Department of Transport

Bureau of Air Safety Investigation

INVESTIGATION REPORT
9401043

DOUGLAS DC-3 VH-EDC
Botany Bay, New South Wales
24 April 1994

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GLOSSARY OF TERMS AND ABBREVIATIONS

AMSL	Above mean sea level
AAC	Airworthiness Advisory Circular
AD	Airworthiness Directive
AEP	Aerodrome Emergency Plan
AIP	Aeronautical Information Publication
Altitude	Height above mean sea level in feet
AOC	Air Operators Certificate
ARDU	Aircraft Research and Development Unit
ATC	Air Traffic Controller
ATIS	Aeronautical Terminal Information Service
ATPL	Air Transport Pilot Licence
ATS	Air Traffic Services
AVR	Automatic Voice Recording
AWI	Airworthiness Inspector
BASI	Bureau of Air Safety Investigation
BOM	Bureau of Meteorology
CAA	Civil Aviation Authority
CAAP	Civil Aviation Advisory Publication
CAO	Civil Aviation Orders
CAR	Civil Aviation Regulation
CAVOK	CAVOK is given in lieu of the standard information on visibility, weather and cloud, when the following conditions are observed to occur simultaneously at the time of the observation: (a) visibility 10 km or more; (b) no cloud below 5,000 ft, or below the highest minimum sector altitude, whichever is the greater, and no cumulonimbus; and (c) no precipitation, thunderstorm, shallow fog, fog patches, fog at a distance, low drifting snow or dust devils.
CCC	Common Crash Call
CG	Centre of Gravity
COORD	Coordinator
CRM	Crew Resource Management
DVR	Disaster Victim Registration
EFATO	Engine Failure After Takeoff
ELT	Emergency Locator Transmitter
EROPS	Extended Range Operations
EST	Eastern Standard Time
FAC	Federal Airports Corporation
FOI	Flight Operations Inspector
Height	Vertical distance in feet above a fixed point
Hg	Mercury
IAS	Indicated Airspeed
IFR	Instrument Flight Rules
kt(s)	Knot(s)

KIAS	Knots—Indicated Airspeed
LAME	Licensed Aircraft Maintenance Engineer
MAOC	Manual of Air Operator Certification
MOU	Memorandum Of Understanding
MTOW	The Maximum permissible Take-off Weight of an aircraft as specified in its Certificate of Airworthiness
NASS	National Airworthiness Surveillance System
POB	Persons on Board
QNH	An altimeter sub-scale setting to show height above sea level
PNG	Papua New Guinea
P&W	Pratt and Whitney
RAAF	Royal Australian Air Force
RFFS	Rescue Fire-fighting Service
RPM	Revolutions Per Minute
RPT	Regular Public Transport
SPA	South Pacific Airmotive Pty Ltd
MSB SPA	Maritime Services Board Sydney Port Authority
SAR	Search and Rescue
SOAP	Spectrographic Oil Analysis Program
SR&S	Safety Regulation and Standards
TAA	Trans-Australia Airlines
TBO	Time Between Overhauls
TWR	ATC responsible for aerodrome control
V_1	Decision speed. The airspeed indicator reading defining the decision point on takeoff at which, should one engine fail, the pilot can elect to abandon the takeoff or continue. In effect it is the last point at which a pilot can safely decide to abandon a takeoff in an emergency.
V_2	Take-off safety speed. The airspeed indicator reading at which the aircraft can climb safely using one engine only. The aircraft is required to attain this speed before entering an area in which there may be obstacles higher than 50 ft. Such an area is regarded as commencing at the end of the runway at an altitude of 50 ft. Because in the DC-3 the distance needed to climb to 50 ft is greater than the distance required to stop, $V_1 = V_2$ and this value is 81 knots.

Note 1	'Ground effect' refers to the decrease in induced drag and increase in lift resulting from the alteration of the wing airflow downwash characteristics when the aircraft is operated close to the ground.
Note 2	CAA Bankstown' and 'CAA Moorabbin' refer to the CAA district offices located at Bankstown and Moorabbin Airports.
Note 3	The Civil Aviation Authority (CAA) was replaced in July 1995 by Airservices Australia (AA) and the Civil Aviation Safety Authority (CASA). CASA is the aviation safety regulator.
Note 4	AOC holder refers to the parent company Groupair based at Moorabbin Airport.
Note 5	All bearings are in degrees magnetic unless otherwise indicated.
Note 6	All times are Australian Eastern Standard Time (Co-ordinated Universal Time + 10 hours) unless otherwise stated.

INTRODUCTION

The main purpose for investigating air safety occurrences is to prevent aircraft accidents by establishing what, how and why the occurrence took place, and determining what the occurrence reveals about the safety health of the aviation system. Such information is used to make recommendations aimed at reducing or eliminating the probability of a repetition of the same type of occurrence, and where appropriate, to increase the safety of the overall system.

To produce effective recommendations, the information collected and the conclusions reached must be analysed in a way that reveals the relationships between the individuals involved in the occurrence, and the design and characteristics of the systems within which those individuals operate.

This investigation was conducted with reference to the general principles of the analytical model developed by James Reason of the University of Manchester (see Reason, *Human Error* (1990)).

According to Reason, common elements in any occurrence are:

- *organisational failures* arising from managerial policies and actions within one or more organisations (these may lie dormant for a considerable time);
- *local factors*, including such things as environmental conditions, equipment deficiencies and inadequate procedures;
- *active failures* such as errors or violations having a direct adverse effect (generally associated with operational personnel); and
- *inadequate* or *absent defences* and consequent failures to identify and protect against technical and human failures arising from the three previous elements.

Experience has shown that occurrences are rarely the result of a simple error or violation but are more likely to be due to a combination of a number of factors, any one of which by itself was insufficient to cause a breakdown of the safety system. Such factors often lie hidden within the system for a considerable time before the occurrence and can be described as *latent failures*. However, when combined with local events and human failures, the resulting sequence of factors may be sufficient to result in a safety hazard. Should the safety defences be inadequate, a safety occurrence is inevitable.

An insight into the safety health of an organisation can be gained by an examination of its safety history and of the environment within which it operates. A series of apparently unrelated safety events may be regarded as *tokens* of an underlying systemic failure of the overall safety system.

SYNOPSIS

On Sunday 24 April 1994, at about 0910 EST, Douglas DC-3 aircraft VH-EDC took off from runway 16 at Sydney (Kingsford-Smith) Airport. The crew reported an engine malfunction during the initial climb and subsequently ditched the aircraft into Botany Bay. The DC-3 was on a charter flight to convey a group of college students and their band equipment from Sydney to Norfolk Island and return as part of Anzac Day celebrations on the island. All 25 occupants, including the four crew, successfully evacuated the aircraft before it sank.

The investigation found that the circumstances of the accident were consistent with the left engine having suffered a substantial power loss when an inlet valve stuck in the open position. The inability of the handling pilot (co-pilot) to obtain optimum asymmetric performance from the aircraft was the culminating factor in a combination of local and organisational factors that led to this accident. Contributing factors included the overweight condition of the aircraft, an engine overhaul or maintenance error, non-adherence to operating procedures and lack of skill of the handling pilot.

Organisational factors relating to the company included:

- inadequate communications between South Pacific Airmotive Pty Ltd who owned and operated the DC-3 and were based at Camden, NSW and the AOC holder, Groupair, who were based at Moorabbin, Vic.;
- inadequate maintenance management;
- poor operational procedures; and
- inadequate training.

Organisational factors relating to the regulator included:

- inadequate communications between Civil Aviation Authority offices, and between the Civil Aviation Authority and Groupair/South Pacific Airmotive;
- poor operational and airworthiness control procedures;
- inadequate control and monitoring of South Pacific Airmotive;
- inadequate regulation; and
- poor training of staff.

During the investigation, a number of interim safety recommendations were issued by the Bureau. These recommendations, and the CAA’s responses to them, are included in this report.

1. FACTUAL INFORMATION

1.1 History of the flight

This accident involved a DC-3 aircraft which was owned and operated by South Pacific Airmotive Pty Ltd, who were based at Camden, NSW. It was flown on commercial operations under an Air Operators Certificate held by Groupair, who were based at Moorabbin, Vic.

The aircraft had been chartered to convey college students and their band equipment from Sydney to Norfolk Island to participate in Anzac Day celebrations on the island. A flight plan, submitted by the pilot in command, indicated that the aircraft was to proceed from Sydney (Kingsford-Smith) Airport to Norfolk Island, with an intermediate landing at Lord Howe Island to refuel. The flight was to be conducted in accordance with IFR procedures, with a departure time from Sydney of 0900. The aircraft, which was carrying 21 passengers, was crewed by two pilots, a supernumerary pilot and a flight attendant.

Preparations for departure were completed shortly before 0900, and the aircraft was cleared to taxi for runway 16 via taxiway Bravo Three. The pilot in command occupied the left control position. The co-pilot was the handling pilot for the departure. The aircraft was cleared for takeoff at 0907:53.

The crew subsequently reported to the investigation team that all engine indications were normal during the take-off roll and that the aircraft was flown off the runway at 81 kts. During the initial climb, at approximately 200 ft, with flaps up and the landing gear retracting, the crew heard a series of popping sounds above the engine noise. Almost immediately, the aircraft began to yaw left and at 0909:04 the pilot in command advised the TWR that the aircraft had a problem.

The co-pilot determined that the left engine was malfunctioning. The crew subsequently recalled that the aircraft speed at this time had increased to at least 100 kts. The pilot in command, having verified that the left engine was malfunctioning, closed the left throttle and initiated propeller feathering action. During this period, full power (48 inches Hg and 2,700 RPM) was maintained on the right engine. However, the airspeed began to decay. The handling pilot reported that he had attempted to maintain 81 KIAS but was unable to do so. The aircraft diverged to the left of the runway centreline.

The co-pilot and the supernumerary pilot subsequently reported that almost full right aileron had been used to control the aircraft. They could not recall the skid-ball indication. The co-pilot reported that he had full right rudder or near full right rudder applied.

When he first became aware of the engine malfunction, the pilot in command assessed that, although a landing back on the runway may have been possible, the aircraft was capable of climbing safely on one engine. However, when he determined that the aircraft was not climbing, and that the airspeed had reduced below 81 kts, the pilot in command took control, and at 0909:38 advised the TWR that he was ditching the aircraft. He manoeuvred the aircraft as close as possible to the southern end of the partially constructed runway 16L.

The aircraft was ditched approximately 46 seconds after the pilot in command first advised the TWR of the problem.

The four crew and 21 passengers successfully evacuated the aircraft before it sank. They were taken on board pleasure craft and transferred to shore. After initial assessment, they were transported to various hospitals. All were discharged by 1430 that afternoon, with the exception of the flight attendant, who had suffered serious injuries.

Immediately following the pilot in command's call that the aircraft was ditching, the COORD in Sydney Tower raised the crash alarm. He then activated the AEP 'Crash in the Vicinity of Sydney Airport (including Botany Bay)' checklist. The COORD notified the RFFS fire control centre at 0909:55. At 0910:00 he activated the CCC and contacted the Police, Ambulance, FAC and NSW Fire Brigade.

1.2 Injuries to persons

	Crew	Passengers	Other	Total
Fatal	–	–	–	–
Serious	1	–	–	1
Minor	2	–	–	2
None	1	21	–	22

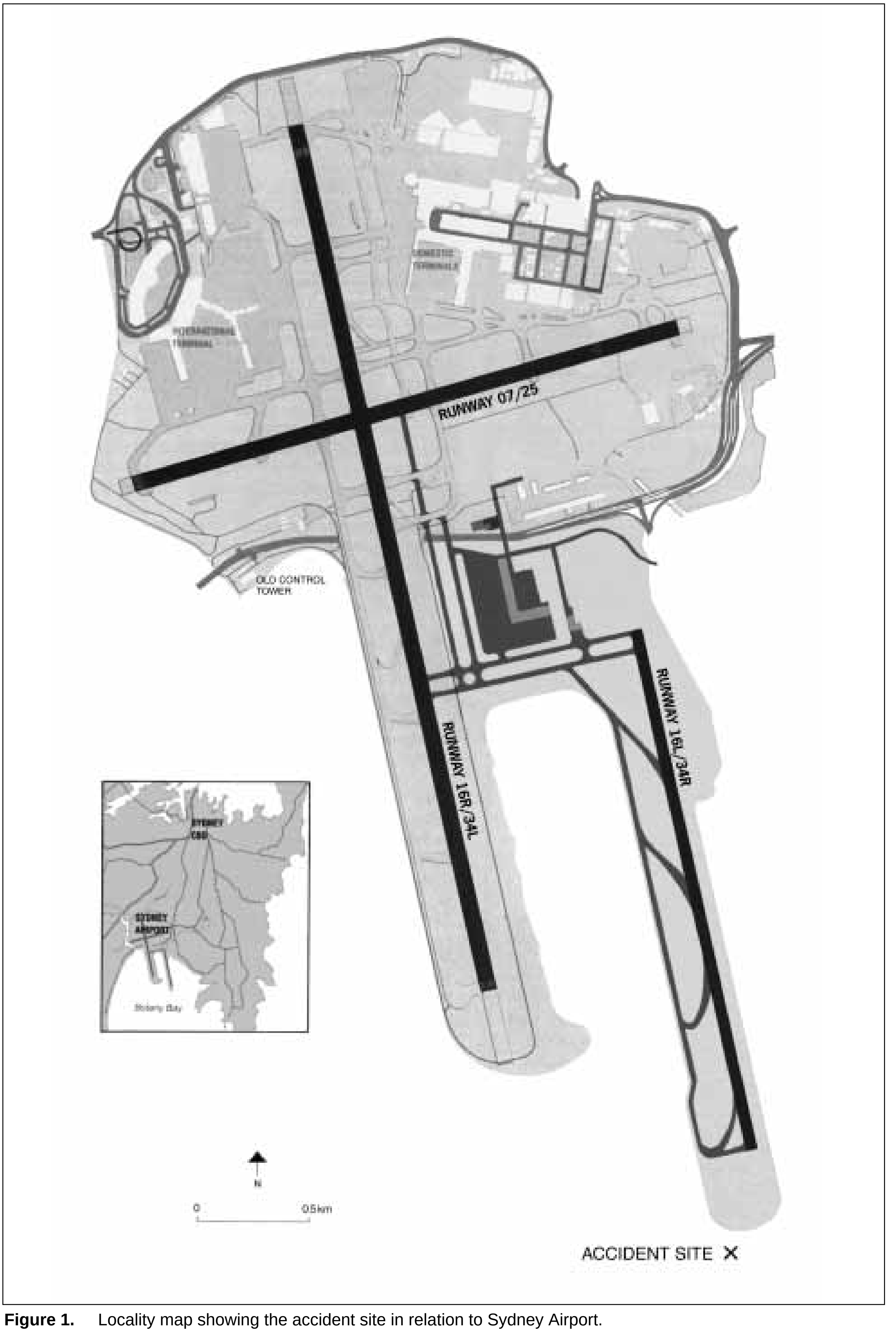

Figure 1. Locality map showing the accident site in relation to Sydney Airport.

