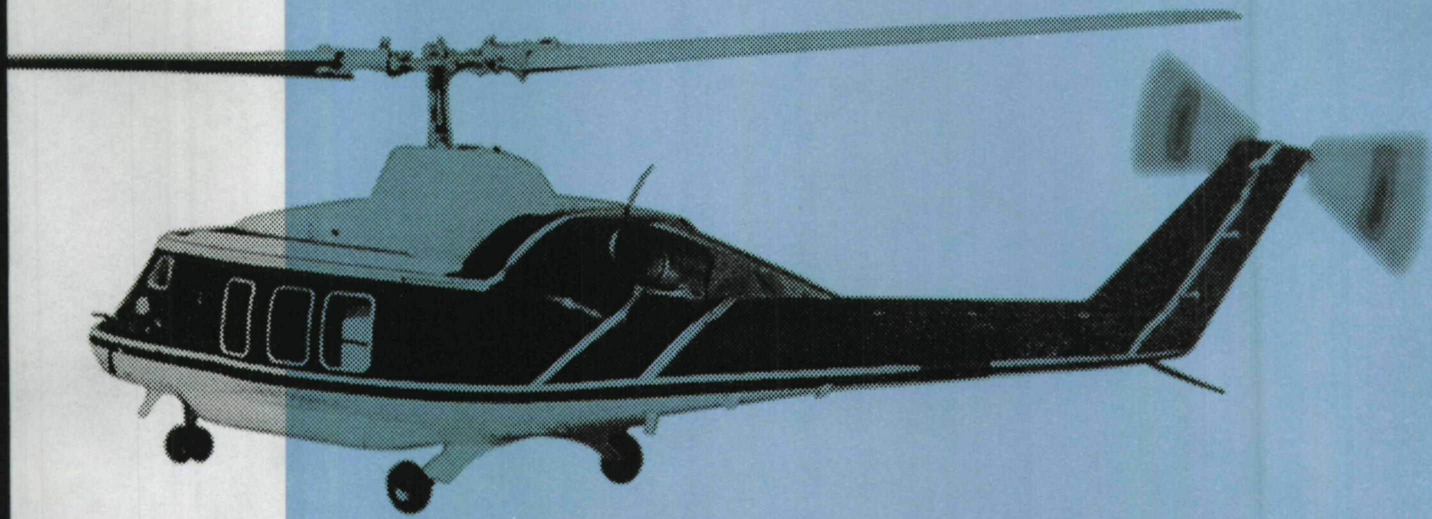
BUREAU OF AIR SAFETY INVESTIGATION REPORT

BASI Report B/916/1017



Bell 214ST Helicopter VH-HOQ
Timor Sea
Latitude 12° 30' south
Longitude 124° 25' east
22 November 1991

BASi
Bureau of Air Safety Investigation

Transport and Regional Development

Department of Transport and Communications

Bureau of Air Safety Investigation

ACCIDENT INVESTIGATION REPORT
B/916/1017

Bell 214ST Helicopter VH-HOQ
Timor Sea
Latitude 12° 30' south
Longitude 124° 25' east
22 November 1991

BASi
Bureau of Air Safety Investigation

Released by the Director of the Bureau of Air Safety Investigation
under the provisions of Air Navigation Regulation 283

When the Bureau makes recommendations as a result of its investigations or research, safety, (in accordance with our charter), is our primary consideration. However, the Bureau fully recognises that the implementation of recommendations arising from its investigations will in some cases incur a cost to the industry. Consequently, the Bureau always attempts to ensure that common sense applies whenever recommendations are formulated.

BASI does not have the resources to carry out a full cost-benefit analysis of every recommendation. The cost of any recommendation must always be balanced against its benefits to safety, and aviation safety involves the whole community. Such analysis is a matter for the CAA and the industry.

ISBN 0 642 19395 9 June 1993

This report was produced by the Bureau of Air Safety Investigation (BASI), PO Box 967, Civic Square ACT 2608.

The Director of the Bureau authorised the investigation and the publication of this report pursuant to his delegated powers conferred by Air Navigation Regulations 278 and 283 respectively. Readers are advised that the Bureau investigates for the sole purpose of enhancing aviation safety. Consequently, Bureau reports are confined to matters of safety significance and may be misleading if used for any other purpose.

As BASI believes that safety information is of greatest value if it is passed on for the use of others, copyright restrictions do not apply to material printed in this report. Readers are encouraged to copy or reprint for further distribution, but should acknowledge BASI as the source.

CONTENTS

ABBREVIATIONS

AD	Airworthiness Directive
ATPL/H	Airline Transport Pilot's Licence (Helicopters)
CAM	Cockpit Area Microphone
CAO	Civil Aviation Order
CPT	Cockpit Procedural Trainer
CVR	Cockpit Voice Recorder
ECU	Electronic Control Unit
FDR	Flight Data Recorder
HMU	Hydromechanical Unit
HUET	Helicopter Underwater Evacuation Training
Np	Power Turbine RPM
Nr	Rotor RPM
TTIS	Total Time In Service
TTL	Total Torque Limiting

SYNOPSIS

On 22 November 1991 at 0912 hours Australian Central Standard Time (Greenwich Mean Time + 9.5 h), a Bell 214ST helicopter was ditched into the Timor Sea shortly after takeoff from a floating production facility. The two crew and 15 passengers evacuated uninjured from the floating helicopter, prior to the right main flotation bag being punctured and the helicopter capsizing.

The report concludes that at a critical stage of the takeoff, at an altitude of approximately 120 ft above the sea, one of the engines experienced a high-side speed excursion. This was followed by an aircraft main rotor speed increase which illuminated a cockpit indication warning that the aircraft main rotor speed was out of limits.

The captain reacted to what he thought was an engine power loss by lowering the collective, which is the prescribed response to that situation, thereby unloading the main rotor which rapidly accelerated to 116.7%. The electrical control unit of the ungoverned engine, sensing a power turbine overspeed, actuated the fuel sequence valve to shut off fuel to the engine.

As the overspeeding engine accelerated, the other engine, while attempting to compensate, decelerated to idle power because of the lowered collective command. The captain's action in lowering the collective exacerbated the rapidity of the event, and because of insufficient aircraft altitude, there was not enough time for the engine still under power to pick up the load, or for the captain to take further corrective action to avoid a sea ditching.

At the time of the emergency, the captain was demonstrating a takeoff to his co-pilot.

1. FACTUAL INFORMATION

1.1 History of the flight

The helicopter was engaged in charter operations transporting workers, their baggage and freight between the operator's island base and nearby offshore floating production facilities. The flight was planned from Troughton Island and return, with scheduled stops at *Challis Venture*, *Jabiru Venture*, and *Skua Venture*. The helicopter departed Troughton Island at 0652 hours. Scheduled landings were made to exchange passengers and freight at *Challis Venture* and *Jabiru Venture*. The departure from *Jabiru Venture* was conducted by the co-pilot. On arrival at *Skua Venture*, the aircraft main and tail rotors were not stopped and one passenger with baggage disembarked.

