Total
Crew	0	0	0	1	1
Ground	0	0	0	0	0
Passenger	2	0	0	2	4
Total	**2**	**0**	**0**	**3**	**5**

Aircraft Manufacturer:	Bell Helicopter Co		
Aircraft Model:	206L-1		
Aircraft Registration:	VH-RHQ	**Serial Number:**	45257
Type of Operation:	Charter Passenger		
Damage to Aircraft:	Destroyed		
Departure Point:	Dauan Island QLD		
Departure Time:	0945 EST		
Destination:	Thursday Island QLD		

Approved for Release: Thursday, May 1, 1997

FACTUAL INFORMATION

History of the flight

The helicopter was conducting a charter flight transporting four passengers from Dauan Island to Thursday Island. After landing on Dauan Island to pick up the passengers, the pilot refuelled the helicopter without shutting down its engine. With the helicopter's engine still running, the passengers then boarded the helicopter and the pilot briefed them in the helicopter cabin. Each passenger was provided with a life jacket that was folded into a pouch fixed to a belt. These jackets were fitted around each passenger's waist but the passengers were not directed to don the jackets before takeoff.

The helicopter lifted from the pad at approximately 0945 hours EST, and departed to the south-east. During climbout, the pilot disarmed the emergency flotation system and advised his company base of the departure from Dauan Island.

Soon after takeoff and as the pilot began to level the helicopter at about 500 ft, he felt the helicopter yaw slightly as the engine lost power. The pilot noticed that the engine power turbine revolutions per minute (RPM) indicator needle indication split from the main rotor RPM indication, reporting that it initially decreased below 50% before appearing to recover to between 50% and 60%. He later did not recall however, hearing the "engine out" audio warning or seeing any caution lights. Turning towards Dauan Island, the pilot placed the helicopter in an autorotational descent. He stated that he had insufficient time to arm the emergency flotation system or to make an emergency radio call. He did not recall shutting the engine down during the descent.

Although the helicopter had a functional radio altimeter, the pilot did not refer to it during the autorotation. He attempted to flare the helicopter to arrest its rate of descent before water impact, although he indicated that the conditions made visual height assessment difficult. The chin bubble windows imploded on water impact and the cabin rapidly filled with water as the helicopter rolled left and sank.

The pilot and three passengers escaped from the wreckage after the ditching. One passenger remained in the helicopter as it sank. The pilot and a passenger reported that the occupant who remained in the rear cabin appeared unconscious after the impact. The pilot made several unsuccessful descents into the cabin, attempting to release the remaining passenger's seat belt buckle. Soon after, one of the passengers, who escaped the wreckage but resisted attempts by the pilot to correctly fit and inflate his life jacket, failed to stay afloat and disappeared beneath the water.

Several witnesses on Dauan Island saw the helicopter hit the water and advised police, who commenced a search. Approximately 2 hours after the helicopter had ditched, the pilot and the two surviving passengers were sighted by another helicopter, which dropped a life raft to them. The survivors were rescued by boat soon after.

The helicopter sank in an area of poor water visibility and rapid tidal current movements. The wreckage was not recovered.

Weather conditions

The area weather forecast indicated that the wind was expected to be south-easterly with scattered thunderstorms and patchy showers in the area. The cloud included occasional cumulonimbus, base 2,000 ft, with broken stratus at 800 ft in precipitation, scattered cumulus at 1,800 ft, scattered stratocumulus at 4,000 ft, and broken altocumulus above 12,000 ft.

The reported weather was similar to that forecast and the pilot stated that there was a light drizzle during the takeoff and that he had levelled the helicopter at 500 ft to remain visual.

The helicopter

The helicopter was a Bell 206L-1 Longranger, equipped with inflatable emergency floats fitted to the helicopter's skids. The helicopter's float-arming switch was on the left side of the instrument panel, with the firing switch mounted on the collective control head. The arming switch location required the pilot to remove his hand from the collective control to arm or disarm the flotation system. Additionally, each of the company's Longranger helicopters had the arming switch in different locations. The helicopter's flight manual prohibited flight with the floats armed above an airspeed of 52 kts.