1.3 Damage to aircraft

During the ditching the aircraft sustained substantial damage from impact forces. Additional damage occurred during the subsequent recovery operations and as a consequence of salt-water immersion.

1.4 Other damage

No other damage was reported.

1.5 Personnel

Technical crew

	Pilot in command	Co-pilot	Supernumerary pilot
Licence category	ATPL (1st class)	Commercial	ATPL (1st class)
Medical certificate	Class 1	Class 1	Class 1
Instrument rating	M.E. command	M.E. command	M.E. command
Total hours	9,186	500	2,741
Total on type	927	250	22
Total last 90 days	30.1	25	70
Total on type last 30 days	1.2	5	1
Total last 24 hours	0	0	2
Last flight check	22 June 1993	9 Jan. 1994	26 Jan. 1994
Aircraft endorsement	DC-3 command	DC-3 command	DC-3 co-pilot

Cabin crew

Proficiency status	Received initial training on 25 Sept. 1993
Experience	Approximately ten flights
Last proficiency test	25 Sept. 1993
Last check	Refamiliarisation (23 Apr. 1994)

Previous 72 hours history

Pilot in command. During the two days prior to the accident, the pilot in command planned the flight and refamiliarised the flight attendant with emergency duties on overwater flights. He reported that he had had a normal sleep period prior to commencing duty on the day of the accident.

Co-pilot. The co-pilot advised that he was unable to remember his activities during the 72 hours prior to the accident.

Supernumerary pilot. The supernumerary pilot reported that his sleep pattern had been normal for the 72 hours prior to the accident.

Cabin crew. The flight attendant advised that her sleep pattern had been normal for the 72 hours prior to the accident.

Recent operational experience

Pilot in command. The pilot in command had flown a total of 2.9 hours (including 1.2 hours on the DC-3) in the previous 30 days and a total of 30.1 hours (26.8 hours on the DC-3) in the previous 90 days. He had completed his initial endorsement on the DC-3 type in 1979 and had recommenced flying the type in November 1992.

In January 1993, the pilot in command had been approved by the CAA to act as the Groupair DC-3 flight captain, and had been granted check-and-training approval for the DC-3 in May 1993. His most recent formal check flight was carried out by a CAA FOI in June 1993.

Co-pilot. The co-pilot, who was also part-owner of the aircraft, had flown 5 hours total in the last 30 days and a total of 25 hours in the last 90 days, all on the DC-3. He had been granted a commercial pilot's certificate in the USA on 16 January 1992. On 13 August 1992, he was issued with an Australian CAA certificate of validation for the purpose of acting as flight crew of an Australian registered aircraft at 'unrestricted pilot standard' for day-VFR operations. This was valid until 13 November 1992. The co-pilot had advised the CAA that he had completed DC-3 command endorsement training in the USA on 5 April 1992, and on the basis of this advice, his certificate of validation was annotated with a DC-3 type rating. He was issued with a special pilot licence in January 1993 and an Australian commercial pilot licence on 20 September 1993. The co-pilot's most recent formal check was for the renewal of his command instrument rating on 9 January 1994.

Supernumerary pilot. The supernumerary pilot had flown a total of 25 hours (including 1 hour on the DC-3) in the previous 30 days and 70 hours (including 10 hours DC-3) in the previous 90 days. He was normally employed as a flying instructor and had completed a DC-3 co-pilot endorsement in January 1994. He was employed by the operator in a part-time capacity and was present on this flight to gain further DC-3 experience.

Cabin crew. The flight attendant held a certificate of competency issued in September 1993 by the operator, and had undergone refresher training on the day prior to the accident.

1.6 Aircraft information

1.6.1 Significant particulars

First registered	17 November 1949 VH-JVF
Registration	VH-EDC (formerly VH-JVF and VH-CAR)
Manufacturer	Douglas Aircraft Company
Model	DC-3C-S1C3G (formerly C47A)
Common name	DC-3
Manufacturer serial number	12874
Country of manufacture	USA
Year of manufacture	1944
Engines	2 Pratt & Whitney R1830-92
Engine type	Radial/piston
TTIS	40,195:05 hours
Certificate of registration	
Number	1680
Issued	30 July 1992

Certificate of airworthiness	
Number	1680
Issued	3 October 1980
Category	Transport
Maintenance release	
Number	202756
Issued	6 March 1994 at 40,191:15 hours
Valid to	40,291:15 hours

Additional engine and propeller data

- Left engine: Pratt & Whitney R1830-92, Serial Number CP329666. Time since overhaul: 1,027:56 hours.
- Right engine: Pratt & Whitney R1830-92, Serial Number BP463388. Time since overhaul: 1,085:53 hours.
- Left propeller: Hamilton Standard 3 blade, Model 23E50473, Serial Number 1G1B14. Time since overhaul: 550:25 hours.
- Right propeller: Hamilton Standard 3 blade, Model 23E50473, Serial Number FA 5612. Time since overhaul: 830:48 hours.

At the time of the accident, both engines were operating on CAA-approved concessions to overrun the published TBO of 1,000 hours.

1.6.2 Weight and balance

On the day prior to the accident, the pilot in command completed a weight and balance calculation based on anticipated weights. These calculations were as follows:

Weight as calculated by the pilot in command

	Weight (kg)
Aircraft operating weight	**8,569**
Supernumerary pilot	77
Catering (70 kg included in operating weight. Because 30 kg required, reduce operating weight by 40 kg)	-40
Remove 2 seats (11 kg each)	-22
Adjusted operating weight	**8,584**
16 male adolescents (63 kg each)	1,008
4 male adults (84 kg each)	336
1 female adult (69 kg)	69
Total passenger weight	**1,413**
Life rafts	70
Forward locker (baggage)	350
Fuel (430 gal (imp))	1,363
Ramp (taxi) weight	**11,780**
Subtract taxi/runup fuel (23 kg)	-23
Take-off weight	**11,757**
MTOW	**11,884**

Weight as calculated during the investigation

A weight-and-balance summary was compiled from known and estimated data gathered during the investigation. Using the operational weight for the 24-seat configuration adjusted by 22 kg for the removal of two seats, the weight calculation was completed as follows:

Adjusted operating weight	**8,584**
Passenger weight (as reported by the passengers)	1,634
Baggage (as weighed by passengers after the accident)	483
Life rafts (actual)	92
Toolbox, oil drums & spare parts (actual)	230
Fuel (456 gal (imp)—168 + 168 + 120 (estimated))	1,446
Taxi weight	**12,469**
Subtract taxi/ runup fuel	23
Take-off weight	**12,446**
MTOW	**11,884**

The aircraft weight at takeoff was therefore 562 kg or 4.7% above the MTOW.

1.6.3 DC-3 asymmetric performance—general

From October 1947 to December 1948, the RAAF carried out asymmetric handling and performance flight tests of Dakota C47B aircraft. The test schedule was performed by ARDU with the intention of producing a report for the information of airline operators and the then Department of Civil Aviation. At a weight of 11,884 kg (26,200 lb), the tests showed that with the left engine failed at 86 kts, the landing gear down, and the left propeller windmilling, a climb rate of 63 ft/min could be obtained. The rate of climb reduced to zero if the airspeed was increased to 94 kts or reduced to 78 kts.

In 1953, further tests were carried out by ARDU to investigate the possibility of raising the maximum all-up weight of the Dakota aircraft from 11,884 kg to above 12,700 kg. Comprehensive measurements of the rate of climb with one engine inoperative and the propeller windmilling were made for the weights listed below:

Weight (kg (lb))	Rate of climb (ft/min)
11,794 (26,000)	100
12,700 (28,000)	0
13,608 (30,000)	-90

As part of the tests one takeoff was made at 12,928 kg (28,500 lb) with a simulated left-engine failure at 88 kts. In this instance the aircraft was able to maintain height only while flown in ground effect.

In 1954, TAA investigated the approved take-off speeds for the DC-3. A series of takeoffs with simulated engine failure at the take-off safety speed of 75.5 KIAS showed that at a weight of 11,884 kg (26,200 lb) the aircraft would not climb at this speed. It was then decided to determine the airspeed at which satisfactory asymmetric performance could be achieved at weights of 11,884 kg for passenger aircraft, and 12,202 kg (26,900 lb) for freight aircraft. The tests showed that the best climbing speed with the landing gear down, one propeller windmilling and take-off power on the other engine, was between 80 kts and 85 kts. With the landing gear retracted, one propeller windmilling and take-off power on the other engine, the best climb speed was 90 kts.

On 14 May 1955, the following information concerning asymmetric take-off tests was printed in a TAA Supplement to Aircrew Bulletin:

> Satisfactory asymmetric take-offs were performed at 26200 pounds with the engine failing at 81 knots, and at 27000 pounds with the engine failing at 86 knots. Previous tests had shown that at 26900 pounds with the engine failing at 80 knots the aircraft lost airspeed as the climb was started and fell back onto the runway. It is felt that the extra 5 knots is required at this weight to allow for the drop in airspeed when the aircraft attitude is changed on beginning the climb. It was suggested that the takeoff safety speed be 81 knots for weights of 26200 and below, increasing linearly to 86 knots at 26900 pounds.

The TAA report stated that the success of an asymmetric takeoff was greatly dependent on the flying technique adopted after the engine failure. For example, sudden changes of attitude were accompanied by loss of airspeed and a consequent inability to climb away. It therefore recommended that upon engine failure at the critical engine failure speed, the aircraft should be held at this speed while the undercarriage was being retracted, and the speed then increased to 90 kts while the propeller was being feathered.

1.6.4 VH-EDC performance and handling

Examination of data obtained from the performance testing of the DC-3 demonstrated that only minimal climb performance is available after engine failure at V_1/V_2 (81 kts) during takeoff at the MTOW of 11,884 kg (26,200 lb). At higher weights, the aircraft will not achieve any climb performance unless the take-off safety speed is increased linearly with the increase in aircraft weight. The data showed that at weights above 12,202 kg (26,900 lb) the DC-3 is unlikely to achieve any climb performance unless all parameters are within their optimum ranges.

The crew flew VH-EDC off at 81 kts and subsequently reported that the aircraft accelerated to at least 100 kts before they shut down the left engine. Despite engine instrument indications that full power was being obtained from the right engine, the crew were unable to prevent the speed reducing below the takeoff safety speed of 81 kts.

The following is an extract from Groupair's operations manual for VH-EDC:

> CRITICAL ENGINE AND MINIMUM SPEEDS AT MAXIMUM AUW
>
> The PORT engine is the critical engine. Minimum speeds vary from an absolute minimum of 68 knots IAS with the port engine feathered and power settings of 42 inches manifold pressure and 2250 on the starboard engine to 76 knots IAS with the port airscrew windmilling in full fine pitch and full power of 48 inches manifold pressure and 2700 RPM on the starboard engine. The limiting factor V_{MCA} of 180 pounds foot pressure is reached at approximately 73 knots. It is preferable to keep straight by use of rudder alone, rather than using the aileron. The foot load is within the capabilities of all pilots, but there is a danger of the foot slipping up on the brake pedal unless the rudder pedals are adjusted before takeoff so that full rudder can be applied with the heel. For long legged pilots, this makes for a rather uncomfortable seat position, with the control column fouling the knees.
>
> The DC-3 aircraft at all-up weight has a marginal performance at V_2 speed (81 knots) on one engine, and this requires concentration on the part of the pilot to see that the best performance is obtained. It is of vital importance that the climb performance of the DC-3 in the asymmetric condition is fully understood.

1.6.5 Single-engine performance VH-EDC

Factors which may have affected the single-engine performance of the aircraft were:

- configuration;
- temperature;
- weight and CG position;
- age and condition of airframe;
- atmospheric turbulence;

- ground effect; and
- pilot technique.

Configuration

The engine malfunction occurred when VH-EDC was still in the take-off configuration, with the landing gear retracting, the wing flaps retracted, and full power on both engines. The pilots expressed differing views on exactly when, after the takeoff, the malfunction occurred. As the emergency situation progressed, the configuration changed as the landing gear completed retraction, and the left propeller moved toward the feathered position. Although the aerodynamic drag acting on the aircraft was substantially reduced by these latter actions, additional significant drag was induced when the co-pilot, having applied right rudder control, then also applied substantial right wing down aileron control in response to the aircraft continuing to yaw to the left.

The pilot in command indicated that the malfunction occurred after the landing gear was selected up, at a height of approximately 200 ft with the airspeed in excess of 100 kts and probably close to the normal climb speed of 113 kts. He also indicated that despite an initial airspeed in excess of 100 KIAS and power indications on the right engine of 48 inches Hg and 2,700 RPM, the aircraft would not climb or maintain altitude.