At about 0910 the helicopter took off from *Skua Venture* with two crew and 15 passengers. After establishing a low hover and completing the hover checks, the captain lifted the helicopter into a 20-ft hover above the helideck. (At this time the rotor RPM was in the normal range and the indicated torque, as reported by the co-pilot, was 100%.) With all indications normal, the captain initiated his departure and called 'committed'. The captain reported hearing a bang coincident with vibration and a slight decrease in rotor RPM. Believing the emergency to be a compressor stall, the captain lowered the collective to recover the rotor speed. Almost immediately after the departure was initiated, the co-pilot noted that the RPM light on the annunciator panel had illuminated and called 'Rotor RPM, Rotor RPM'. The co-pilot looked aft to check the helicopter-to-landing platform clearance and when he rechecked his flight instruments, was unable to read the engine instruments because of airframe vibrations. He noted that the RPM light was still illuminated but that there was no audio signal.

Analysis of the cockpit voice recorder (CVR) provides no evidence of the bang after the captain called 'committed', or any evidence of a decrease in rotor RPM at this time.

In an attempt to gain airspeed, the captain dived the helicopter and raised the collective as it approached the water. The RPM light momentarily extinguished, then illuminated, and the aural low rotor warning sounded. At this point the captain called 'ditching' and the co-pilot deployed the helicopter flotation bags. The helicopter was settled onto the water. While the captain initiated a shutdown the co-pilot directed activities in the passenger cabin.

After the rotor blades stopped, the liferafts were deployed by the captain, the exit windows were pushed out and the passengers and crew exited the aircraft into the liferafts. Shortly after evacuation of the crew and passengers into the port and starboard liferafts, the right main flotation bag deflated. The loss of residual buoyancy allowed the helicopter to roll inverted in the water. The helicopter remained afloat until it was recovered by a salvage vessel and transported to Darwin for inspection.

The helicopter ditched beside *Skua Venture* at approximately 0912 hours Central Standard Time on 22 November 1991 at lat. 12°30' S, long. 124°25' E.

1.2 Injuries to persons

Nil.

1.3 Damage to aircraft

The aircraft structure, engines, transmission components and equipment suffered extensive salt-water contamination despite liberal washing with fresh water after removal from the sea. The washing was also insufficient to prevent the rapid onset of corrosion to magnesium alloy components of the transmission gearbox and salt-water ingress to the engines and their electronic control components. Skin-lap surfaces of the aircraft structure were inundated with salt water, as were the flight instruments and avionics equipment. The tail rotor blades suffered minor damage to their tips during the recovery operation. Scuff marks on the port elevator were also reported as being sustained during the recovery operation. The main flotation bag fairings, passenger steps and step actuators suffered damage during operation of the flotation equipment, during water impact or during the recovery operation.

1.4 Other damage

Nil.

1.5 Personnel information

The pilot in command (captain) was aged 38 years. He held a current Airline Transport Pilot Licence (Helicopters) (ATPL/H) with a valid medical certificate and was endorsed to fly the Bell 214ST helicopter. At the time of the occurrence he was also endorsed to fly the following helicopters: Bell 206, 204/205, 222 and 412; Aerospatiale AS 350B; and Boeing Vertol CH47C. He had a total rotary-wing flying experience of 3,825 h, with 793 h on type and 609 h in command. Approximately 1,650 h of his total rotary-wing experience was gained in single-engine helicopters. His last proficiency base check was carried out on 15 June 1991. He had undergone helicopter underwater escape training on 2 April 1991.

The captain was adequately rested prior to the flight, was within his normal duty cycle period and had no known medical problems.

The co-pilot was aged 47 years. He held a current ATPL/H with a valid medical certificate and was endorsed to fly the Bell 214ST helicopter as co-pilot. At the time of the accident he had 12,076 h experience, most of which was on a variety of helicopters. He was an experienced check-and-training captain on Aerospatiale AS 330 Puma and Bell 212 helicopters. He had undergone a conversion to the Bell 412 two weeks prior to the accident. His conversion training to the Bell 214ST was completed on 18 November 1991. He had extensive experience in offshore operations.

The co-pilot was within his normal duty cycle period and had no known medical problems.

The co-pilot had completed the takeoff from *Jabiru Venture*. His technique differed from company procedures after the aircraft had climbed vertically to 20 ft. According to the captain, instead of then transitioning into forward flight by continuing the climb, the co-pilot descended the aircraft to accelerate.

The captain, whilst subsequently taking off from *Skua Venture*, was demonstrating the technique of the 'towering takeoff' which complied with the company procedures.

1.6 Aircraft information

Bell 214ST helicopter Serial No. 28121 was manufactured by the Bell Helicopter Textron, Fort Worth, Texas in 1983.

Certificates of Registration and Airworthiness for VH-HOQ, No. BN 325 were issued to the owner/operator on 30 June 1988. These certificates were current at the time of the accident.

Maintenance Release Certificate No. 5309 was issued on 25 July 1991 at Troughton Island. This maintenance release was current and valid until 25 July 1992 or 3,487 h total time in service (TTIS). The helicopter's TTIS prior to the accident flight was 3,371 h. There were no deferred defects or maintenance due which was outstanding.

The helicopter was powered by two General Electric CT7-2A engines. Engine log records showed:

Number one engine, Serial No. 343067:
Time since new 3,563 h
Cycles since new 2,078

Number two engine, Serial No. 343008:
Time since new 3,293 h
Cycles since new 2,439.

The engines were not due for overhaul and did not have any cycle-limited components due for replacement.

The captain advised that he had experienced a problem with this aircraft on the day prior to this occurrence. He observed that while the throttles were being advanced to the fly position the main rotor speed accelerated from 70% to approximately 103% before the throttle was fully open. Subsequent to a throttle reduction and increase, engine response was normal. This incident was not documented, although the captain stated that he brought it to the attention of the base engineer who, when asked, denied knowledge of the problem. No maintenance action was taken.

The take-off weight from *Skua Venture* as calculated by the captain was 7,358 kg. This is 510 kg below the maximum take-off weight of 7,868 kg for departure from an offshore platform with the outside air temperature of 30°C.

Review of the aircraft flight plan, sector load sheet and loading data weight detail form for this aircraft, indicated that the helicopter was being operated within the weight and centre of gravity limitations of the Flight Manual. Weight and centre of gravity considerations were not factors in this occurrence.

1.7 Meteorological information

The following weather statement was made by the master of the MV *Lady Cynthia* in his report. (The *Lady Cynthia* was secured by mooring line to the stern of the *Skua Venture* when VH-HOQ was lifting off from the deck.)

Wind:	light airs
Sea:	rippled
Swell:	south-west 0.4 m
Barometer:	1011 hPa
Temperature:	28° C
Cloud:	3/8 fine and clear.

Weather conditions were not a factor in this accident.

1.8 Aids to navigation

Not relevant to this accident

1.9 Communications

Not relevant to this accident.