A radar altimeter, which precisely indicated the helicopter's height, was also on the left side of the instrument panel, outside the pilot's normal instrument scan.

The pilot stated that the helicopter weight on takeoff was approximately 1,660 kg, 176 kg less than the allowable maximum all-up weight, and that it had 440 - 500 lbs of fuel on board. At the reported weight and load disposition, the helicopter was within centre of gravity limits.

The engine

The helicopter was powered by an Allison 250 C28 gas-turbine engine fitted with a Bendix fuel control and governing system, which schedules the fuel flow to control power turbine speed (N2), and therefore main rotor speed (NR). Some known reasons for engine power loss include:

(a) governor rundown which closes the fuel-flow metering valve to minimum flow and effectively reduces engine power to zero;

(b) partial blockage of the fuel feed to the engine; and

(c) contaminated fuel, which is more likely to cause the engine to flame out.

Governor rundowns can be caused by an internal governor failure or a loss of compressor discharge air pressure (Pc). Pc air is used to regulate fuel for engine starting, acceleration and deceleration. The most probable causes of engine governor rundown include Pc line failure as a result of B-nut insecurity or line fracture, fuel control unit (FCU) bellows failure (internal FCU sensing of Pc air), or internal power turbine governor failure (mechanical). Allison 250 engines, prior to the C40 version and unlike some other helicopter turbine engines, do not incorporate an emergency reversion facility to manually control the metering valve following a governor rundown.

Symptoms of a governor rundown include the reduction of the compressor speed (N1) to below normal flight-idle with the N2 also reducing to below normal flight-idle. An indication of impending Pc supply failure includes slow engine starts, although this is also symptomatic of other engine problems.

Engine cockpit warnings include a caution light with an associated intermittent audio signal which activates when N1 falls below 55%. A low main rotor RPM warning light illuminates with an associated steady audio signal when NR falls below 90% and the collective pitch lever is raised off the bottom stop.

Following an engine failure or governor rundown in the Bell 206, the pilot is committed to conducting an autorotational approach and landing. Depending upon all-up weight and main rotor pitch rigging, the rate of descent during established autorotation is approximately 1,500-1,800 ft/min. The rate of descent is even higher until the helicopter is established in the autorotational profile.

The pilot

The pilot's licence and medical examination were current and appropriate. He was endorsed on the Bell 206 and complied with dates for his biennial flight review and Civil Aviation Order (CAO) 20.11 (emergency equipment competency qualification) and dangerous goods course. He had been flight- checked by the company's chief pilot two days prior to the accident and had accumulated 2,789 flying hours, of which approximately 90 were on the Bell 206.

He had acquired experience in over-water operations during previous overseas employment, receiving float training in Hughes 500 and Bell 47 helicopters.

He was within crew duty limitations and his prior 72-hour history revealed nothing that may have affected his ability to conduct the flight.

Pilot's emergency response

A Royal Air Force study conducted in a helicopter simulator concluded that it may take up to 5 seconds for pilots to recognise and react to an engine problem requiring them to place the helicopter in autorotation. The study also highlighted that the pilots involved in the experiment, although unaware of the study, had a high expectation of an emergency occurrence by just being in the simulator. The study noted that pilots in real flying conditons would have a lower expectation of being confronted with an emergency and that the time required to recognise a problem and then to organise and execute a response, would probably extend the reaction time.

Another relevant consideration, not noted in the study, is that the experiment pilots were flying a standard configuration simulator, one similar to their helicopter. The pilots would have been comfortable in the cockpit environment and would have formed habit patterns relating to the location of controls and switches.

Other studies have demonstrated that pilots may react to information overload by load shedding or regression. Load shedding is a filtering process wherein the pilot ignores some information and focusses on one or two aspects of the flight. The visual field sometimes narrows, as if the pilot were wearing blinkers. In extreme cases, pilots' attention may become focussed on just one process to the detriment of all others, often resulting in their senses becoming less effective.