The co-pilot stated that he thought the aircraft may have been at 200 ft with the landing gear retracting when the failure occurred, and that he could remember maintaining 81 kts after the malfunction. He was unclear as to the speed reached when the malfunction occurred. The supernumerary pilot said he was not paying close attention to the instruments. However, he did hear the sound of the engine malfunctioning, and was aware that the aileron control was held at about 90° from the neutral position.

The landing gear was observed by witnesses located in a small pleasure craft under the flight path to be retracted prior to the aircraft being ditched. The pilot in command had to manoeuvre the aircraft to avoid hitting the craft whilst making the approach to ditch.

Temperature

The temperature recorded on the ATIS at the time of the accident was 16°C.

Weight and centre of gravity

The pilot in command had completed a weight and balance document (trim sheet) on 24 April 1994. The trim sheet showed the take-off weight as 11,757 kg with the CG position within the CG envelope.

The take-off weight calculated during the investigation was 12,446 kg, which was 562 kg in excess of the MTOW.

Age and condition of airframe

The asymmetric performance figures referred to in 1.6.3 are based on the results of test flights conducted by professional test pilots under controlled conditions, being pre-planned exercises specifically flown to determine single-engine performance. Under such conditions the test pilot is readily able to set up and maintain the aircraft in the required configuration for the duration of the test.

The tests would have been flown using aircraft in excellent condition. The result achieved would have reflected the optimum performance for the aircraft with the objective being simply to demonstrate that the aircraft met the required level of performance.

In service, the airframe condition can deteriorate and factors such as dents, chipped and flaked paint, misfitting doors, hatches and cowls and modifications incorporating additions to the external airframe will tend to reduce the aircraft performance. This particular aircraft had flown about 40,000 hours.

Atmospheric turbulence

At the time of the accident, the wind was light and variable with no reports of turbulence.

Ground effect

The Groupair DC-3 operations manual recognised the benefit to be obtained by utilising ground effect during a single-engine takeoff. The manual indicates that, in the most critical take-off condition with the left engine failed, at 81 kts, the propeller windmilling in fine pitch, and with the landing gear down, the aircraft will accelerate to a speed of 95 KIAS if held close to the ground.

The pilot in command, when assessing his options, discounted the use of ground effect because he considered that if the aircraft failed to achieve climb performance, he would then be faced with ditching the aircraft on the far side of Botany Bay. In this circumstance, the rescue of the passengers and crew would not have been effected as expeditiously as in the case of an immediate ditching.

Pilot technique

The Groupair operations manual for VH-EDC comprehensively described the procedures and techniques to be adopted in the event of an engine failure after V_1/V_2. However, it contained conflicting information about the actions of individual technical crew members in the event of an emergency during the take-off phase.

According to section B1.6 of the manual (page 10):

> When the Captain permits the F/O to carry out a take-off or landing he must ensure that he is always in a position to take over control of the aircraft immediately; should a malfunction occur it is required that the Captain does take over.

However, section B1.3 (page 8) indicated that the pilot flying should continue to fly the aircraft in the event of an emergency, and the non-flying pilot should provide assistance to the pilot flying. The pilot in command advised that he used the latter procedure because the aircraft had suffered an engine failure after takeoff and he complied with the operations manual (emergency) procedures. Additionally, he believed the co-pilot held a command endorsement on the DC-3 and was capable of flying the aircraft correctly in any emergency situation.

The operations manual contained instructions describing the actions that needed to be taken by the crew to ensure that optimum single-engine performance at MTOW was achieved. These included accurate airspeed control (minimum 81 kts), directional control using rudder alone, full power on the remaining engine, landing gear and flaps retracted and, if necessary, the use of ground effect. Once the propeller had feathered, the speed was to be increased to 91 kts. Operations at weights above MTOW were not permitted and therefore were not addressed in the operations manual.

The take-off emergency response briefing was conducted by the co-pilot and was general in nature. It included the take-off safety speed of 81 kts, and a return for a landing in the event of an engine failure.

1.7 Meteorological information

The current ATIS information was: wind light and variable; QNH 1026; temperature 16°C; CAVOK.

The BOM assessed the conditions in the vicinity of the crash site as: surface wind calm; visibility greater than 10 km; weather hazy; sky clear; QNH 1026; temperature 18°C; dew point 14°C; and relative humidity 77%.

1.8 Aids to navigation

Not relevant.

1.9 Communications

Communications on Sydney ground and aerodrome control frequencies were normal until the time at which the crew first advised Sydney TWR of the problem. Following this, the aircraft's microphone became stuck intermittently in the 'transmit' position.

1.10 Aerodrome information

Sydney (Kingsford-Smith) Airport is located on the shore of Botany Bay. Runway 16, the runway in use at the time of the accident, extends approximately 1,800 m into the bay. The parallel runway is to the left of runway 16, and extends approximately 2,500 m into Botany Bay. At the time of the accident, this runway was still under construction. The distance from taxiway Bravo Three to the end of runway 16 is 3,330 m.

1.11 Recorded information

The aircraft was not equipped with a flight data recorder or cockpit voice recorder, nor were these required by regulation.

Recorded radar data were analysed. Due to the proximity of the aircraft to the radar head, the flight path and airspeed information was considered to be of insufficient accuracy. However, the performance trend was evident. Altitude information was not available due to garbled transponder mode-C responses from the aircraft.

Analysis of the AVR data provided additional information regarding the timing of the sequence of events.

1.12 Wreckage and impact information

1.12.1 Accident site description

The aircraft sank adjacent to the end of runway 16L, 100 m from the sea wall and in approximately 16 m of water. The geographical co-ordinates of the accident site were latitude 33°58'33.94" south and longitude 151°11'33.89" east.

1.12.2 Aircraft recovery

The aircraft was floated to the surface using inflatable air bags, and then transferred to an aircraft hangar for examination. It was intact, except for the right engine and propeller assembly, which was recovered later.

1.12.3 Technical examination of the wreckage

1.12.3.1 Structure

The aircraft damage was consistent with collision with the water during the ditching and the effects of the subsequent recovery operation.

1.12.3.2 Flight controls

No evidence was found of any pre-existing defect or malfunction of any part of the flight control system. It was determined that the wing flaps were extended approximately 20–22°.

1.12.3.3 Powerplants

Left engine

During dismantling of the left engine the following abnormalities were noted:

1. On removal of the no. 3 cylinder inlet valve pushrod cover, pushrod and tube, excessive wear of the pushrod and of the cylinder where the pushrod enters the valve rocker housing was apparent. Further inspection revealed that one of the thrust washers which are fitted either side of the rocker arm on the rocker shaft was not fitted to the shaft. The thrust washer subsequently fell out of the valve rocker housing. The loose washer was oval in shape, having sustained impact damage during engine operation. At the last time of fitting, the shaft was installed but failed to engage the washer which subsequently was left within the rocker housing. The housing, through which the cover tube is located and through which the pushrod operates, was damaged at the point coincident with the damage on the pushrod.

   (A review of the CAA major defect reporting system for P&W 1830 series engines and of the BASI accident and incident summary reports for DC-3 aircraft did not identify any previous reports relating to the misassembly of cylinders, valves, rockers, shafts or thrust washers.)

   The cylinder, complete with inlet and exhaust valve assemblies, inlet valve pushrod and cover and the damaged washer, was examined. The aim was to determine when and how the washer was damaged, and the likelihood of this loose component jamming the inlet valve in the open position. The rocker arm end of the pushrod contained heavy rub marks which penetrated the pushrod to about 25% of the wall thickness. The curved edges of these wear marks matched the deformed washer. There was also a curved depression within the rocker housing, adjacent to the inlet pushrod tube, which matched the shape of the deformed washer. Plastic deformation of the cylinder head material into this depression indicated the nature of the compressive loads applied to the pushrod. The amount of material rolled inside the depression mark suggested that the washer had been in this position for a considerable period. With the washer located in the depression, it could become jammed between the cylinder head and the pushrod, thus preventing the inlet valve from closing. The amount of valve lift provided by the jammed pushrod was approximately 4 mm.

Figure 2. The deformed thrust washer and the deep rub marks on the push rod.

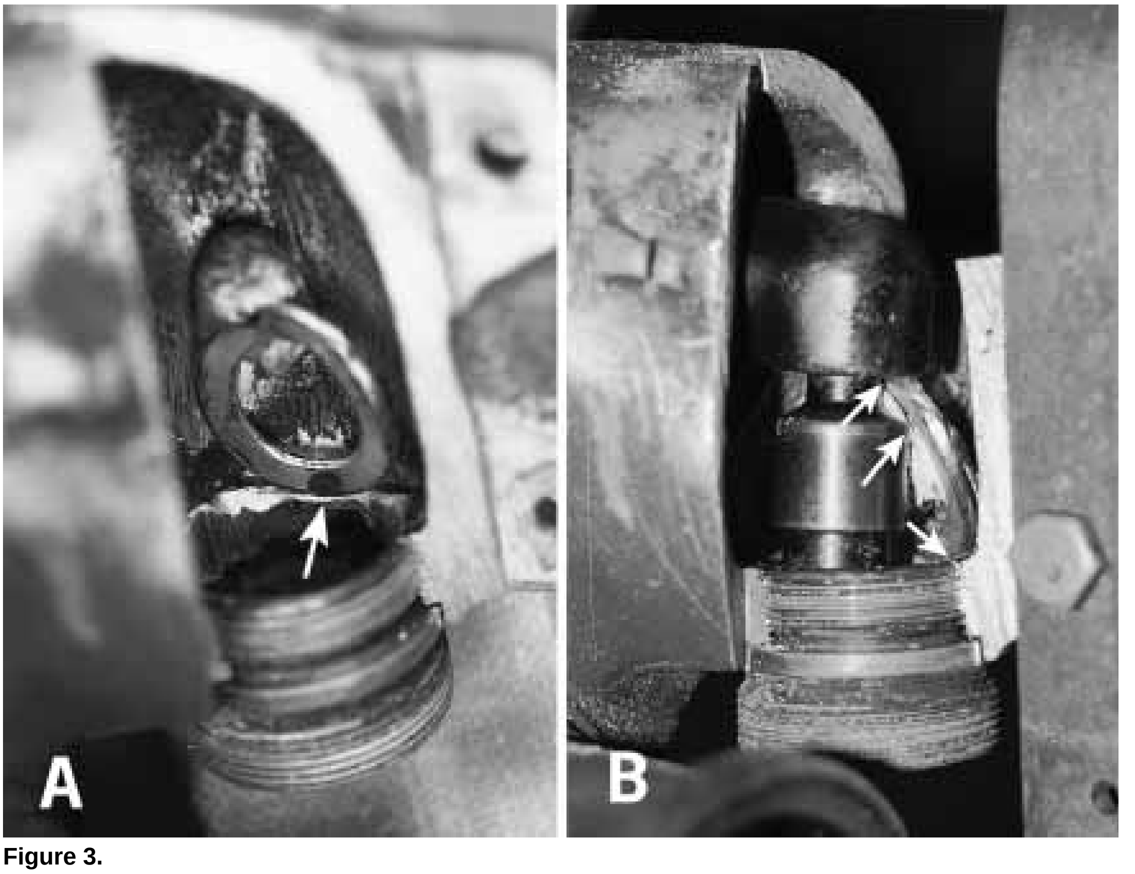

Figure 3.

(A) The mark on the edge of the cylinder head rocker assembly housing is shown. Its shape matched the shape of the thrust washer.

(B) The thrust washer with one side forced against the rocker assembly housing, while the opposite side is jammed between the rocker arm and the push rod upper end. To facilitate this demonstration, an adhesive was used to hold the washer in position.

The firing of the spark plugs on the cylinder while the inlet valve was jammed open would cause the fuel-air mixture in the common induction system to ignite. In addition to the loss of power from the no. 3 cylinder, the resultant disruption of the fuel-air mixture to the remaining cylinders would cause irregular engine operation and a reduction in power. The engine manufacturer has advised that a power loss of up to 50% could result, accompanied by backfiring through the intake manifold and carburettor. Fire residues and soot deposits were found in the no. 3 cylinder intake cavity and the adjacent intake manifold. Examination of the air intake assembly revealed deposits of black soot within the carburettor air intake and on the debris screen, indicative of backfiring, and possible intake fire.

The investigation was unable to determine where or when the assembly error occurred.

2. The left magneto was found to have been secured at the fully anticlockwise timing adjustment position. Subsequent removal of the magneto revealed that the splines of the accessories' driving gear were worn well beyond service limits and that failure of positive drive to the magneto was imminent. Detailed examination revealed that the driving gear material did not meet the required hardness standard. The left magneto had a different serial number to that recorded in the engine logbook as having been fitted when the engine was last overhauled in 1987. Since the overhaul, 1,025 hours of engine operation had been recorded. However, because there were no certifications as to when the magneto was changed, it could not be determined when the driving gear splines were last inspected. The

crew reported that pre-flight magneto RPM drop checks were satisfactorily completed.

3. The propeller governor pitch control cable 90° pulley block securing bolt was excessively worn. There was a certification on the periodic inspection worksheets at the time of issue of the current maintenance release on 25 February 1994, some 6–8 operating hours prior to the accident, that the assembly had been renewed.

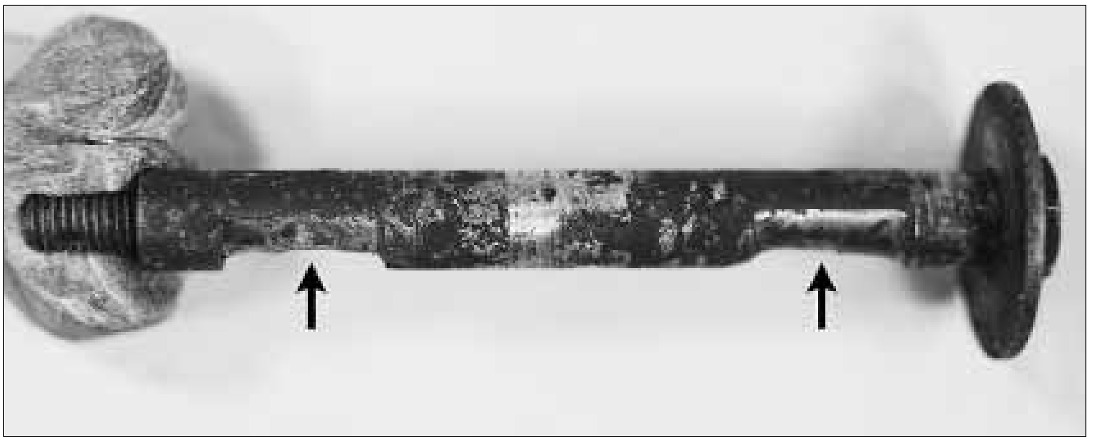

Figure 4. The worn pulley block securing bolt.