1.10 Aerodrome information

The helicopter was lifting off the helideck of the floating production facility *Skua Venture.* The helideck was located aft on the port side of the vessel, approximately 90 ft above the sea. The helideck was suitable in design and location and was appropriately marked for helicopter operations.

The helideck of the *Skua Venture* was not a factor in this accident.

1.11 Flight recorders

1.11.1 Flight recorder regulations

Current Australian regulations require all aircraft with a maximum take-off weight greater than 5,700 kg, including helicopters, to carry a separate CVR and flight data recorder (FDR). However, because of technical difficulties with regard to the recording of suitable parameters for helicopter operations, helicopters are currently exempt from the requirement to be fitted with a FDR. The aircraft was equipped with a Fairchild A100 CVR.

1.11.2 Cockpit voice recorder system

The Fairchild A100A CVR Pt. No. 93-A100-83, Serial No. 6480 installed in this aircraft was capable of recording the following audio signals on:

Channel 1 – 3rd crew member or public address
Channel 2 – Co-pilot's station
Channel 3 – Pilot's station
Channel 4 – Cockpit area microphone (CAM)

Replay of the tape revealed that there were no signals recorded on Channel 1, and that Channel 2 was unserviceable. VH-HOQ was certificated prior to the requirement for 'hot mike' wiring, in accordance with Civil Aviation Order (CAO) 103.20; therefore, the microphones were not live to the CVR at all times.

The crew channels record conversation from the headset microphones when radio transmissions or intercommunications are made. With the co-pilot's channel unserviceable, the fact that both crew members' voices were recorded on the pilot's channel indicates that the intercom was switched on.

The CAM was centrally mounted on top of the instrument panel glare shield. This live microphone received signals emanating from the operating crew, instruments, DC and AC inverters, engines and noises generated by gearboxes, drive trains, pumps and the airflow over the helicopter. The CVR does not directly record engine or transmission component operating parameters.

This CAM has a specified frequency response range of 1,000–5,000 Hz. Examination of signals recorded on this microphone would normally be restricted by these limitations. However, due to the loudness of the noises associated with the operation of this helicopter, identifiable tones, which were recorded outside of this range, were used in the analysis.

1.11.3 Cockpit voice recorder examination

Normal disassembly of the undamaged recorder revealed that salt water had penetrated the case. Wires connected to the motor had been trapped between the armoured case and the lid, preventing the surfaces from sealing. Corrosion was present where the tape contacted the heads and guide rollers. When the tape-to-head pressure pad springs were moved to release the tape, the pads remained stuck to the heads, thus locking the tape. Subsequent disassembly was effected after fresh-water washing. The tape was in good condition with slight discolouration only at the point of contact between the tape and the corroded heads.

1.11.4 Cockpit voice recorder tape replay

The CVR tape covered a period of approximately 33 min of aircraft operation beginning during the cruise flight from *Jabiru Venture* to *Skua Venture*, until 146 s after water impact.

Signal tones recorded through the CAM and the pilot's crew channel were identified. Crew intercommunication and air-to-ground transmissions were recorded on one channel only due to the unserviceability of the co-pilot's channel.

Excitation frequencies produced by the engines and drive-train components of the Bell 214ST helicopter have been identified and documented by Bell Helicopter Textron. Their table of predominant frequencies, compiled from trials on the 214ST, show a fundamental tone generated by the main rotor of 9.57 Hz at 100% N_r. This is equal to 287 RPM.

The CVR tape replay speed was adjusted to compensate for AC inverter output frequency tolerances and to equate the frequency of the main rotor upper planetary and primary control system 1 hydraulic pump to those specified by Bell.

By comparing the data recorded on the CVR of VH-HOQ to the table of frequencies produced by Bell, engine and transmission operating characteristics of this helicopter were extrapolated.

The recorded level and intelligibility of the crew radio transmission and intercommunication signals was good with all conversations discernible. A transcript of information which had been recorded on the pilot's crew channel, was used during the analysis of recorded frequency tones from the CAM to establish crew comments into the tone sequence.

Spectrographs of noise frequencies were taken during the following periods:

- the cruise flight to *Skua Venture*;
- on the helideck;
- the subsequent hover; and
- through the event to after the helicopter contacted the water.

Analysis of these spectrographs revealed:

(i) Meshing frequency tones of the main rotor upper planetary and PCS1 hydraulic pump, when compared to the Bell 214ST excitation frequency tables, extrapolated a main-rotor speed of 100% N_r whilst in the cruise. The steady traces indicated stable operation.

(ii) Similar stable lower tones from the same components whilst the helicopter was on the deck, were indicative of a reduced power setting and a main-rotor speed of approximately 77% N_r. This speed then increased to 100% N_r before the pre-takeoff checks.

(iii) During the hover transition a slight split in the tones representing power turbine speed was identified. The speed split was confirmed by the crew conversation.

(iv) The frequencies came together as the lower speed engine accelerated 2–3% to join the higher speed engine. At this point the captain called that he was committed.

(v) Approximately 2 s later the high-side engine tone increased with a corresponding slight increase in main rotor speed (this would have corresponded with the main rotor speed warning light in the cockpit). This was followed by a split in engine tones as the accelerating engine rapidly increased in speed to a point at which the N_p overspeed protection operated, approximately 8 s after the committed call, and in response to collective lever position.

(vi) Coincident with the acceleration of one engine, the other was decelerating as commanded by the torque load share system of the electronic control unit (ECU).

(vii) At no time during the acceleration of N_r/N_p did the low rotor RPM aural alerting system function. The low rotor aural warning did not operate until after the rotor RPM had peaked at approximately 120% and then dropped to below 96%, 2.5 s prior to water impact.

(viii) The helicopter contacted the water 13 s after the 'committed' call.

1.12 Impact and wreckage information

The helicopter contacted the water with a low rate of descent and little forward speed. The flotation equipment was set to operate automatically but was manually activated by the co-pilot just prior to water impact. The helicopter was intact when it contacted the water. The emergency windows were jettisoned by the passengers during the evacuation. After the helicopter rolled over, the inundation by salt water resulted in deterioration of the magnesium alloy components of the transmission gearbox assemblies. Salt water contaminated the electronic, instrument and avionics equipment. Minor damage was sustained by the tail rotor blade tips during the recovery operation.

1.12.1 *Post-recovery engine examination*

1.12.1.1 Power plants

Examination of the power plants included a detailed in-situ inspection of both engines, all accessories and both engine control systems. After removal from the aircraft and separation from the combining gearbox, a detailed boroscope internal inspection of the engines was carried out. This examination failed to detect any pre-existing damage which could have contributed to the reported engine power loss.

The engines were not capable of being run as part of their examination due to the corrosion damage sustained by the bearings which support the engine rotating assemblies and accessory components.