Visual cues

A pilot's ability to perceive depth is very important during the final stages of a visually flown autorotative approach. The pilot has to continually assess the helicopter's height and progress across the ground or water to choose a point at which to commence a progressive flare. (The flare uses stored energy in the main rotor to minimise the helicopter's rate of descent and groundspeed, aiming for zero speed at touchdown.)

Depth perception is the ability to see objects in three dimensions, and permits the estimation of object distances. The human eye combines a variety of cues to assist with perceiving depth, including:
(a) object relative size;
(b) object overlap;
(c) object surface texture;
(d) retinal disparity for objects closer than 9 M; and
(e) eye convergence.

The ability of the eye to utilise these cues can be impeded by low illumination or haze.

Maintenance

Seventeen days prior to the accident, the helicopter was serviced to replace a cracked windscreen and leaking tail rotor seal, to implement an AD Bell 206.126 (mast support check) and to troubleshoot slow engine starts. The engine had undergone 27 start cycles and the helicopter had flown approximately 23 flying hours since the servicing. Although no entry had been made in the helicopter's maintenance release regarding the engine, company personnel had reported to the licensed aircraft maintenance engineer (LAME) that the engine was suffering slower than normal starts. The Pc filter and fuel nozzle were cleaned during the servicing. Fault-finding procedures for slow engine starts are published in the Allison 250-C28 series maintenance manual. The procedure includes checking the air lines and fittings for looseness and for cracking in the air tubes and combustion case.

The LAME was qualified and experienced on the Allison 250. He stated that he referred to copies of the relevant pages of the maintenance manual during the servicing and had checked the security of the air lines, visually checking for line fractures. He also stated that the Pc filter had a small amount of foreign matter in it which he removed. After completion of the checks and cleaning, the helicopter's engine starts returned to normal. The LAME visually inspected the tube for cracks using the engine manufacturer's approved method. He stated that during an engine ground run, he felt around the pressurised Pc line to check for leaks. The maintenance organisation stated that this was a sound practice on the Allison 250 engine, even though "feeling" for leaks is not a recognised engineering practice, is not recommended by the engine manufacturer, and is not a procedure which is in accordance with the maintenance manual.

There are numerous warnings throughout the Allison 250 C28 Series Operation and Maintenance Manual emphasising the need for the correct installation and torquing of the pneumatic tubes to prevent flameout, power loss, or overspeed. The engine maintenance manual and other Allison references require the use of torque paint on the rigid tube B nuts. The LAME reported, however, that there was no evidence of prior application of torque paint when he serviced the Pc filter, and that he did not apply any torque paint after reconnecting the Pc line.

Operating documentation

The company operations manual required the pilot in command to brief passengers before departure on the location and use of life rafts and life jackets, although the donning of life jackets for over-water flights was not specified. Also not specified were the conditions under which passengers should be briefed (with engine running, in the helicopter, and on intercom). The printed safety material mandated by CAO 20.11 was not detailed in the company operations manual nor was it carried in the helicopter.

Whilst hot refuelling (engine running, rotor turning) was a common practice within the company, the operations manual only authorised refuelling under CAO 20.9 which required the helicopter's engines to be shut down unless specifically approved. CAO 21.10 permits the hot refuelling of helicopters provided the operations manual authorises and details the procedures to be followed. No specific approvals or instructions were contained in the company operations manual.

The company reported that it has since acquired waistcoat-type life jackets for passengers, that company helicopters are now carrying appropriate printed safety material, and that it has amended the operations manual to authorise and detail hot refuelling procedures.