4. During removal of the no. 12 cylinder, two of the 16 cylinder base studs were found to be sheared and missing. Light loosening pressure applied to the nut of a stud adjacent to these two resulted in that stud breaking also. Removal of the cylinder revealed an area of galling/fretting in the vicinity of the broken studs, indicating cylinder movement on its mounting pad. Examination revealed that the recovered broken stud had failed in fatigue, initiating from multiple origins around the stud circumference. It is a maintenance requirement for the cylinder base attachment studs to be inspected at each periodic inspection. Records of the periodic inspection conducted 6–8 operating hours before the accident contained no reference to the failures despite there being a blackened area adjacent to the broken studs.

5. On removal of the spark plugs from the engines it was found that the electrode ‘gap’ settings were inconsistent between plugs, and that the majority of plugs showed evidence of electrode wear beyond normal life. After cleaning and re-gapping, the spark plugs were examined and tested. On test some plugs were found to be electrically breaking down. The condition of the spark plugs was not considered consistent with certification for maintenance release issue some 6–8 operating hours prior to the accident.

Right engine

This engine was subjected to strip examination, along with an inspection of the engine records and SOAP analysis submitted for the TBO extension. With the exception of the propeller governor, no pre-existing abnormalities were found.

Right engine propeller governor

When initially fitted to the test rig, the governor failed the test specifications. However, when correctly adjusted, the unit met the manufacturer’s specifications. Examination found that the hexagonal mounting hole in the alloy pulley, which mates to the hexagonal rack shaft in the governor, was excessively worn. Additionally, the locked castellated nut securing the pulley to the shaft was found to be loose. It is likely that the excessive wear had permitted the pulley to rotate into the out-of-rigging position when the operating cables were subjected to substantial loads as the engine separated at impact.

1.12.3.4 Propellers

Left propeller

Initial inspection confirmed that the left propeller was at 65–66° of pitch instead of the 88° pitch of the fully feathered position. There were no visual indications of abnormal wear on any part of the pitch change mechanism, or of other anomalies that would inhibit the normal functioning of the propeller system. Further propeller examination was conducted to establish the reason for the propeller not being in the fully feathered position. This examination revealed the following:

1. Torque to turn individual blades within the hub was found to be approximately 55 ft lb, 40 ft lb and 25 ft lb respectively. This compared with the manufacturer's specified torque value of 30–40 ft lb.
2. Each blade butt had been fitted with a plastic sleeve during hub assembly to prevent water ingress. The sleeve of the blade which required 55 ft lb to turn was dislodged from its position. An engineering investigation concluded it was likely that at some time prior to the accident, the sleeve became dislodged, permitting water penetration and consequent corrosion. The higher torque required to turn this blade was probably due to the presence of corrosion by-products and corrosion-related pitting at the bearing area. However, it is unlikely that the higher torque required would have prevented the propeller from moving to the fully feathered position.
3. Once removed from the dome, the cam assembly with the piston attached remained in the 'as found' position and did not respond to a force applied to move it towards the fine or feathered pitch positions. (Correctly assembled cams with the piston attached move freely throughout the range when being propelled by their own weight and without any outside forces being applied.)
4. Disassembly of the cam/roller mechanism revealed that both the internal and the external cams contained heavily polished roller contact marks and grooving wear over a distance equivalent to that of the propeller mechanism moving in the operating range. There were lightly polished areas on the cams indicating that the rollers had at some time been operating through to the fully feathered position. All four roller assemblies rotated freely and contained no flat spots.
5. Despite the cam profile in-service wear, when the cam assembly pre-load nut was released by about 40°, the mechanism achieved unrestricted movement of both cams throughout their range, driven by their own weight, and without any application of an external force.
6. There was no damage or abnormal wear to any of the blades or blade operating mechanism within the hub which would have prevented the blades from reaching the fully feathered position had the cam assembly pre-load nut been correctly tightened.
7. Subsequent testing of the feathering pump and propeller governor/pressure switch assembly revealed no operational abnormalities.
8. There were no certifications to indicate that the left propeller had been 'desludged'. Airworthiness Directive AD/PROP/1 Note 1 requires that this should be accomplished at each 500 hours time in service.

The co-pilot advised that he considered that the propeller was slow to stop rotating after feathering action was initiated.

Consideration was given to reports that the blades on this propeller had moved from the fully feathered position during aircraft recovery operations. However, the specialist examination concluded that the propeller had not been able to operate to the full feather position for some period of time preceding the accident. Moreover, a review of the video taken of the aircraft on the bottom of Botany Bay before recovery operations were commenced, showed clearly that the propeller was not in the fully feathered position.

Right propeller

On recovery, the right propeller was still attached to the engine. The three blades were bent symmetrically rearwards at the mid-position.

Examination found the blades in the fine pitch operating range, consistent with the power setting at the time of the ditching. No pre-existing defects or malfunctions likely to affect normal operation of the propeller were found.

1.12.3.5 Landing gear and hydraulic system

Examination of impact damage to the main landing gear indicated that it was in the retracted position at water impact.

The hydraulic system was found to be capable of normal operation. The cockpit hydraulic selector was found in the rear position (normal for takeoff) and the landing gear selector and lever lock were selected to the landing gear retract position.

1.12.3.6 Fuel system

A number of fuel samples were taken from various parts of the aircraft's fuel system and from the source from which the aircraft was refuelled. Analysis of those samples confirmed that the fuel met the required specifications.

Examination of the engine fuel system did not detect any pre-existing defect which would have prevented normal operation. The airframe fuel system was also found to be capable of normal operation. However, fuel system anomalies were found.

To obtain fuel samples from the left engine, the fuel lines from the carburettor fuel filter to the fuel pump and from the fuel pump to the nacelle fuel filter, and the carburettor to tank return line were disconnected. There was no fuel found in the carburettor fuel filter. The line between the nacelle fuel filter and the engine-driven fuel pump contained only a small quantity of fuel, as did the fuel line from the carburettor filter housing to the fuel pump. There was also no water found in the fuel lines. The fuel lines were visually inspected for condition, with no defect being apparent. The nacelle filter was inspected and found to be full of fuel. The carburettor was dismantled and quantities of fuel, approximately consistent with the capacities of the fuel chambers, were found. The left engine fire shut-off valve was found to be partially closed, although the cockpit control was positioned to open.

The possibility that the left engine malfunction resulted from fuel starvation was considered in conjunction with other available evidence. The engine malfunction indications reported by the crew and passengers and the subsequent engine examination assessment were not consistent with those associated with fuel starvation. However, the available evidence was consistent with the consequences of an inlet valve held open.

The investigation examined the circumstances in which the fuel lines may have been depleted of fuel. A definitive determination could not be made, due to the number of variables associated with the engine shut-down and with the disruption of the engine installation during the recovery.

The partial closure of the firewall shutoff valve was determined to have resulted from disruption of the valve control by the flexing of the firewall during the ditching and the aircraft recovery operation.

Anomalies were also found with some fuel tank drain valves, such that it may not have been possible during the pre-flight check to ensure that the fuel was not contaminated. On this aircraft, two drain valves, of either the ‘push to drain’ or ‘screw to drain’ type, were fitted to each main and each auxiliary fuel tank. The drain valve fitted to the outboard position of the right auxiliary tank was rendered virtually inaccessible due to misalignment of the valve with the wing skin cutout. Of the two screw-type valves in the left main tank, the swaged turning handle of the inboard valve rotated freely about the shaft. The left main tank outboard valve had been tightened, such that extreme force was required to open the valve.

There was no damage evident, proximate to the valves, to suggest that they became unserviceable as a result of impact forces or by damage sustained during recovery.

1.12.3.7 Instruments

The aircraft instruments had been subjected to salt water corrosion and could not undergo calibration testing. There were no reported pre-existing instrument defects and all required maintenance actions were recorded as having been completed.

1.12.3.8 Aircraft records

Aircraft category

The certificate of airworthiness for the aircraft was issued in the transport category, a consequence of which was that the aircraft was required to be maintained to the class-A requirements. Advice confirming that the aircraft was in the transport category was passed to SPA by the CAA Bankstown Office on 5 February 1993. However, the aircraft continued to be maintained as a class-B aircraft. The class-A system of maintenance is more structured and accountable for quality assurance of continuing airworthiness than is the class-B system.

CAO Section 100.2.3—Categories, Note 1 states in part:

> A Certificate of Airworthiness for an aeroplane, which is not commuter category, of maximum takeoff weight greater than 5700 kg, will normally be issued only in the transport category.

The investigation found that within the CAA, there was documentation which gave conflicting information as to whether this and other DC-3 aircraft were classified as transport or normal-category aircraft, and therefore subject to class-A or class-B maintenance respectively. This resulted in some confusion among those administering the system.

Use of the CAA aircraft register computer as the sole data reference for the production of certificates of airworthiness had not been authorised by the CAA management because the data had not been audited. However, CAA Moorabbin, when assessing this aircraft and SPA for inclusion on an existing AOC, used the computer system as the sole source of data, as the aircraft history file was with CAA Bankstown. It was demonstrated to the investigation team that when the CAA aircraft register computer was queried, it could produce a copy of the certificate of airworthiness for VH-EDC on which the aircraft was incorrectly identified as being in the normal category. (The CAA has subsequently confirmed that, at the time of the accident, all DC-3 aircraft on the register with a current certificate of airworthiness were in the transport category and, with the exception of VH-EDC, were being maintained as class-A aircraft).

Aircraft logbooks

The logbooks which were being used for the certification and recording of the maintenance history of this aircraft and its major components, were superseded versions of the book format. Logbooks of this type were suitable for use for normal-category aircraft, but more comprehensive recording systems are available for the more complex requirements of transport category aircraft.

It is common practice for many operators to continue to use similar logbooks which have been superseded, possibly several times. These may contain invalid instructions, and are less able to provide an adequate aircraft maintenance history and audit trail.

SPA was unable to substantiate the aircraft maintenance history for the period between June 1977 and May 1988, which covered 12,565 hours of aircraft operation. Consequently, the AD compliance status of the aircraft could not be established during the investigation.

AAC 6-12 dated 13 June 1991 advised of the availability of a new aircraft logbook. The new logbook incorporates the loose-leaf concept, and each section is provided with specific instructions to users.

An aviation regulatory proposal circulated for comment on the proposed introduction of the new logbook received adverse industry comment. Consequently, the CAA has not mandated its use. However, the use, throughout the life of VH-EDC, of a similar system, could have provided a comprehensive aircraft maintenance history.

Engine TBO concessions

Right engine. On 28 June 1993, SPA submitted to CAA Bankstown an application for a concession to exceed the published engine TBO period for the right engine. It included two oil sample analysis reports and a compression/ground run test report. The CAA approved a TBO extension of 100 hours, and SPA was notified accordingly on 6 July 1993.

Left engine . On 24 December 1993, SPA submitted to CAA Bankstown an application for the left engine to exceed the TBO period. Two oil sample analysis reports and a compression/ ground run test report were included. The application was approved by the CAA on 1 February 1994 for 100 hours overrun, and SPA was notified of this on 4 February 1994.

The AWI assigned to SPA had been verbally advised by SPA on 26 April 1994 that the right engine had been changed on VH-EDC. The AWI expressed the opinion that both engines should not operate on the same aircraft in the overrun period at the same time. However, the CAA did not have a policy to this effect. When the left engine was granted overrun approval, the AWI assumed that the right engine had been changed. There was an entry dated 24 April 94 in the VH-EDC aircraft logbook that the right engine Serial Number BP463388 had been removed and Serial Number 667 installed. This entry had subsequently been crossed out and noted as an ‘incorrect entry.’

At the time SPA commenced operating the aircraft, the left engine time since overhaul was 840:43 hours. Oil samples to support the concession application for overrun of the engine TBO were taken for analysis at 949 and 996 hours. The analysis reports from both these samples indicated abnormally high wear metals of iron, lead and aluminium. The reports recommended that the oil be re-sampled after a further 100 hours. However, without a previous trend to compare them against, the samples were not valid indicators of engine health. Furthermore, they represented only about 150 hours of engine operation by SPA (47 hours between samples) and were not indicative of either operating technique or type of operation.

On receipt of the application, the CAA Bankstown Office forwarded it to CAA Central Office for approval. Despite the indications that the engine was suffering mechanical distress together with marginal cylinder compression recordings, further information prior to approval was not sought by either CAA Bankstown Office or CAA Central Office.

CAA Central Office approved the concession and SPA was advised by CAA Bankstown on 4 February 1994. However, SPA had pre-empted the approval by operating the engine past the TBO period for approximately 15 hours. During the 15 hours TBO overrun, flight crews were not alerted to the engine TBO expiry, as an entry to identify the engine maintenance requirement had not been made on the aircraft maintenance release.

1.13 Medical information

There was no evidence to suggest that any crew member suffered from any pre-existing condition which might have contributed to the occurrence.

1.14 Fire

There was no evidence of pre- or post-impact fire, except for some burning which was contained within the left-engine induction system.