1.12.1.2 Engine controls

Engine power demand is signalled by two angular position inputs to the hydromechanical unit (HMU) of each engine and an electrical reference signal to the ECU of each engine. A gearbox at the end of each control teleflex cable from the cockpit is splined onto the power available spindle and the load demand spindle shafts. Control rigging of the teleflex cables is assured by angular marks on the gearbox housing. Examination of the rigging of both engines showed that the cables from the collective levers were rigged to give a spindle position 13° and 15° too advanced for a given collective position.

The effect of the incorrect rigging of the engine mechanical controls would be firstly, a possible limitation of the engines to reach ground idle power with the collective lever lowered; and secondly, some torque being delivered to the main rotor during auto rotations with the engines running.

The incorrectly rigged controls to the load demand spindles on both engines would not have contributed to this occurrence.

1.12.1.3 Engine electrical connections

Initial post-recovery examination of the engine installations revealed that the E1 electrical connector on the ECU of the number one engine was not tight but could be rotated with light finger pressure requiring three-quarters of a turn to tighten. This was considered to be a possible source of moisture ingress prior to the occurrence. However, moisture ingress at this connector should not have caused a control malfunction that would have led to a high-side speed excursion.

1.12.1.4 Lubrication systems

The lubrication systems of both engines, as well as the combining, main and tail rotor gearboxes, were examined. Magnetic chip detectors and filters revealed no pre-existing abnormalities which would have indicated failure of any oil-wetted components.

1.12.1.5 Fuel systems

Examination of the airframe fuel system, including the filters, showed the system to be salt-water contaminated. (A sample of fuel taken from the aircraft after it had been refuelled on the morning of the occurrence was submitted for laboratory examination and determined to be aviation turbine fuel uncontaminated by salt water.)

Fuel was present in both engine fuel systems and the filters. The fuel sample in the right engine was clear and bright; however, the fuel in the left engine fuel filter was cloudy and light brown in colour. A sample (approximately 500 mL) of the discoloured fuel taken from the filter bowl, together with the filter element, was submitted for specialist laboratory examination.

Examination of the samples taken from the fuel filter bowl and particulates on the filter within the bowl of the number one engine confirmed contamination. This contamination consisted of a high level of dark brown particles confirmed as being consistent with alpha quartz, iron, aluminium, basic magnesium silicate (talc) and calcium carbonate (calcite). There were other minute particles of fibreglass, red, white and blue paint, metallic and black oxides, textile and cellulose linters, and glass microspheres.

The origin of the high proportion of dark-brown material was not determined. The total particulate level in the small 50-mL sample was extremely high but its significance was uncertain because the sample was taken from a fuel filter and may have merely indicated that the filter was working effectively.

It is considered that the contaminated fuel from the number one engine filter bowl which was seen and confirmed by examination, did not contribute to this occurrence.

1.12.2 Examination of engine and electronic controls

The removed engines, complete with all of the components and accessories necessary for engine operation, were returned to the engine manufacturer for detailed examination under the control of the Bureau of Air Safety Investigation (BASI).

1.12.2.1 Component/harnesses electrical checks

Extensive electrical testing of the components and harnesses fitted to each engine confirmed that salt water had penetrated the following electrical components: the yellow, green and blue harnesses; the ECUs; the alternators; the power turbine speed sensors; and the overspeed and torque sensors.

The electrical harnesses and components, except the ECUs which were dealt with separately, were oven dried, retested and found to meet electrical testing specifications.

The ECUs were electrically tested, their covers removed and visually inspected. Resistance measurements failed to meet specifications and all pins showed a +ve DCv indication indicative of battery-like behaviour. The presence of salt water was confirmed electrically, visually, and by the corrosion deposits which had started to form as a result of their submersion in salt water. Initial attempts to clean and dry the electrical connectors on the ECUs which connect to the wiring harness looms, and thus to the engine electrical sensors, were unsuccessful.

It is probable that capillary action, following cold-water quenching of the hot engine components and accessories, had induced salt-water penetration of the potted electronic modules of the ECUs and the harness wire cores. This was evidenced by the abnormal electrical resistance measurements obtained across and within these modules, and corrosion discolouration of the elements within the modules.

To facilitate drying, both ECUs were placed in a vacuum oven and baked at 100°C for over 40 h. This extensive vacuum drying succeeded in removing all of the moisture related to the electrically measured inconsistencies.

Thermal cycling of the ECUs, between +70°F and +200°F for 48 h, whilst measuring their electrical performance to the specification, was carried out and repeated on a vibration table. These tests failed to reveal any system problem which could have induced an engine-control high-side failure.

It is certain that any moisture which had been present within the harnesses or the ECUs prior to their submersion would have been dried out in this process, and its effect, if present, eliminated.

1.12.2.2 Hydromechanical units

The HMUs after removal from the engine and subsequent to electrical integrity checks of harness connectors and physical examination, were functionally bench tested. No faults were identified in these units.

1.12.2.3 Power turbine casings

Examination of the power turbine casings revealed each to be corroded on the top external surfaces. The corrosion on the number one engine was considerably more advanced than that of the other engine. The significance of this may have been dependent on the engine casing temperature at the time of immersion in salt water as the helicopter rolled over. It was later determined that both casings were of the same modification standard but that one had been in service considerably longer than the other.

Case corrosion is not a factor in this occurrence.

1.12.3 Caution annunciator panels examination

The master caution annunciator panels from the pilot and co-pilot instrument panels, and the central warning panel segments were examined to determine whether or not they were capable of providing an indication of a related fault. Each segment is fitted with more than one globe. One defective globe was found in each of the following segments:

Master Caution Annunciator:
'Floats arm' (Right panel)
'Master Caution Press to Reset' (Left panel)

Central Warning Panel:
'Left Oil'
'Brakes'
'Right Anti-ice'
'No. 2 Fuel Filter'
'No. 2 Hyd'

Indicating segments of both master caution panels and the central warning panel were found capable of providing an indication of related faults.

1.12.4 Engine governor trim panel

The governor trim panel, removed from VH-HOQ, was examined for electrical-resistance integrity and the measured readings compared against a known serviceable unit.

Trim adjustment knobs were measured and found to be selected as follows:

- Engine RPM trim indicator 4 mm towards negative; and
- Engine number two trim indicator 8 mm towards negative.

Measured resistances of the VH-HOQ panel were generally higher than those of the serviceable unit with the trim pots set in similar positions. These discrepancies are considered to be the result of salt-water contamination.

The manufacturer advised that the worst-case potential failure mode for this component is a diode failure with both trims at maximum deflection. This condition would equate to approximately 107% N_p.

The governor trim panel was not considered to be a factor in this occurrence.

1.13 Medical and pathological information

There was no evidence to suggest that the captain or co-pilot had any medical condition which might have contributed to this occurrence.

1.14 Fire

There was no fire.

1.15 Survival aspects

1.15.1 Evacuation

Prior to the helicopter making contact with the sea, the emergency flotation equipment was manually activated by the co-pilot. Satisfactory operation of the flotation system, and supervision by the crew, enabled all occupants to evacuate the helicopter without injury. After the rotors had stopped, the evacuation was conducted in an orderly manner, with passengers making their exit via the port and starboard emergency pop-out windows.