Survival equipment - life jackets

The passengers were wearing RFD KSE 35L8 units which were in a pouch fitted on a belt. This type of jacket requires unpacking and donning before inflation. The passengers did not don the jackets before takeoff. The requirement to wear lifejackets is in CAO 20.11.5.1. The company reported that a representative of the then Civil Aviation Authority (CAA) approved the use of the RFD KSE 35L8 life jacket, and subsequent surveillance conducted by the CAA and the Civil Aviation Safety Authority (CASA) did not highlight any problems with the company's use of this jacket.

After the helicopter impacted the water, the male passenger escaped but did not don his life jacket. The pilot stated that the life jacket remained in its pouch and that the passenger fought off attempts by the pilot to unpack and fit the jacket.

The girl passenger also refused to don the life jacket, but the pilot assisted her to remain afloat. The pilot later inflated her jacket and she held on to it until a liferaft was dropped by another helicopter.

The pilot managed to unfold the adult female survivor's jacket and place it over her head before inflating it.

Survival equipment - liferafts

Despite the helicopter company having provided in-flight monitoring as well as there being eyewitnesses to the ditching, more than 2 hours elapsed before the survivors were rescued. There was no requirement to carry a liferaft on this flight as detailed in CAO 20.11.5.2. The adult female survivor stated that she "went blank" several times following the accident and before recovery. The pilot stated that by the time a liferaft was lowered to the survivors, the child was cold and shaking.

Survival equipment - survival beacon

With the availability of continuous air-ground communication and there being no requirement to carry a liferaft, provision of a survival radio beacon was not mandated under CAO 20.11.6.

The helicopter inverted soon after impact and there were no reception reports of the helicopter's Artex ELS10HM fixed emergency locator transmitter (ELT).

Exits

The front doors were hinged to the helicopter's structure and the pilot stated that he could not open his door, having to exit through the door's sliding window. The pilot had not undergone any helicopter underwater escape training, although he had received advice on underwater escape techniques from the company's chief pilot several days prior to the accident. The pilot stated that he recalled the advice, which proved instrumental in his successful exit from the submerged wreckage.

As the male passenger did not survive the post-accident events, it was not possible to ascertain his escape route or actions. The female passenger who did not escape the wreck sat in a forward-facing seat next to the rear left fore/aft sliding door. Evidence indicates that the passenger was unconscious after the impact and had therefore made no attempt to open the door. The helicopter wreckage rolled left and submerged with the right skid protruding above the water's surface for a short time. The pilot entered the wreckage through the right rear door several times but was unsuccessful in releasing the passenger's seat belt.

Sitting next to the rear left door but facing aft, the girl passenger survivor floated to the surface after the adults. There was no indication as to the escape route followed.

The rear right door was hinged to the fuselage and the adult female survivor who sat next to the door stated that the pilot had shown her the emergency door release and how to operate the seatbelt. She stated that she also read the instructions placarded on the emergency door release before takeoff and had used the emergency door release to escape the helicopter.

Fuel

Fuel was drawn from a sealed drum on Dauan Island prior to takeoff. During the search for the missing helicopter, another Bell 206 refuelled from the same drum, nearly emptying it. The other company helicopter experienced no fuel-related problems afterwards. Fuel later drawn from the drum for testing was insufficient for complete analysis. The fuel drawn was analysed to the extent possible and found to be free of contaminants, although the report stated that it could not reject or implicate the fuel as a cause of the helicopter crash.

The pilot had conducted a hot refuel for which procedures had not been detailed in the operations manual. The hot refuelling procedure followed by the pilot, however, appeared to be industry standard, although he had not conducted a visual contaminant check on the fuel from the pump outlet before fuelling the helicopter.

Testing

With no wreckage recovered, it was not possible to positively ascertain the cause of the power loss through an engineering inspection.

Testing performed on a similar Bell 206L-1 fitted with an Allison 250 C28 engine revealed that when the PC line was disconnected:
(a) the engine experienced a governor rundown, N1 rapidly reducing to 37% with the N2/NR following to 32% over approximately 5 seconds (possibly due to the low rotor drag caused by the flat collective pitch);
(b) the turbine outlet temperature indication rose markedly before falling back to approximately 500 degrees C; and
(c) the "engine out" light illuminated and the low rotor RPM warning light and horn activated.