1.15 Survival aspects

1.15.1 Seats and seating configuration

The cockpit of VH-EDC was equipped with two flight crew seats and an additional forward facing jump seat which was positioned in the aisle at the cockpit bulkhead. The flight crew each had a four-strap/three-point harness with each shoulder harness attached to an inertia reel. The jump seat was fitted with a lap belt only.

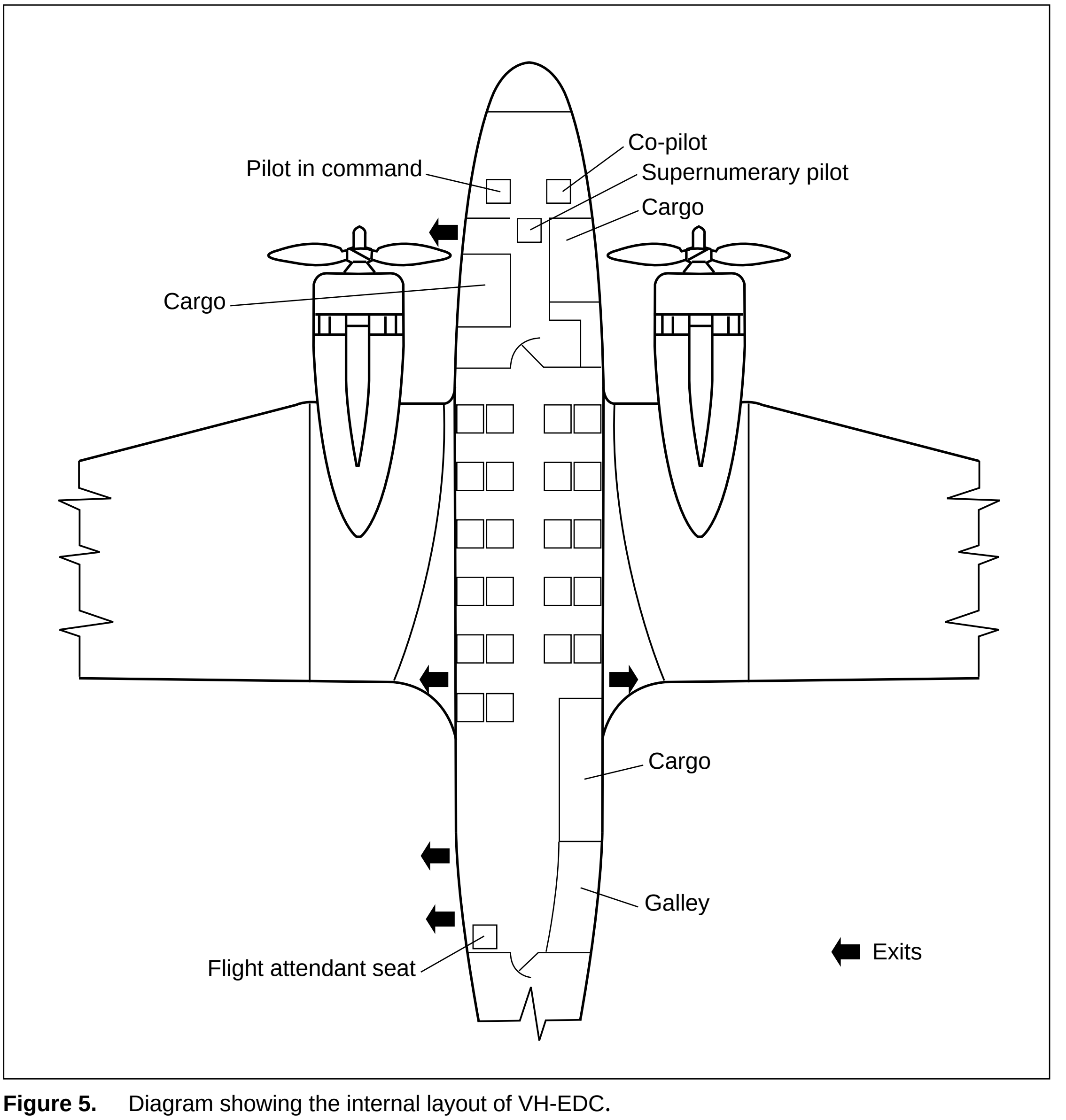

Figure 5. Diagram showing the internal layout of VH-EDC.

At the time of the accident, the cabin contained 22 passenger seats and one flight attendant seat. There were five rows of four seats and one row of two seats, with a central aisle. The final seat row on the left side of the aircraft contained two seats. Each seat was fitted with a lap belt.

The flight attendant's seat was located at the rear of the passenger cabin near the rear main door. Because the seat was not adjacent to a window, the flight attendant when seated was unable to see the aircraft outside the cabin. A shoulder harness was fitted to the seat, but without an inertia reel.

The operating crew reconfigured the seating layout on the day prior to the accident. It is a regulatory requirement that a seating reconfiguration on a class-A aircraft be certified by an approved person. However, CAR schedule 8 allows a pilot of a class-B aircraft to perform seat reconfiguration.

1.15.2 General

The rapid onset of the emergency and the resulting cockpit workload left no time for the flight crew to brief the passengers or the flight attendant. The supernumerary crew member attempted to indicate by hand signal to the flight attendant that there was a problem. The flight attendant was later unable to recall having seen the gesture, or to recall any aspect of the ditching. At no time was any signal given to indicate that it was safe for the flight attendant to leave her seat.

Cockpit

The seats of the pilot in command and the co-pilot were each fitted with shoulder restraints incorporating an inertia reel. However, neither pilot was wearing a shoulder restraint. The pilots reported that the operation of the inertia reels interfered with their ability to carry out their duties. On impact, the pilot and co-pilot were thrown forward against the windscreen, receiving minor injuries. There were no failures of the lap belts or seat structures.

The flight crew encountered no difficulty in leaving their seats. The pilot in command and the supernumerary pilot entered the passenger cabin to facilitate the evacuation of the passengers. The co-pilot egressed through the cockpit escape hatch.

Cabin

Prior to takeoff, the flight attendant had briefed the passengers, checked that all seat belts were fastened and advised the flight crew that the cabin was secure. On returning to her seat, she had fastened the lap belt but not the shoulder restraint, as the common view within SPA was that the lap belt was sufficient.

Passengers reported that during the ditching, the flight attendant was projected over the last passenger seat row and onto the next seat row. She was assisted from the aircraft to a life raft by passengers to whom she had appeared to be concussed and confused. Consequently, she was unable to perform her passenger safety function during the evacuation.

The flight attendant had no recollections of the ditching. Her injuries were the result of colliding with the passenger seats located on the left side of the aircraft. The injuries were consistent with those which would arise as a result of her seat harness being completely unfastened. Examination of her seat and its harness disclosed no pre-existing defects and that it had not failed.

Passenger seats and seat belts

At impact, one seat belt detached from seat 3D, and seat rows 1C/D, 5A/B and 6A/B separated from the seat rail on the outboard side. Examination of these seats indicated that the three outboard feet of seat rows 5 and 6 were not in the seat rail. The positioning pins were operational and there was no damage to either the seat rail or the feet of the seat. The rear two outboard feet of row one were not in position. No damage had occurred to either the seat rail or feet and the positioning pin was stowed, with the adjusting mechanism absent.

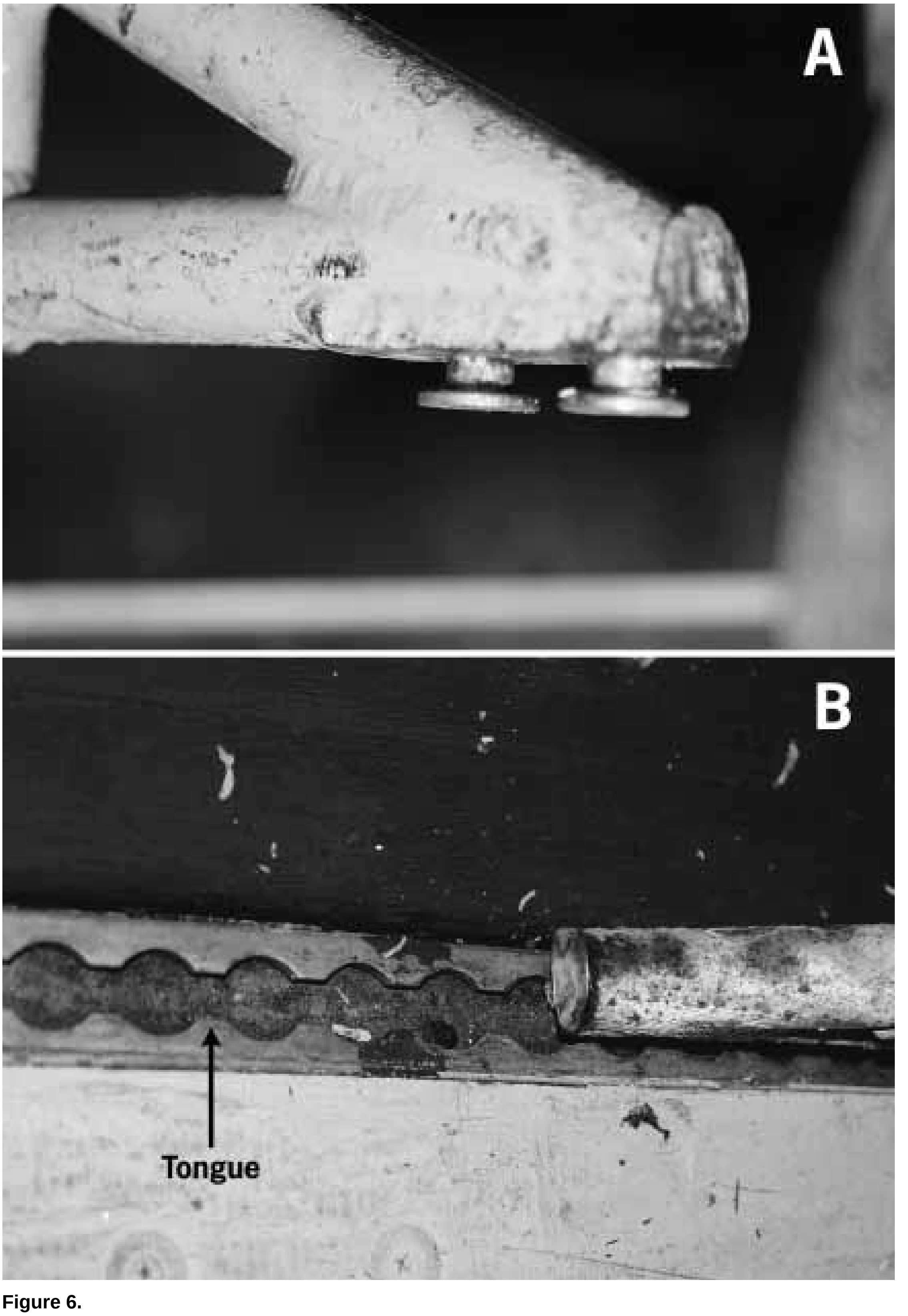

Figure 6.

(A) The lower arm of the seat structure showing the two rear locating feet.

(B) The Douglas track floor rail into which the feet of the passenger seat locate, under the rail tongue. The seat is retained in position by a spring-loaded locating pin which engages in the rail recess.

In addition to the seat belt which detached from a seat, three further seat belt fixtures were found to be deficient. The outboard half of the 3D seat strap was dislodged, and the spring-loaded gate which secures the fitting to the seat structure was found to be jammed in the open position. The gate was also jammed open on the inboard side of 3D. Both springs were absent, as they also were on the outboard side of the belt for seat 2C. The gate itself was deformed and was partially open. The spring was present on the outboard seat attachment for seat 5C; however, the gate was deformed and partially open. Examination of the belts and their fittings did not indicate any pre-existing fault.

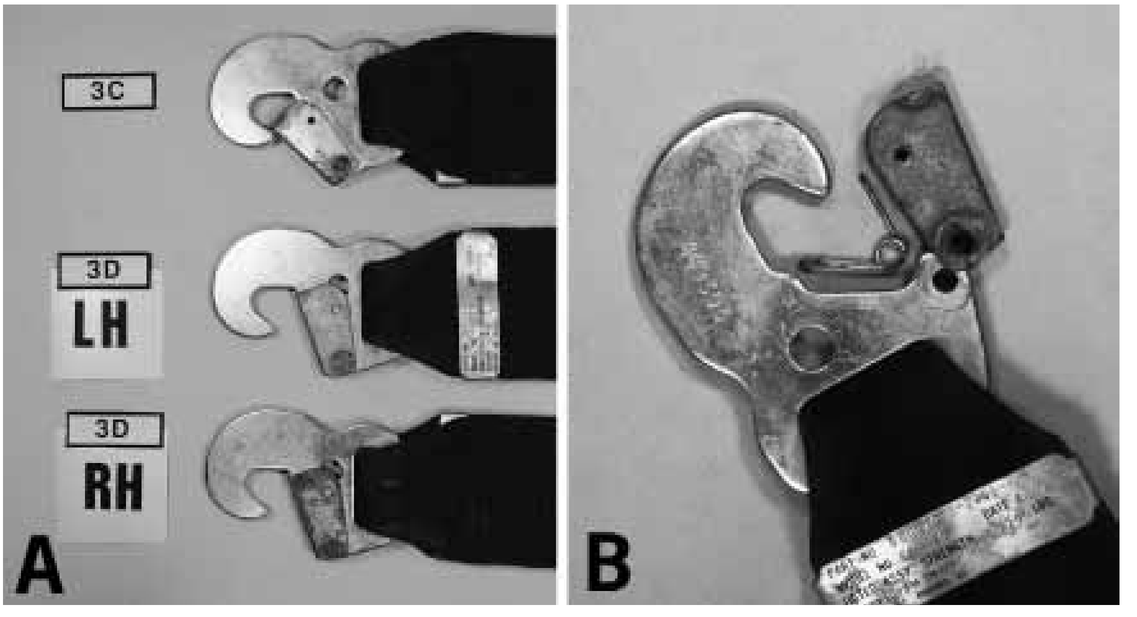

Figure 7.