Difficulty was experienced by the person detaching the right emergency pop-out window which resulted in some tearing of the fuselage skin adjacent to the window aperture when the window was pushed out. Normally a 50-lb force applied to the corners of the window, as indicated by placards, is all that is required to remove the window.

Inspection of the emergency exits in accordance with AD/General/37 Amdt 5 had been complied with on 30 June 1991, five months before this occurrence. (AD/General/37 Amdt 5 is a 12-month repetitive inspection requirement.)

The co-pilot exited into the port liferaft. The captain remained in the cockpit to make radio contact with the rescue vessel *Lady Cynthia*, to arrange pick-up of the passengers and to supervise recovery of the essentially undamaged floating helicopter. When the helicopter started to roll to the right after the flotation bag deflated, the captain exited via the left-hand hinged cabin door window and was assisted into the liferaft by the co-pilot.

1.15.2 Liferafts

The two Sargent Industries, 12-man liferafts, Pt. No. 105104-101, were manufactured in 1983 and were due for their next inspection on 22 August 1993. Deployment of the rafts was initiated by the captain. The starboard raft reportedly self-inflated after deployment, whilst the port raft inflation was manually activated by a passenger pulling on the lanyard. Both rafts reportedly bounced off the main flotation bags as they deployed.

Before the liferafts could get clear of the helicopter, the starboard main flotation bag was punctured. It then deflated and the helicopter rolled over to the right. Although the captain reportedly stopped the blades in the fore-and-aft position with the rotor brake on, occupants of the raft and the rescue vessel reported that a main rotor blade had fallen across the raft trapping the occupants, partially flooding the raft and threatening to capsize it. The liferaft was subsequently pulled free by the rescue launch from the *Lady Cynthia*. This liferaft suffered substantial damage to the canopy and handling loops.

Witness and passenger statements revealed that an open-bladed knife had been produced by an occupant of the starboard liferaft. The passengers in this raft were unable to locate the raft's safety knife.

The open-bladed knife was used to cut the retaining lanyard and separate the raft from the helicopter. Coincident with the lanyard being cut, there was a noise and a rush of air reported by the individual using the knife.

Occupants of the liferafts were taken by the *Lady Cynthia's* rescue boat to the *Lady Cynthia*. Post-recovery examination of the liferafts established that each was fitted with a safety knife adjacent to the canopy hatch which could have been used to cut the lanyard.

1.15.3 Flotation bags

Laboratory microscopic examination of the starboard flotation bag tear revealed a 20-mm long cut in the third compartment. The tear, passing through this cut to the adjacent cells, was not restrained by the cell compartment walls, and extended across four cells and their inter-cell bulkheads. The longitudinal tear was located on the ocean side of the bag, remote from the fuselage structure and the torn skin adjacent to the starboard emergency window exit.

The design specification has no requirement for specific tear stoppers to be fitted between cell compartments during construction of these flotation bags.

The possibility of the loss of one cell by deflation, rupture or puncture was considered by the manufacturer in the failure mode and defect analysis of the Bell 214ST emergency flotation kit. This condition was assessed by the manufacturer as having no effect on the aircraft or system. In this case the puncture of one cell did not limit deflation to that cell only but resulted in a tear which extended across adjacent cells. The loss of residual buoyancy from more than one cell resulted in the helicopter capsizing.

The laboratory examination determined that there was no deterioration of the rubber-encased fabric by age or embrittlement.

1.16 Tests and research

1.16.1 Passenger evacuation questionnaire

A questionnaire prepared for this investigation was sent to all occupants of the helicopter. The survey solicited information concerning seating, location of emergency exits, pre-flight briefings, notification of the emergency situation, seats and seat belts, evacuation, operation of exits, launching the liferafts, exiting the aircraft and training.

Of the 17 occupants, 14 (82%) completed the questionnaire.

1.16.2 Awareness of emergency procedures

Eleven respondents to the questionnaire indicated that they had received helicopter underwater evacuation training (HUET) specifically covering procedures to be adopted in the event of ditching. Two others said they had not been given any pre-flight or ditching briefing on the day of the occurrence. Generally, passengers were conversant with, and had read, the safety briefing card and were aware of the emergency exit placards. Company procedures require pre-flight briefings to be given to all occupants prior to departure from Troughton Island, but not by the crews when running-rotors boarding is carried out. Some occupants indicated that they had not received a pre-flight briefing prior to departure from the rigs and that their last briefing had taken place two weeks earlier, when they departed Troughton Island. Several respondents recalled their surprise at the positioning of the liferafts relative to the helicopter, the manner of their restraint by the lanyard, or their behaviour when they saw them jettisoned.

1.17 Additional information

1.17.1 High-side failure—discussion

In 1983 the Service Engineering Division of General Electric Aircraft Engines published in the series *CT7 Engine Topics* a bulletin titled *Potential Electrical Control System Failures*. Among other things, this document describes high-side failure of the electrical control system. The following extract clarifies the circumstances which confronted the pilot of VH-HOQ shortly after takeoff from *Skua Venture*.

> **High-Side Failure–Electronic Control Unit (ECU) Failure Driving the Hydromechanical Unit Torque Motor to Maximum.**
>
> This failure results in the loss of power turbine (N_p) governing, load sharing, temperature (T4.5) limiting and total torque limiting (TTL) on the engine experiencing the failure. The effect on engine performance will be to accelerate the engine with the failure to a gas generator speed limit. N_p governing, load sharing, T4.5 limiting and TTL on the engine without the failure are still operational. As a result, when the engine with the failure increases in torque, the other engine will reset the N_p reference up in speed 3% in an attempt to load share with the engine having the failure. This will, in turn, result in an increase in power turbine speed of 3% unless TTL intervenes. At this point, if the failed engine is still driving N_p/N_r up, the non-failed engine's torque output will decrease to a level sufficient only to maintain the 3% N_p increase.
>
> The pilot action required for this condition is to observe the engine parameters and retard the throttle on the 'failed' engine until the other engine comes back on line. The 'failed' engine can then be trimmed manually with the throttle to a torque value that is approximately 10% below the non-failed engine.
>
> CAUTION–Should the aircraft be in a very lightly loaded flight condition it is possible that N_r and N_p of the engine experiencing the failure might increase to the N_p overspeed trip and cause the engine to shut down. If this should occur, the remaining engine would then accelerate and support the entire load. The pilot should then follow normal air restart procedures and control the failed engine manually.

The engine manufacturer advises that during the period 1982–1988 there were 40 high-side failure incidents. Events after this date have not been tracked by the manufacturer. Incidents have declined significantly due to a variety of maintenance initiatives and system component product improvements introduced by the engine and vendor manufacturers. Known conditions which would have caused an engine high-side failure, when identified, have been controlled by either modification and/or advice to the industry for improved maintenance control. Because of information indicating moisture ingress as a potential cause of control malfunction, General Electric have instituted sealing of plugs, harness and components.