For safety reasons, the testing was confined to ground-running the helicopter with flat collective pitch at 100% N2/NR.

ANALYSIS

The reported stabilisation of the N2 indicates that the engine had not suffered a flameout. The cause of the engine power loss could not be determined as the helicopter wreckage was not recovered. However, the reported engine indications suggest that the engine suffered either a governor rundown or partial fuel system blockage.

Fuel

The fuel loaded at Dauan Island is considered unlikely to be a factor in the accident as the drum was sealed before use and fuel from the drum was subsequently used by another helicopter immediately after the accident. Although fuel tests were incomplete due to the amount available for testing, the tests indicated that the fuel was free of contamination. With no prior evidence or maintenance requirements suggesting an impending fuel-feed problem, a partial fuel system blockage appears unlikely, although possible.

Whilst hot refuelling was not permitted by the company operations manual, the procedures followed by the pilot appeared to preclude introduction of contaminants to the fuel. The hot refuel is therefore not considered a factor in the accident.

Maintenance

Whilst the engine manual maintenance actions had not been fully complied with, the work conducted on the Pc filter appeared to have remedied the engine starting problem. There was no evidence to indicate that the servicing conducted 17 days prior to the accident contributed to the engine power loss.

Human factors

After the engine lost power, the pilot was committed to an autorotational approach and landing. He had disarmed the flotation system in accordance with the pilot's notes, and to re-arm the system, the pilot would have had to move his hand from the collective control, a primary flight control during autorotation. The total time available to the pilot following the engine power loss to water impact was probably in the order of 10 seconds. With possibly more than 5 seconds being required to recognise, organise and react to the problem, the pilot had less than 5 seconds remaining in which to initiate a flare before touchdown. The pilot was in an extremely high workload environment and his attention would most probably have been focussed on achieving a successful ditching, thereby filtering out any awareness of the warning tone and lights.

The lack of standardisation in the location of the flotation arming switch denied the pilot a chance to build a habit pattern which would have permitted him to readily arm the system in an emergency. It was highly unlikely, given the high workload environment and the cockpit switch configuration, that the pilot had an adequate opportunity to arm the helicopter's flotation system.

Insufficient collective pitch application was used to adequately cushion the water impact, resulting in the chin bubble windows imploding and the helicopter rapidly filling with water. A more controlled ditching would have lessened the airframe damage and probably reduced the rate at which the cabin filled with water. It was not possible to ascertain whether or not the impact caused one of the passengers to appear unconscious as the helicopter sank.

Weather conditions on the day were poor, with rain, low cloud and low illumination caused by the extensive cloud cover. The sea was relatively smooth and no clear horizon was visible. The ability of the pilot to assess the correct flare height, attitude and cushioning height was probably diminished by the lack of visual cues. The pilot's height assessment problem was compounded by the radar altimeter being outside his normal instrument scan.

Survival

Although life jackets were provided and worn in accordance with the CAOs, it is most probable that the passengers suffered shock and disorientation after the landing. Their ability to don the jackets therefore, would have been severely impaired, and it is highly unlikely that any passenger would have correctly used a life jacket had the pilot not been available.

Evidence indicated that the survivors probably experienced shock following the accident and with no access to a liferaft, their continued immersion in water may have exacerbated their symptoms. In accordance with CAOs, the helicopter was not required to carry a liferaft and did not do so. Additionally, the carriage of a survival radio beacon was associated with the liferaft requirements. The helicopter submerged on impact, which made the fitted ELT ineffective. If the crash had not been reported by eyewitnesses, the requirement to conduct a visual search unaided by electronic location measures long after the event would probably have increased the recovery time substantially.

Without wreckage evidence, it could not be ascertained as to why the pilot was unable to open his door. With the helicopter submerged right side up, it is likely the surviving passengers escaped through the right rear door after the adjacent passenger used the emergency release. Although the company had not provided written instructions as required by CAOs, the passenger had used the placarded instructions to operate the door.