(A) The seat 3D belt straps as found, with the attachment gates jammed in the open position. The seat 3C strap is shown to demonstrate the position of a correctly functioning gate.

(B) Detail showing the orientation of the spring within the gate mechanism.

Life jackets and rafts

The aircraft carried life rafts and life jackets sufficient for all passengers and crew. The crew reported that three types of life jackets were carried. However, five different types were recovered, all of which differed in colour, packaging or the manner in which they were secured or fitted. There were eight life jackets of the type demonstrated by the flight attendant during her pre-takeoff briefing of the passengers. The location and fitting of the life jacket shown on the passenger safety card also differed from that of the life jacket demonstrated during the safety briefing.

Many life jackets were displaced during the impact sequence. Eight passengers reported that life jackets had moved forward within the luggage racks or the cabin. Twelve passengers encountered difficulty in locating a life jacket, and nine passengers experienced some difficulty in fitting the jacket. Eleven reported that the instructions provided by the flight attendant were inappropriate to the jacket provided at their location. With the exception of all crew members and one passenger, all occupants donned a life jacket prior to leaving the aircraft.

Evacuation

The passengers, one of whom opened the rear main door, began the evacuation in an orderly manner. A life raft was deployed, and it was used to transfer two passengers and the flight attendant to two pleasure craft. By the time this initial transfer had been completed, water had already begun to enter the aircraft through the forward fuselage. The pilot in command therefore instructed the passengers to expedite their evacuation. When the remaining passengers had egressed, the pilot in command and the supernumerary pilot left the aircraft through the rear exit.

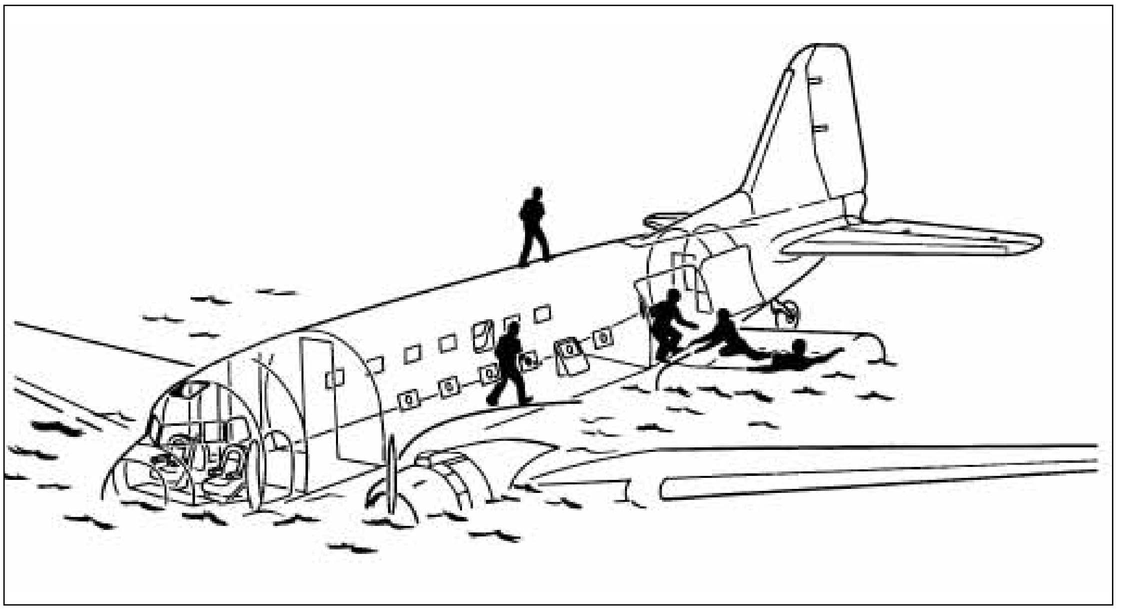

Figure 8. Use of emergency exits during evacuation from a ditched aircraft.

1.15.3 Emergency response

Following receipt of the call from the pilot in command advising that the aircraft was ditching, the ATS Tower COORD activated the crash alarm. This occurred at 0909:38. The 'Crash in the Vicinity of Sydney Airport (including Botany Bay)' checklist was then activated. The RFFS control centre was notified at 0909:55 and the Police, Ambulance, FAC and NSW Fire Brigade were informed by the CCC that a DC-3 aircraft had crashed off the end of runway 16. These agencies were informed that the emergency involved a 'level 2' aircraft. This classification refers to aircraft seating between 19 and 150 persons.

Tower personnel contacted Melbourne SAR at 0915, after a delay caused by the telephone number for SAR no longer being available on the tower telephone. There was some confusion regarding the number of POB. The flight plan indicated 25 passengers and crew. However, the pilot in command advised police at the accident site that there were 24 POB. He had been advised of a late cancellation by one passenger, but was not aware that another passenger had then been included on the flight. The passenger manifest listed 21 passengers and four crew. It took approximately one hour to confirm that all persons had safely exited the aircraft.

The FAC, CAA RFFS, NSW Police including Water Police and Air Wing, NSW Fire Brigade, NSW Ambulance and Airborne Medical Services all responded to the emergency in accordance with the AEP. MSB, SPA and the Volunteer Coast Guard also responded. The Coast Guard vessel was in the vicinity when the aircraft ditched, while SPA were informed by the Tower COORD.

By the time the Water Police and the MSB were in the vicinity of the aircraft, the majority of the passengers and crew had been taken on board pleasure craft. Eight boats were used to transfer the passengers and crew to shore.

After medical assessment of the passengers and consultation with the various hospitals by the Ambulance Co-ordination Centre, five persons were taken to Prince of Wales Hospital, six to St George Hospital and 14 to Prince Henry Hospital. All arrived between 1030 and 1040. With the exception of the flight attendant, all were discharged by 1430 that afternoon.

1.15.4 Emergency locator transmitter

The ELT fitted to this aircraft was a NARCO ELT Model 10, Serial Number A 22782. The battery showed a ‘replace by’ date of 28 July 1992, 21 months prior to the accident. SPA advised that the battery had been changed at the 100-hourly period inspection which was completed in March 94. (The certification records of the inspection do not reflect this.) Inspection of the ELT confirmed that the g-switch had not activated and that the battery pack had not been recently renewed.

1.16 Tests and research

Not relevant.

1.17 Management and organisational information

1.17.1 Overview

In accordance with the provisions of section 27 of the Civil Aviation Act, the CAA could issue an AOC to authorise flying or operation of an aircraft within Australian territory for commercial purposes, subject to conditions specified by the Authority. An AOC would be issued unless the applicant had not complied with, or had not established the capability to comply with, the provisions of the regulations relating to safety, including provisions relating to the competence of persons to conduct operations of the kind to which the application relates.

The effect of the requirements of the Civil Aviation Act and CARs concerning the certification and surveillance of air operators was contained in the MAOC. Volume 1 part A chapter 9 stated:

> The issue of an AOC certifies that the standard of personnel, aircraft, documentation and facilities of an operator were adequate at the time of issue to ensure that the air services of that operator could be conducted safely and in accordance with the regulations.

Volume 2 part A chapter 3 of the MAOC addressed the variation of an AOC for the purpose of addition of a new aircraft type. Section 3.3 stated:

> An operator is required to submit an application to include an additional aircraft type on his AOC in reasonable time for the Authority to assess the operator’s competence to utilise that type.
>
> Based upon his knowledge of the operator’s current fleet, the Inspector normally assigned to the operator will assess the need for further inspection of the operator’s facilities, training and checking organisation, maintenance organisation and aircraft. If it is determined that these are necessary, the operator should be asked to provide details of when the facilities and aircraft will be available for inspection. The operator must also provide appropriate operations manual and training and checking manual amendments and if one is not available from airworthiness records, the aircraft flight manual.
>
> Addition of the new aircraft type is to be conditional upon the approval of the assigned inspector, who will be responsible for document evaluation and any required inspections.

The MAOC described the subsequent program of surveillance and inspections by the CAA necessary to ensure that the ongoing operation continued to meet the required standards. The surveillance and inspections were intended to include the conduct of annual/periodic aircraft, training, facilities, documents and records inspections. Details of specific inspections were also provided in the MAOC, and included information on the purpose, frequency, methods, conduct, reporting and follow-up requirements of inspections. The MAOC provided checklists to facilitate those inspections. The target level of coverage for each inspection activity was also listed in the manual.

Airworthiness surveillance of approved organisations was required by the CAA to be conducted in accordance with the policies, procedures, planning and instruction guidelines of the NASS. Instructions for NASS users were contained in the 'Policy and Procedures' and 'Planning System User and Training' manuals. Section 1.1 of the former stated:

> The purpose of this manual is to document standardised practices and procedures by which Airworthiness Officers engaged in airworthiness surveillance activities will be able to plan, conduct, record and report those activities in an effective and efficient manner. This will ensure that safety regulation of the aviation industry is conducted in an equitable manner whilst at the same time providing the Authority with a means to effectively control its surveillance activities.

At the time of the accident, a CAA SR&S district office for the area in which an operator maintained its main base normally had responsibility for the flight operations and airworthiness surveillance of that operator. The MAOC stated:

> When planning individual work schedules, senior examiners and surveyors should ensure that inspections and surveillance are given the necessary priority. If, during the year, it becomes apparent that the minimum level of surveillance may not be achieved in some area, the senior examiner/surveyor should take immediate steps to have resources allocated to the area in question.

In addition to the provisions of NASS, procedures for the airworthiness surveillance of operators by the CAA were promulgated in the MAOC. Airworthiness surveillance of an operator's aircraft, which could be carried out at any time, was to concentrate mainly upon ramp inspections and line aircraft inspections. If the holder of the AOC was also an approved aircraft maintenance organisation, then the surveillance was to cover all activities specified in the certificate of approval.

1.17.2 VH-EDC air operator certification and surveillance

The company which owned and operated VH-EDC was located at Camden, NSW. A principal of SPA was also a partner in a company (Groupair) based at Moorabbin, Vic., which had been issued an AOC for the operation of normal-category aircraft. The principal was employed at an overseas location by a major international airline as a technical operations manager. He was an experienced LAME and had worked with the manufacturer on aspects of its DC-3 ageing aircraft program.

To enable the commercial operation of VH-EDC, CAA Moorabbin was requested by Groupair to vary their AOC to include DC-3 aircraft. This was completed on 8 February 1993. CAA Moorabbin was responsible for surveillance of the DC-3 operation.

Groupair's chief pilot had limited multi-engine experience and no DC-3 experience. Consequently, CAA Moorabbin agreed that a DC-3 flight captain, based at Camden, could be appointed to exercise some of the chief pilot's responsibilities. This function was delegated to the pilot in command of the accident flight. In May 1993, the pilot in command was also approved as check-and-training captain. However, overall supervision of the operation of the aircraft remained the responsibility of the chief pilot, who was based at Moorabbin.

When assessing an operator for approval of an AOC or for the addition of a new aircraft type to an existing AOC, the MAOC intended that compliance with both operation and airworthiness regulatory requirements be assessed. These requirements included a system of maintenance, and appropriate facilities, equipment and documentation. The variation to the AOC to include the DC-3 was approved by CAA Moorabbin without an inspection being conducted to ensure that the airworthiness requirements were met.

Surveillance of Groupair was controlled by CAA Moorabbin. However, as the aircraft and SPA were based at Camden, the Bankstown Office, at the request of the Moorabbin Office, accepted airworthiness surveillance responsibility, and the conduct of specific operational surveillance on request from the Moorabbin Office. The MAOC-recommended mechanism—the MOU by which surveillance and audit responsibilities should be delegated between CAA offices—was not used.

The intended level of CAA flight operations and airworthiness surveillance activity for SPA was a total of three days per year. Most of the CAA Bankstown involvement with SPA during the period leading up to the accident focused on the DC-3 flight captain, the check-and-training approval process, and operations and performance limitations. No formal flight operations surveillance, responsibility for which had been retained by CAA Moorabbin, was conducted. However, implicit in the DC-3 flight captain and check-and-training approval process was an element of flight operations surveillance.

Airworthiness surveillance actually conducted was limited to one ‘opportunity’ inspection in March 1994, by CAA Bankstown, when the aircraft was flown to Bankstown for radio maintenance.

No evidence was found to indicate that the chief pilot had fulfilled his supervisory responsibilities with regard to the DC-3 operations. Being located at Moorabbin, he was remote from the DC-3’s operational base at Camden. As a consequence, the executives of Groupair and SPA tended to exclude him from activities associated with planning and operation of the DC-3. However, there was evidence that the pilot in command, as DC-3 flight captain, advised the chief pilot of all commercial operations. All ongoing supervision of both general operations and check and training was left to the pilot in command.

1.17.3 Task planning

Performance charts

Aircraft performance charts relevant to the accident were as follows:

Chart DCA PK16.1/1 (take-off weight chart) and DCA PK16.1/2 (landing weight chart) were developmental services charts used during operations in PNG and were not approved for use in Australia. However, they were included in the operations manual accepted by the CAA.

Chart TAA P19 Issue 1 (take-off chart) and TAA P20 Issue 1 (landing weight chart) were originally produced to permit operations up to a MTOW of 12,202 kg (26,900 lb). At the time of the accident these charts were valid for use up to the CAA-approved MTOW of 11,884 kg (26,200 lb).

The operations manual required that charts P19 Issue 1 and P20 Issue 1 be used for all normal operations, but gave the pilot in command discretion to use PK16.1/1 and PK16.1/2. However, the circumstances in which the pilot in command might exercise such discretion were not identified. Use of Chart P19 Issue 1 would have precluded takeoff from Lord Howe Island, whereas use of PK16.1/1 allowed the operation, with the caution that the accelerate/stop distance would not always be available when using that chart.