Subsequent to this occurrence and the preliminary investigation procedures which identified an engine control high-side failure, Bell Helicopter Textron issued document OSN-214ST-92-6 on 8 January 1992, requesting all operators to review procedures and training related to rotor speed excursions. Similarly, General Electric Aircraft Engines, citing this occurrence, issued an All Operators Wire No. 92-01 on 27 March 1992, concerning engine electrical control system high-side failures.

1.17.2 Operational aspects

1.17.2.1 Crew simulator experience

Neither the captain nor his co-pilot had previously undertaken simulator training to practice a governor high-side failure during takeoff. However, the captain's attention had been drawn to the Bell 214ST Flight Manual's written procedures for the N_p high-side failure during his company check and training.

The co-pilot advised that he had never been trained in any helicopter simulator or cockpit procedural trainer (CPT).

Neither the Civil Aviation Regulations nor company procedures specified any requirements for pilots to undergo CPT or flight-simulator training. At the time of this occurrence, the only rotary wing simulators in Australia suited to this type of training on twin turbine-engine helicopters were owned and operated by the military. These are not normally made available to civilian operators. Consequently, the operator would have had to send its crews to the USA for such training. It had decided that this was not a commercially viable option.

1.17.2.2 Simulation of the VH-HOQ scenario

Following the engine uncontrolled N_p overspeed failure of VH-HOQ, emergency procedures for the Bell 214ST were evaluated in the Flight Safety International cockpit procedures trainer.

This evaluation was conducted with the help of experts from Bell Helicopter Textron and Flight Safety International. Information which had been gained by detailed analysis of the background noises recorded on the CVR of VH-HOQ was used to set the scenario.

1.17.2.3 Cockpit procedural trainer

N_p overspeeds were simulated by a very experienced Bell 214ST simulator instructor using two failure-mode responses. The simulations were watched by, and discussed with, the Flight Safety International chief pilot, another simulator instructor, a Bell 214ST test pilot, a Bell 214ST pilot/human factors engineer, Bell's Chief Safety Engineer, and Bell's Chief of Flight Safety.

The first response utilised existing, approved, Bell 214ST Flight Manual emergency procedures. The second response used the procedure of lowering the collective as occurred with VH-HOQ.

When the simulator pilot's emergency drill was performed in accordance with the approved Bell 214ST Flight Manual, (i.e. the N_p overspeed failure was correctly identified by noting the increase in rotor RPM), the Bell 214ST flew away without loss of height.

High-side failures were then simulated using the data obtained from the CVR in VH-HOQ. To simulate a high-side failure similar to the VH-HOQ event, the instructor had to:

- select 100% torque;
- press one side of the throttle-stop release switch;
- roll a throttle fully open to ECU lockout;
- maintain the 130° full throttle position; and
- fully lower the collective.

Lowering the collective unloaded the main rotor which resulted in a rapid increase in main rotor RPM and a very large torque split. The good engine torque needle reduced to the idle position as the faulty engine torque needle increased. It took about 8 s for the joined power turbine/main rotor RPM needles to reach 116.7% N_p/N_r, at which time the overspeed sensor caused the faulty engine to flame out. The good engine torque needle began to increase but at a rate which would not have permitted VH-HOQ to fly away before contacting the water. It took about 8 s for the engine to flame out in VH-HOQ after the committed call.

During the simulations the rapidity with which N_p/N_r increased to engine flameout surprised the experts.

The three very experienced simulator instructors, who took part in the simulator trials of the governor high-side failure, stated that their past trainees, with few exceptions, had failed to cope with the N_p high-side failure until the practice of identifying the emergency and controlling rotor RPM had become instinctive as a result of training in the CPT. The instructors emphasised that experienced single-engine pilots training to fly the Bell 214ST were very prone to lower the collective instinctively in the event of any perceived emergency. The instructors were adamant that even most highly experienced twin-engine helicopter pilots often react like the captain of VH-HOQ until they have practised the N_p overspeed failure drill in the CPT.

It was the opinion of the experts viewing the simulation that the actions of the captain of VH-HOQ were instinctively those of a twin- engine helicopter pilot who had not had the benefit of previous simulator training to cope with an N_p overspeed emergency at what was considered to be a most critical stage of flight.

The key to properly coping with a N_p overspeed failure is first to identify correctly the N_p high-side failure and then to comply with the emergency procedures listed in the Bell 214ST Flight Manual. In the Bell 214ST, it is unnecessary to lower the collective during an N_p overspeed. By not lowering the collective, the main rotor is not unloaded, and the problem of the N_p overspeeding to the extent that the overspeed sensor shuts down an engine is thereby avoided.

1.17.2.4 Noise at critical stage

The captain reported hearing a loud noise during the critical stage of the takeoff coincident with vibration and an engine power loss. The loud noise, referred to as a 'bang', was also reported by two passengers sitting in the rear section of the passenger cabin.

There was no loud noise recorded on the CVR during the initiation sequence of this event. However, two loud noises, one later in the sequence, coincident with the flotation bags inflating, and the second when the helicopter touched the water, (the splash), were recorded.

1.17.2.5 Uncontained engine failure VH-LAT

A few weeks prior to this occurrence another Bell 214ST, operated by the same company (but with a different crew), had experienced an uncontained engine failure whilst in cruise flight. Subsequent examination of the engine (Serial No. ESN 343061) removed from that aircraft by the engine manufacturer, revealed the cause to be a failure of the stage 2 turbine nozzle static seal resulting from excessive reduction in thickness due to oxidation.

The stage 2 turbine nozzle seals on the engines fitted to VH-HOQ (Serial Nos. 343067 and 343008) were examined by the engine manufacturer to determine serviceability. Although they were found to have some oxidation present, the unoxidised thicknesses were not below minimum.

The stage 2 turbine nozzle static seals of the engines fitted to VH-HOQ were not factors in this occurrence.

2. ANALYSIS

2.1 Introduction

Frequency analysis of the recorded background noises on the CVR in the presence of BASI and the engine and aircraft manufacturers, revealed that one of the engines had suffered a control 'high-side' failure and not an engine failure (power loss) as reported by the pilot. This analysis confirmed the preliminary findings of the BASI evaluation of the CVR tape. Consequently, further examination of the engine and electrical components concentrated on determining the cause of an engine control high-side failure. However, limited engine disassembly and a repeat internal boroscope examination of both engines, failed to identify any pre-existing mechanical inconsistencies or engine damage which would have contributed to this occurrence.

Post-recovery examination of the helicopter failed to detect any pre-existing mechanical failure, damage or condition which could be considered as contributory to this occurrence. There were no documented unserviceabilities which would have contributed to, or which were relevant to the loss of, engine electronic control.

The difficulty experienced on the previous day with throttle control may have been an indication of a pending engine electronic control malfunction and relevant to the subsequent high-side failure which was experienced during the accident flight.