Engine configuration

Available evidence indicates that the engine may have suffered a governor or Pc malfunction. Without a method of reverting to manual fuel control, the pilot was committed to an autorotational approach and landing despite the engine probably being mechanically capable of producing full power.

SIGNIFICANT FACTORS

1. The helicopter's engine suffered a significant loss of power.

2. There was no manual overide facility for the engine's governing system; therefore, the pilot would have been unable to recover engine power if the power loss was caused by a failure of the engine's governing system.

3. The effect of the poor location of the helicopter's float arming switch, combined with the low altitude at which the engine ran down, was that the pilot most probably had insufficient time to activate the flotation system before water impact.

4. The lack of good visual cues and the location of the radar altimeter reduced the pilot's ability to judge the helicopter's height during the final stage of the autorotational descent. The inability of the pilot to accurately judge the helicopter's autorotational flare height probably caused the heavy landing.

5. The lifejackets were not fully donned by the passengers before takeoff and only one passenger correctly donned a jacket, with assistance, after escaping the wreckage.

SAFETY ACTION

The Bureau of Air Safety Investigation is continuing to investigate a number of safety deficiencies in both operations and engineering that have been identified in this accident. Any safety outputs will be directed to the relevant action agencies and will be published in the Quarterly Safety Deficiency Report.

From part of this investigation, the Bureau issued interim recommendation IR 960138 to the Civil Aviation Safety Authority on 9 December 1996:

"The Bureau of Air Safety Investigation recommends that the Civil Aviation Safety Authority:

"(i) review the current orders and regulations to ensure that the intention of Civil Aviation Order 20.11 part 5, governing the wearing of a life jacket is clear and unambiguous, and that jackets worn in accordance with the order afford the wearer maximum safety benefit;

"(ii) educate the industry on the need to have life jackets worn in such a manner that they afford the wearer maximum safety benefit;

"(iii) encourage the carriage and use of portable ELTs in aircraft where the fixed installation is not readily accessible in an emergency, particularly for fare-paying passenger operations; and

"(iv) review Civil Aviation Order 20.11 part 6 governing the carriage of signalling equipment, so that in those instances where a life raft is not required, some additional means of signalling is available to the survivors, particularly for fare-paying passenger operations".

The following response was received from the Civil Aviation Safety Authority on 4 March 1997.

"I refer to your BASI Interim Recommendation 960138 concerning the accident involving Bell Helicopters 206L-l, VH-RHQ near Duaun Island, on 7 May 1996. The following comments are forwarded for your consideration.

The IR indicates that a briefing was given to passengers prior to the flight as required by CAO20.11.4. However no details of the nature and circumstances of the briefing are described. As the briefing can be critical to the survival of the occupants of an aircraft following an accident, it should be given under the most favourable circumstances possible.

Where a briefing is not given in the first language of the occupant or where the briefing is conducted in noisy or windy circumstances such as with the rotor and engine of a helicopter running, there is potential for misunderstanding or misinterpretation. Furthermore, if the briefing itself is cursory or inadequate, then the occupant may not have sufficient information on which to base his or her actions following an emergency.

It is possible that the briefing may have been a factor contributing to the result of this accident.

Interim Recommendation (1).

It is CASA's opinion that the current provisions of CAO 20.11.5 are essentially adequate. However, this issue will be referred to the relevant Technical Committee under the Regulatory Framework Program for its review.

Interim Recommendation (2).

CASA supports this proposal and is considering the best means to give effect to this recommendation.

Interim Recommendation (3).

CASA agrees with this recommendation, and is also considering the best means to encourage industry to adopt this approach.

Interim Recommendation (4).

CASA agrees with the intent of this recommendation and will also refer this issue to the relevant Technical Committee for review under The Regulatory Framework Program."

The Bureau has classified this response as: CLOSED ACCEPTED.