Prior to the accident flight, the pilot in command had been advised both orally and in writing by CAA Bankstown of the requirement to include only the approved performance charts in the operations manual. Although he amended Chart P19 Issue 1 to reflect a maximum take-off weight of 26,200 lb (11,884 kg), the pilot in command did not remove Chart PK16.1/1 or Chart PK16.1/2 from the manual as he had been advised to do by the CAA. The chief pilot was not aware of the incorrect charts as he was not included in the meeting with the CAA at Bankstown nor did he receive their written advice.

SPA carried out initial task planning some time prior to the accident flight and provided the charterer with a load availability of 2,160 kg. The load availability figure was derived from the normal basic weight of the aircraft, adjusted for seat removal and fuel to be carried. However, it did not take into account the weight of life rafts, additional drums of oil, or aircraft spare parts and tools, that were to be carried. Additionally, no provision was made in the calculations for inclusion of the supernumerary crew member. Thus, the load availability given by SPA to the charterer exceeded what was actually available on the accident flight by approximately 600 kg.

Performance calculations using Chart PK16.1/1 were made by the pilot in command, despite his knowledge that the performance chart was not approved. To be able to complete the flight to Norfolk Island, the aircraft had to stage through Lord Howe Island. This would have required takeoffs at the Chart PK16.1/1 MTOW from Lord Howe on both the outbound and inbound legs. SPA was awarded the charter contract after offering payload availability on the basis of using that performance chart.

Aircraft loading

The pilot in command prepared a load sheet prior to his arrival at the airfield. This indicated that the aircraft's weight would be 11,757 kg at takeoff, or 127 kg below the MTOW. He used the CAAP-suggested weights for the passengers, and estimated the weight of the freight, including the life rafts. He calculated the load as 1,833 kg, although the charterer had been advised that the availability would be 2,160 kg. The load delivered by the charterer, as determined during the investigation, weighed 2,117 kg, but the charterer had not advised SPA of the actual weights, nor were they required to.

The volume of freight (band instruments) delivered had concerned both the pilot in command and the co-pilot. The pilot in command indicated that although he assessed that the weight was in excess of what he had expected, he considered that the additional weight would not exceed the 127 kg he had already calculated was still available. He did not attempt to check the weights despite an operations manual requirement that the pilot in command confirm the actual weights in the event of any concern about their accuracy.

The result was that the aircraft began the takeoff approximately 562 kg in excess of the MTOW. (The various weight and balance calculations are set out in section 1.6.2.)

1.17.4 Training and checking

General

Apart from flight attendant training, no formal check-and-training records, as required by the operations manual, were available. There was no evidence available to indicate that the co-pilot had operated the aircraft type at representative weights following an engine failure on takeoff. The pilot in command, as Groupair's DC-3 check-and-training captain, had not checked the co-pilot's ability in such situations. At the time of the accident, the CAA CARs and CAOs did not specify a required aircraft load status for the conduct of asymmetric training or checking.

The crew had not received any formal CRM training, nor was such training required by the CAA.

Pilot in command

The pilot in command was responsible for operational standards and training. He accepted the co-pilot's DC-3 credentials (type rating) without checking that person's proficiency on the aircraft with regard to emergency procedures.

The investigation did not find any evidence that the chief pilot, or the CAA, attempted to ensure that the pilot in command was complying with the operations manual check-and-training requirements.

Co-pilot

The co-pilot's licence was endorsed with a DC-3 type rating, following his representation to the CAA that he had completed DC-3 pilot in command endorsement training. The investigation found no evidence to establish that the co-pilot had actually completed the required training.

The flying experience recorded in the co-pilot's logbook, which was used to substantiate his application for a DC-3 type rating, was insufficient to qualify the pilot for the rating.

The US pilot who provided the training advised the investigation team that its purpose was to familiarise the trainee with the co-pilot duties. The trainee was not given instruction or a flight check to enable him to fly as pilot in command.

There was no indication that the co-pilot's logbook entries had been checked by the pilot in command prior to allowing the co-pilot to fly as crew in a DC-3. There was also no record of a check of his ability to handle the aircraft from the right control position during abnormal or emergency situations.

During the accident investigation, the co-pilot produced an instrument rating test form to show that he had completed a command instrument rating renewal at Cairns, Queensland on 9 January 1994. The form indicated that the test was conducted in a DC-3. However, the test results had not been submitted as required to the CAA.

The co-pilot's logbook showed that he had been flying VH-EDC as a flight crew member since 13 August 1992, and that he first flew the aircraft as pilot in command on 25 November 1992. The pilot was not qualified to fly as a crew member on commercial flights before 20 September 1993, when he gained the commercial pilot licence. The co-pilot's logbook showed that he undertook the commercial pilot licence test in a DC-3, VH-EDC. However, the documentation forwarded to the CAA by the test officer listed the aircraft as a PA-39, VH-MNN.

Consequently, the co-pilot was subject to the operations manual check requirements only from September 1993. No evidence was found to indicate that he had undergone initial checking or training on commencement of commercial operations as required by part C of the operations manual. The operations manual requirement was that two checks be conducted per calendar year and that they be at least four months apart. The instrument rating renewal met the requirements for one of these bi-annual checks but did not satisfy the requirement for the initial checking and training on commencement of commercial operations.

Flight attendant

Company records indicated that the flight attendant was trained and checked proficient in accordance with the operations manual on 25 September 1993. This consisted of approximately two hours of training during which the operation of exits, therapeutic oxygen, fire extinguishers and seat belts was explained. She was also informed of cabin safety procedures such as checking that passenger seat belts were fastened, and determining from the signal from the cockpit when it was safe to commence cabin service. Evacuation procedures were also discussed, including the use of exits away from the fire or problem. The training was undertaken by the pilot in command.

On the day prior to the accident, the pilot in command spent approximately two hours training the flight attendant in the emergency procedures associated with a ditching.

1.17.5 Aircraft operations manual

Groupair produced an operations manual for the DC-3 which included a check-and-training section. Groupair was subsequently advised in a letter from CAA Moorabbin that 'The Groupair Operations Manual Part B and Part C have now been approved by the Civil Aviation Authority'. This was a clerical error, as CAA current practice was that the manual was not approved, but was assessed as acceptable. However, the investigation found that the manual contained non-approved take-off and landing performance charts. The manual was also found to contain two different sets of instructions for crew procedures during takeoff when the co-pilot was the handling pilot. An amendment to the manual, which included the procedure used during the engine failure, had been sent to CAA Moorabbin in December 1993. The amendment had been placed on file and not incorporated in the CAA's copy of the manual.

An official Australian flight manual for DC-3 type aircraft was never produced. Information normally available in the flight manual was required to be included in the operations manual. Consequently, because these data were included in the operations manual, they were not subjected to an approval process by the CAA. Such data included take-off and landing performance charts, limit and critical airspeeds, weight and CG information.

Advice from the CAA Airworthiness Branch was that a single set of official Australian DC-3 performance charts had never been produced. In the past, when the major airlines operated DC-3 aircraft, they produced their own performance charts; consequently, there are numerous such charts in use. However, the charts PK-16.1/1 and PK-16.1/2, which were retained in the operations manual for VH-EDC and used by the pilot in command when planning the flight, were not approved by the CAA.

The inclusion in the operations manual of the invalid take-off and landing performance charts was identified by CAA Bankstown in December 1993. Replacement performance charts were dispatched to the operating company by CAA Bankstown that month. However, SPA did not include the replacement charts in the manual, nor were the invalid charts discarded. A copy of the letter which accompanied the replacement charts was sent from CAA Bankstown to the CAA Moorabbin DC-3 type specialist, but not to the Moorabbin FOI overseeing the DC-3 operation or to the chief pilot.

A meeting was held at Bankstown between SPA and the CAA one month prior to the accident to discuss weight control of the aircraft. At this meeting the pilot in command was informed as to which take-off performance chart was to be used. The chief pilot was not included in these discussions. The pilot in command subsequently completed performance planning for the flight, aware that the take-off performance chart he was using was not approved.

It was the chief pilot's responsibility to ensure compliance with the operations manual. Groupair did not retain a copy of the manual, to be used as a reference by the chief pilot, and the investigation found that the chief pilot was not aware of all aspects of the DC-3's operations. No evidence was found to indicate that the chief pilot had conducted any direct supervision of the Camden operation. Nor was it established that CAA Moorabbin was aware of the lack of an operations manual in Groupair's office or of the chief pilot's lack of supervision.

The operations manual included procedures to be adopted in the event of a number of abnormal situations, including forced landing and ditching. The manual indicated the duties to be undertaken by both the pilot in command and co-pilot. However, the duties of the flight attendant in such situations were not included. Further, in the case of premeditated forced landing or ditching procedures, there was no reference to passenger briefings or to the evacuation of passengers.

1.17.6 Aircraft handling

Neither the CAOs nor the company operations manual set out the minimum experience and training required before a co-pilot was permitted to conduct a takeoff from the right control position. The operations manual contained two different instructions regarding crew actions when the co-pilot was conducting the takeoff. One instruction required the pilot in command to follow through on the controls during takeoff and to resume control immediately on recognition of a problem. The other required that the co-pilot continue to fly the aircraft while the pilot in command provided support. The latter procedure did not address the implications of the limitations imposed by the lack of flight attitude instruments located at the right side control position.

The pilot in command indicated that it was his policy that the handling pilot should continue to fly the aircraft and deal with the emergency while the non-handling pilot provided support.

During the accident sequence, when the co-pilot called an engine failure on the left engine, the pilot in command performed the phase-1 engine failure checklist. The crew referred to the engine instrument indications to verify the failed engine. The pilot in command feathered the propeller on confirmation by the co-pilot of correct identification, and shut down the engine, while the co-pilot continued to fly the aircraft. The pilot in command took control of the aircraft when it became apparent to him that, despite the right engine being selected to, and indicating, full power, the aircraft performance had deteriorated and the co-pilot was unable to fly the aircraft safely.

The pilot in command, having assessed the options, did not attempt to land on the remaining runway ahead of the aircraft, as the available distance appeared to him to be marginal and there was the possibility of sliding off the end of the runway onto the rocks of the sea wall. The operations manual procedure for the aircraft, at the reported speed at which the malfunction occurred, required that the pilot proceed with the takeoff.

Evidence of the operation of the aircraft during the emergency was obtained from the open microphone transmissions recorded by the AVR facility. Following the engine shutdown, the co-pilot attempted to maintain 81 kts (the take-off safety speed for MTOW, as prescribed in the operations manual). However, within 20 seconds after the pilot in command had advised ATC that the engine was shut down, the aircraft's performance decayed to the degree that the decision was made by the pilot in command to ditch the aircraft.

1.17.7 Licensing of the co-pilot

The co-pilot claimed to have completed DC-3 endorsement training in the USA. The FAA advised that the co-pilot had not applied for, nor had he been granted, a DC-3 type endorsement by the FAA.

In August 1992, the co-pilot submitted his FAA commercial pilot licence to CAA Bankstown, seeking Australian validation. He also produced his pilot logbook and identified an entry which he claimed to be verification of the required training for the issue of a DC-3 type rating.

The CAA staff involved had intended to validate the licence to the Australian unrestricted *private* pilot licence standard. However, the certificate of validation issued by the CAA stated that the FAA licence had been validated to 'unrestricted pilot standard'. The CAA also included a DC-3 type rating, without requiring substantiation beyond the logbook entry of completion of the required training. CAA policy at the time required that a rating should not be issued for foreign training unless the type was endorsed on the applicant's overseas licence by the relevant authority.

In January 1993, over two months after expiration of his certificate of validation, the co-pilot was issued with a special pilot licence which carried a DC-3 endorsement without restriction.

In September 1993, the co-pilot was issued an Australian commercial pilot licence, which again included the DC-3 type rating. However, subsequent investigation has determined that, at the time the licence was issued, the pilot had not completed the required DC-3 endorsement training.

1.17.8 CAA airworthiness surveillance

SPA acquired VH-EDC on 24 June 1992 and was maintaining the aircraft at its Camden base. Groupair's maintenance certificate of approval, which was limited to normal-category aircraft, was amended on 16 October 1992 to include the DC-3 aircraft type. CAA Moorabbin, using the aircraft register computer as the sole data reference, incorrectly identified the DC-3 as a normal-category aircraft. Surveillance of the maintenance of VH-EDC was to be controlled by CAA Moorabbin.

CAA Moorabbin did not inspect the aircraft file, the aircraft, or the aircraft's logbooks before allowing VH-EDC, which had been out of service for the previous two years, to enter service on commercial charter operations.

CAA Moorabbin drew up a functional line reporting diagram for the maintenance management of the aircraft which showed the engineering manager of Groupair as the chief engineer responsible for the management of the DC-3 maintenance. However, the engineering manager subsequently indicated that he was not aware of the type of maintenance required, and was not directly involved in the planning or introduction of the DC-3 into commercial service. In addition, he was unaware of the maintenance management plan and did not exercise any control over maintenance at Camden, nor did he believe it was his responsibility. He left the employment of Groupair in February 1993, at about the time that VH-EDC entered service, and was not replaced. Consequently, Groupair did not exercise management control of the DC-3 maintenance.

Airworthiness surveillance by CAA Moorabbin between February and May 1993 did not disclose that Groupair's engineering manager position was vacant and that the maintenance management plan was therefore no longer valid. When CAA Moorabbin transferred airworthiness surveillance of the aircraft to Bankstown, they passed on the functional diagram which indicated that the LAME at Camden would report to the engineering manager of Groupair.

SPA submitted an aircraft logbook statement to CAA Bankstown on 4 August 1992, seeking approval to maintain VH-EDC as a class-B aircraft. Approval was denied and SPA was advised accordingly on 14 August 1992.

On 5 February 1993, CAA Bankstown wrote to SPA advising that the certificate of airworthiness classified the aircraft as transport category and that the logbook statement, which referred to maintenance of the aircraft in accordance with 'schedule five', was not applicable to class-A aircraft. Furthermore, there was a requirement to submit a 'system of maintenance' for approval with a maintenance control manual and the nomination of a maintenance controller. SPA contacted the CAA officer by telephone on 10 February 1993, and advised that they would submit a maintenance control manual. This was before CAA Bankstown was officially asked by CAA Moorabbin to undertake the AOC (Camden) airworthiness surveillance role.