2.2 Crew training

Correct diagnosis of high rotor RPM resulting from an engine governor high-side failure, and compensating actions in accordance with the Flight Manual procedures, would have controlled the rotor RPM and allowed the aircraft to fly away. The captain misidentified this event and therefore did not take the correct actions to compensate for it.

Simulated exercises in the cockpit procedures trainer indicated that pilots who had practised recognition of and techniques to compensate for high-side engine control failure were more able to cope with such an event than those who had not received such training.

Moreover, these exercises and advice from experienced instructors in the USA (see 1.17.2.3) indicated that experienced single-engine pilots, and to a large extent twin-engine helicopter pilots, often react to events such as an N_p overspeed failure by lowering the collective, as the captain did on this occurrence. This instinctive reaction is only eliminated by regular practice in a simulator or procedures trainer. The effect of the simulator training is to condition the pilot to a correct automatic response for an N_p overspeed in a critical situation, given certain cues.

Considering the captain's lack of training in a simulator or procedures trainer, and the significant proportion of his rotary wing experience which was gained in single-engine helicopters, he was clearly ill prepared for an N_p failure at a very critical phase of flight. His decision to lower the collective could be attributed in part to a latent failure in the company's training system which pre-disposed him towards an inappropriate automatic response to the N_p overspeed at a critical phase of flight.

2.3 Rotor RPM warning

Neither pilot appeared to recognise that the rotor RPM warning light, with the absence of the rotor low audio signal, was suggestive of a high rotor RPM and not a low rotor RPM situation. Factors that appear pertinent in analysing this lack of recognition are: the criticalness of the phase of flight at which the failure occurred; the need for immediate action should the event have been failure of one engine; and, the cues available to the captain at the time that the failure occurred.

The N_p overspeed occurred at the most critical phase of the takeoff, that is, just after the captain called 'committed'. At this point, had the emergency been an engine failure, an immediate response of lowering the collective and diving for airspeed was vital to flying the aircraft away safely. In such a case, decision-making time is very limited. This consideration probably influenced the captain's decision as to what response was appropriate to the cues presented to him at the committal point.

At the onset of the event the principal cues available to the captain were the reported bang, the illumination of the rotor RPM warning light and the co-pilot's call of 'Rotor RPM, Rotor RPM'. Little useful information would have been gained from the instruments, even assuming that the captain had time to look inside the cockpit and assimilate the information, as the co-pilot reported that vibration made them very difficult to read. The investigation could not determine conclusively which of these cues was the more powerful influence on the captain's decision-making and whether he actually saw the rotor RPM warning light illuminate.

However, it is likely that the bang and the co-pilot's call of 'Rotor RPM, Rotor RPM' were the most powerful cues. Having reacted to these stimuli by lowering the collective, the pilot had, firstly, altered the cockpit indications by his actions and, secondly, found himself with virtually no time to re-assess the indications and/or the nature of the emergency before the helicopter alighted on the water. Consequently, he had one extremely narrow window of opportunity to correctly assess the nature of the emergency; once he had misidentified it, he had no further opportunity to rectify the initial wrong assessment.

Had the co-pilot called '*High* rotor RPM, *High* rotor RPM' this may have been a cue powerful enough to overcome the stimulus provided by the reported bang. The captain may then have recognised that the immediate action of lowering the collective was not appropriate for this failure. Such a call was not normal practice at the time of the occurrence and was not a part of the co-pilot's training or his experience.

2.4 Rotor RPM warning system

Another factor considered in the analysis of why both pilots failed to recognise the event as a rotor overspeed and not an underspeed was the adequacy of the ergonomics of the rotor RPM warning system. The system, in providing a warning light and an aural warning for low RPM and a light only for high RPM, should have provided adequate resolution of the ambiguity that would exist if only a warning light was available.

Nevertheless, in the case of a high RPM warning the pilot is unable to identify quickly the full nature of the event without first seeing the light and then interpreting the appropriate instrumentation to confirm what the light is telling him. This shortcoming would be more of a problem where the pilot's attention was directed outside the cockpit, as was the case in this occurrence.

This characteristic of the rotor RPM warning system, in combination with the other factors considered above, may have contributed to the crew's failure to identify correctly the event in a critical phase of flight.

2.5 Reported noise coincident with the event

Examination of the aircraft, engines and equipment, to locate a possible source for the bang reported by the captain and two passengers, failed to detect any damage or mechanical abnormalities which could have been factors in this occurrence.

In response to questions regarding compressor stall, the engine manufacturer advised that even when ECU lockout is selected, the HMU still has a governing function which prevents fuel flow rates to the extent of a compressor stall or damage to an engine. However, referring to the approved Bell 214ST Flight Manual section 3 'Compressor Stalls', one of the factors listed that can increase stall sensitivity is 'malfunctioning fuel control components'. One of the indications of the compressor stall, according to the Flight Manual, is that the 'affected engine bangs/pops'.

Considering that analysis of the CVR yielded no evidence of the reported bang, reduction of either engine RPM or a decrease in rotor RPM (at the critical time), and considering that bench testing of the engine fuel system components failed to detect any malfunction, the likelihood of a reported bang being associated with a compressor stall is minimal.

Neither substantiation of a bang nor its source at that time in the sequence of events has been determined.

Considering the rapidity of the event, it is possible that the bang heard by the captain and the passengers was that of the overspeeding engine flaming out when it was starved of fuel by the overspeed sensing system.

2.6 Flotation bags

The longitudinal tear in the starboard flotation bag was initiated by a sharp object, possibly the open-bladed knife which had been used to sever the raft's lanyard. The puncture/rupture damage and deflation of the third cell compartment was not contained and the subsequent tear resulted in the loss of residual buoyancy.

There is no design/certification requirement for 'tear stoppers' at the joints between each cell or the inter-cell bulkheads.

The design and certification of the emergency flotation equipment fitted to this helicopter considered the puncture or rupture of a float bag skin at one cell, and assessed the effect of that on the system and the aircraft as 'none'. This clearly was not true for this occurrence as the effect was considerable because the puncture was not confined to one cell. VH-HOQ was substantially damaged from its submersion in salt water. There was thus a potential for loss of life, either prior to the evacuation or, as in this case, entrapment of the occupied raft by the main rotor blade.

2.7 Evacuation training

A number of difficulties were reported by some of the passengers, the more significant of which were:

(i) difficulty experienced in jettisoning one of the emergency pop-out windows;

(ii) a lack of knowledge regarding the location of the safety knife required to cut the securing lanyard; and

(iii) lack of familiarity with the liferafts—how they were jettisoned and retained by the lanyard, and their proximity and positioning relative to the helicopter.

Those passengers adjacent to the right emergency pop out window reported difficulty in 'knocking' out the window. Placarded instructions for detachment of the emergency window identified a need to apply a 50-lb force at the corners of the window as indicated. Considering that the window had been inspected in accordance with AD/General/37 Amdt 5 and certified as serviceable, reports of passengers 'knocking' instead of pushing out the window suggest that the correct method to detach the window had not been applied.

Given the above, there is concern regarding the knowledge of some of those passengers who were travelling in this helicopter regarding evacuation, safety equipment and survival procedures.

2.8 Carriage of flight data recorders

The lack of an FDR being fitted to the helicopter hampered investigation into those circumstances of this occurrence which led up to the engine high-side excursion, the control inputs and rotor RPM at the critical stage of takeoff, and the subsequent actions by the captain.

Regulation CAO 20.18, which specifies the requirement for carriage of FDRs, was originally promulgated for, and considers, those parameters applicable to fixed-wing aircraft operations. The parameters which are specified to be recorded have not yet been optimised for helicopters, and the accuracy and recording ranges specified for each parameter are not suited to helicopter operations. Because of this, helicopters are currently exempted from the requirement to be fitted with FDR equipment.

Coincident with international considerations of FDRs and health usage monitoring systems for helicopters, BASI is currently reviewing the regulations pertaining to the carriage of FDRs in Australian registered helicopters.

3. CONCLUSIONS

3.1 Findings

1. The pilot and co-pilot were medically fit and qualified to operate the helicopter.

2. There was no evidence of pre-existing damage or mechanical failure which would have contributed to this occurrence.

3. The E1 electrical connection to the number one engine ECU was found to be not fully tightened.

4. On the previous day, the same crew had experienced in this aircraft symptoms indicative of a speed control malfunction but had failed to document the event for corrective action.

5. The engine electrical control unit, for reasons which have not been established, failed to maintain speed control, resulting in an increase in main rotor speed which illuminated a cockpit warning light.

6. The problem occurred at the most critical stage of the takeoff, shortly after the pilot called 'committed'.

7. The co-pilot, in drawing the attention of the pilot to the problem called 'Rotor RPM, Rotor RPM', when a more appropriate call would have been 'High rotor RPM, High rotor RPM'.

8. The pilot did not recognise this event as an engine high-side failure and took action appropriate for failure of one engine.

9. Once the pilot had lowered the collective there was insufficient time available to re-assess the nature of the emergency and to take proper corrective action before the helicopter alighted on the water.

10. Neither crew member was able to explain why he did not recognise the lack of audio alerting accompanying the rotor RPM warning light as being an indication of an *increase* in rotor RPM.

11. Experienced US simulator instructors training pilots to fly the Bell 214ST indicated that those who had not been exposed to high-side failure training in a CPT were very prone to lower the collective instantly in the event of any perceived emergency.

12. Neither the captain nor the co-pilot had received CPT or flight-simulator training.

13. Some passengers departing the offshore production facilities reported that they had not received a pre-flight briefing on the day of the occurrence, and that their last briefing had been two weeks prior to this occurrence when they departed Troughton Island.

14. Three of the passengers who responded to the questionnaire reported that they had not received briefings on how to evacuate a ditched helicopter.

15. Some of the passengers, who had been trained in regard to evacuation of the helicopter and operation of the liferaft and its emergency equipment, were unable to put information gained in training into practice.

16. The flotation equipment operated satisfactorily and kept the helicopter afloat in an upright position for sufficient time to allow evacuation of all the occupants.

17. A cell of the right main flotation bag was punctured by a sharp object, possibly the knife which was used to cut the raft lanyard.

18. The certification requirements and subsequent design of the main flotation bag were deficient in failing to prevent a tear, which had originated from a puncture, from spreading across adjacent cell compartments and intercell bulkheads.

19. One of the main rotor blades fell across the liferaft canopy as the helicopter rolled over, swamping it with water and threatening to capsize it.

3.2 Significant factors

1. The crew failed to document an engine operational problem, the diagnosis and correction of which may have eliminated the cause of the subsequent engine high-side failure.

2. An engine electronic control high-side failure manifested itself at a critical stage of the takeoff, about 1 s after the captain had committed to forward flight.

3. The crew did not identify the event as a governor high-side failure and the captain therefore responded inappropriately for the circumstances.

4. Lack of appropriate and specific training minimised the captain's ability to identify and recover from an engine high-side failure at the critical stage of takeoff.

4. RECOMMENDATIONS

BASI recommends that:

1. Lloyds Offshore Helicopters Pty Ltd ensure that all passengers who are engaged in offshore operations and who are transported in helicopters which they operate are trained in procedures to be adopted in the event of a ditching. The realism of that training should ensure a better understanding both of the emergency exit operation and of the liferaft, including its equipment, deployment and release from the helicopter.

2. Lloyds Offshore Helicopters Pty Ltd ensure that a pre-flight briefing is provided to all passengers engaged in offshore operations immediately prior to each flight. Passengers boarding the helicopter with rotors running should undergo pre-flight briefings prior to entering the helicopter.

3. Lloyds Offshore Helicopters Pty Ltd, and other operators of similar helicopters who have no such training, establish formal, recurrent CPT or flight-simulator training for all pilots to enable them to recognise and counteract the effects of rotor RPM excursions following engine 'high' and 'low side' system control failures.

4. The Civil Aviation Authority (CAA) establish a requirement that pilots of multi-engine helicopters undergo recurrent CPT or flight-simulator training to enable them to recognise and counteract those operational problems which cannot be demonstrated or learned through normal check-and-training activities.

5. The CAA, in conjunction with the US Federal Aviation Administration, review the certification requirements for the construction of flotation equipment, to ensure that integrity and residual buoyancy of flotation bags are maintained when one cell is punctured.

6. Bell Helicopter Textron introduce modifications to flotation bags to incorporate 'tear stoppers' between cells on this helicopter installation, and other similar installations, to prevent the loss of residual buoyancy when one cell is punctured or ruptured.

BASI CONTACTS

basi@dot.gov.au

Brisbane
PO Box 10024
Brisbane Adelaide St
Qld 4000
Telephone: 1800 011 034
Facsimile: (07) 3832 1386
Level 12
Australia House
363 Adelaide Street
Brisbane Qld

Canberra (Central Office)
PO Box 967
Civic Square ACT 2608
Telephone: 1800 020 616
Facsimile: (06) 247 3117
24 Mort Street
Braddon ACT
SITA CBRBACR

Melbourne
Telephone: 1800 011 034
Facsimile: (03) 9685 3611
Level 2
Building 3
6 Riverside Quay
Southbank Vic. 3006

Perth
PO Box 327
Belmont WA 6104
Telephone: 1800 011 034
Facsimile:(09) 479 1550
Suite 2
Pastoral House
277–279 Great Eastern H'way
Belmont WA

Sydney
PO Box Q78
Queen Victoria Bldg NSW 2000
Telephone: 1800 011 034
Facsimile: (02) 9283 1679
Level 7
1 Market Street
Sydney NSW

CAIR
Reply Paid 22
The Manager
CAIR
PO Box 600
Civic Square ACT 2608
Telephone: 1800 020 505
Facsimile: (02) 6274 6461
24 Mort Street
Braddon ACT

ACCIDENT INVESTIGATION REPORT B/916/1017

ISBN 0 642 19395 9