CAA Moorabbin wrote to CAA Bankstown on 28 May 1993 requesting that, as VH-EDC was to be maintained at Camden, Bankstown arrange the required local audit and surveillance activities. This request was accepted. However, the only surveillance undertaken by CAA Bankstown after that date was a NASS-10 survey of the aircraft at Bankstown on 2 March 1994. This was an opportunity surveillance activity, and not part of a planned program of surveillance.

There was no plan formulated in accordance with NASS procedures for surveillance of SPA by the Bankstown-assigned AWI. However, the assigned AWI advised that attempts to contact the company to arrange a meeting when the aircraft and its maintenance documents were together had been unsuccessful. There were no formal, documented attempts by the CAA requesting that the management personnel of SPA make themselves, the Camden facility, the aircraft, or its documentation available to initiate the surveillance process.

Up to the time of the accident, SPA had neither submitted a maintenance control manual for approval, nor nominated a maintenance controller. Furthermore, 100-hourly periodic inspections had continued to be conducted by SPA in accordance with the CAR Inspection Schedule 5, which is not an approved schedule for the maintenance of class-A aircraft.

1.18 Extended range operations

The planned flight involved overwater operations, which necessitated consideration of compliance with requirements for EROPS.

CAO 20.7.1B Issue 2 and CAO 105 AD/General/69 Amdt 1, 3/90, set out the requirements for EROPS for twin-engine aircraft. CAO 20.7.1B, para. 2, 'Application', indicated that the order was only applicable to all new types of piston engine aircraft having a maximum permissible all-up weight in excess of 5,700 kg, which were first registered after 1 June 1963. The DC-3 would therefore not appear to be subject to EROPS requirements. However, this was contradicted by para. 13.4 of the same order, which identified its applicability to twin-engine aeroplanes of a type first registered in Australia on or before 28 October 1985.

CAO 105 AD/General/69 Amdt 1, 'Applicability', identified that the DC-3 aircraft type was required to satisfy the EROPS requirements:

> Applicability:
>
> All passenger-carrying twin-engined aeroplanes certificated for 20 passengers or more intended to be operated on extended range operations except as indicated in Note 1.
>
> Note 1: This Directive is not applicable to aeroplanes of an airframe/engine combination first registered in Australia on or before 28 October 1985 operated by the same operator as on 30 November 1989 under the provisions of CAO 20.7.1B Subsection 13 Paragraph 13.4.
>
> Note 2: For the purpose of this Directive, Extended Range Operations means a distance in excess of 60 minutes flight time from an adequate aerodrome calculated at single engine cruise speed.
>
> Note 3: In addition to the Requirement of this Directive, operational requirements as specified in CAO 20.7.1B subsection 13 shall be complied with before specific extended range operation is approved.

Under the provision of this directive, the operator was required to obtain CAA EROPS approval to conduct the flight using VH-EDC.

During planning for an EROPS flight, an operator would be expected to reference operational CAOs, in particular CAO 20.7.1B. However, CAO 20.7.1B did not refer to AD/General/69 Amdt 1. The investigation team was made aware that other operators and some operational staff of the CAA did not properly understand these orders and directives. Had these orders and directives been understood and complied with, VH-EDC would not have been used for the task on which the accident occurred.

1.19 Additional information

Passenger behaviour

Despite the lack of direction from the flight attendant due to her incapacitation, the passengers were calm and composed during the ditching and subsequent evacuation. Significant features of the evacuation were that:

(a) the passengers perceived that their survival was not threatened, which was due, in the main, to the calm weather and sea conditions, proximity to the shore, the number of pleasure craft in the vicinity, and the initial buoyancy of the aircraft;

(b) one passenger essentially took control of the evacuation process;

(c) the life rafts were highly visible to all the passengers; and

(d) the majority of the passengers knew each other, which facilitated their cooperation during the evacuation.

Passenger briefing

The flight attendant provided an oral briefing and demonstration prior to takeoff. This included the location of emergency exits, life rafts and life jackets. The demonstration included the fitting and inflation of a life jacket, but did not include (it was not required) any instruction on the position to adopt prior to an impact. The passengers' attention was directed to the brace position on the safety briefing card.

None of the passengers braced prior to the impact, despite 17 passengers having referred to the safety briefing card which provided details of the brace position. Prior to impact, the passengers were not directed to adopt the brace position as the crew did not have time to make an announcement over the public address system.

2. ANALYSIS

2.1 Introduction

The investigation has established that the left engine of VH-EDC lost power shortly after takeoff. The aircraft was unable to maintain altitude and performance and the crew elected to ditch it in Botany Bay. That few injuries were sustained primarily reflects the favourable position of the aircraft and the pilot in command's handling of the ditching.

Evidence of a possible engine defect was available to SPA and the CAA prior to the accident flight. The significance of the engine condition information provided by SPA was apparently not recognised when the CAA approved an extension of the engine TBO.

Engineering examination of the left engine has indicated that the malfunction of the engine was most likely attributable to the jamming open of the no. 3 cylinder inlet valve. The effect on the engine operation of an inlet valve jammed open is consistent with the reported circumstances of the engine malfunction.

That the engine malfunction resulted in an accident indicated that other aspects of the aircraft operation were deficient. These deficiencies included aircraft maintenance, aircraft loading, pilot competence, and flight crew procedures.

The use of VH-EDC for the planned flight was inappropriate. The circumstances in which SPA was able to justify its use, together with the procedures adopted by the CAA when approving the addition of the DC-3 operation to an existing AOC have been the principal matters in this analysis.

The analysis of this occurrence indicates that there were latent failures in the aviation system which contributed to the accident, in addition to active failures involving the flight crew and others which contributed to system defences being breached or bypassed.

2.2 Defences

Complex socio-technical systems, such as the civil aviation system, normally incorporate defences (sometimes called the safety net) which are designed to detect and provide protection from hazards resulting from human or technical failures, and to eliminate or reduce their possible effects. When an accident occurs, an important first step in determining why it occurred is to identify what aspects of the system defences were absent, had failed, or were circumvented.

Investigation of this accident revealed that there were defences in the system which, had they not failed or been circumvented, should have prevented the accident. The principal defences relevant to the mechanical malfunction of the engine and to the flight and cabin crews' handling of the subsequent emergency are discussed below.

2.2.1 Failed defences

(a) Engine overhaul/maintenance procedures

Engine maintenance manuals and procedures documentation have been available since the introduction into service of the engine type. The use of this information by operators and maintenance personnel, and compliance with the appropriate CAA maintenance requirements, are intended to prevent incorrect engine component assembly. However, this occurrence involved the incorrect installation of an engine component which subsequently may have caused the left engine to lose power at a critical phase of flight. Thus the defence provided by the established overhaul and maintenance procedures failed.

(b) System for extension of engine TBO

The CAA had in place a system for granting approval to operate engines beyond their specified TBO. This system, if properly applied, should have acted as a defence against engines in poor condition being allowed to continue in service beyond their specified TBO. However, in this instance the system failed. Despite having been provided with oil samples and records of compression tests which indicated that the left engine probably was in poor condition, the CAA granted an extension allowing SPA to continue operating the engine beyond its TBO.

(c) Crew qualification system

This defence comprised, in part, standards and procedures for crew licensing and for check and training of licensed crews to ensure that they were qualified to perform tasks appropriate to their roles. Responsibility for the effectiveness of these defences was shared between the CAA and operators. Despite the CAA having established standards and procedures covering both licensing and check and training, the defence intended by these standards and procedures failed. This was evidenced by the co-pilot in this accident holding an aircraft rating, the qualifications for which could not be substantiated, and there being no record of the operator having ensured that flight crew members had completed the check and training required by the CAA standards.

(d) Operations manual procedures

In producing an operations manual, the operator sets out the instructions, procedures and practices which its operations personnel must follow in order to ensure that they carry out their tasks safely and in accordance with the appropriate provisions of the Civil Aviation Act and Regulations. The operations manual acts as a system defence in that it provides standardised and proven ways of dealing with matters such as the in-flight emergency involved in this accident. Its effectiveness in providing such a defence is contingent upon it being complete and accurate.

Operations manuals were previously required to be approved by the CAA. However, when this operator's manual was submitted in support of the application for the variation to the AOC, the manual was not approved but was 'accepted' by the Authority. As a consequence, the defence inherent in an operator having, and following, sound operations manual procedures failed. This was evidenced by the manual containing erroneous and potentially misleading information which had not been identified during the operations manual 'acceptance' process.

2.2.2 Circumvented defences

(a) MAOC procedures

The MAOC procedures were intended to give effect to CARs and CAOs, by providing guidance to CAA personnel on the issue, control and monitoring of an AOC. The guidance was to ensure that CAA officers adequately assessed the establishment and operation of commercial aircraft services. The MAOC procedures should, if applied correctly, act as a system defence by preventing operators who do not meet the relevant standards from being issued with an AOC. That this defence was circumvented is evidenced by the CAA having approved the addition of DC-3 aircraft to an existing AOC, and the operator having commenced commercial passenger-carrying operations without the CAA having conducted any inspections or surveillance on the DC-3 operation.

(b) Flight manual

An approved flight manual was required by the CAA for most aircraft. The flight manual acted as a system defence in that it served to ensure that essential aircraft information, assessed and approved by the CAA, was available to the operating crew. Included in that information were the take-off and landing performance charts.

The defence provided by the provision of an approved flight manual was circumvented when the DC-3 aircraft type was exempted by the CAA from the requirement to have a flight manual. Information normally contained in the flight manual was intended to be included in the operations manual. However, because the operations manual was not 'approved' by the CAA, the inclusion of incorrect information was not recognised, and that incorrect information remained available to the crew at the time of the accident.

2.3 Active failures

Active failures are unsafe acts which may be classified as either errors or violations. These failures are typically associated with operational personnel such as pilots, air traffic controllers, maintenance staff, etc.

2.3.1 Engine malfunction

(a) Incorrect assembly of components

An inlet valve rocker shaft thrust washer in the no. 3 cylinder was not installed correctly. This could cause the valve to jam open and result in a loss of power.

The left propeller was found to have an over-torqued pitch change mechanism nut which probably caused the failure of the propeller to feather fully.

(b) Approval of TBO extension

CAA officers approved the extension to the left engine TBO, despite a SOAP analysis indicating possible engine internal distress. Cylinder compression test results also did not appear to support the engine extension. The application could either have been rejected or further examination required before the CAA approved the extension.

2.3.2 Aircraft operation

(a) Pilot in command's response to the engine malfunction

The crew assessed that the malfunction had resulted in a total loss of power from the left engine and the engine instrument indications were referenced to confirm the failed engine. The pilot in command assessed that the engine should be shut down and the propeller feathered.

The pilot in command, who was not aware of the degree to which the aircraft was overloaded, had assumed that the co-pilot should have been capable of safely operating the aircraft, despite the engine malfunction. Consequently, he did not initially respond to the incorrect aircraft handling by the co-pilot. The deterioration in aircraft performance was such that when he did take control, there was little option other than to ditch the aircraft.

(b) Co-pilot's response to engine malfunction

Following the engine malfunction, the co-pilot attempted to maintain the take-off safety speed required by the operations manual for weights up to and including MTOW. However, as the aircraft weight exceeded MTOW, that speed was inappropriate, and resulted in a reduction in the single-engine performance capability of the aircraft.

The aircraft performance was further eroded when the co-pilot applied excessive aileron control in an attempt to maintain directional control.

(c) General

The single-engine performance figures quoted for the aircraft were determined under controlled conditions. Following the engine failure after takeoff, the crew were faced with an emergency during a critical phase of flight in an overweight aircraft close to the ground/water. The handling pilot had had no practice in asymmetric flight in a DC-3 at high gross weight, and probably had never been faced with a situation such as this, which required that he rapidly achieve and then maintain optimum aircraft performance.

The aircraft was in a more favourable configuration than the RAAF and TAA test aircraft in that the landing gear was retracting and the propeller was feathered without delay. As the propeller had stopped rotating despite the blades having stopped short of the fully feathered position, there would have been a negligible drag increase above that of a fully feathered propeller. The aircraft should, therefore, have stood a correspondingly better chance of establishing a positive rate of climb with the remaining engine under full power. That this performance was not achieved was in part probably due to the crew's less than optimal management of the aircraft energy balance following the engine failure.

In summary, the evidence suggests that the three significant factors leading to degraded aircraft performance were: the aircraft's gross weight, the crew's lack of understanding of the single-engine performance capability when operating at high gross weight, and the effect of the co-pilot's handling on the aircraft's climb capability. The net effect of these factors, in conjunction with the airframe condition, resulted in a severe reduction of the single-engine climb capability.

2.3.3 Check and training

The pilot in command, as the DC-3 flight captain, did not establish a check-and-training records system for the co-pilot as required by the operations manual. Consequently, flight crew employed by the operator may have operated the aircraft when not qualified to do so.

No documentary evidence of check and training conducted by the pilot in command was made available to the investigation, other than the co-pilot's instrument rating renewal test form. Prior to conducting takeoffs on commercial flights, the co-pilot was not formally assessed by the pilot in command for competence in EFATO with the aircraft at high gross weights.

2.3.4 Violations

Violations involve deliberate deviations from a regulated practice or prescribed procedure. The evidence obtained during the investigation suggests that active failures in this category contributed to the breaching of system defences in the ways shown in the following analysis.

(a) Co-pilot qualifications

At the time of the accident the co-pilot held a valid Australian commercial pilot licence with a DC-3 type rating. However, the pilot was not able to validate his claimed training for the DC-3 rating. The CAA had endorsed his licence without ensuring that he had completed the required training. Consequently, the co-pilot was probably inadequately trained to perform DC-3 co-pilot or pilot in command duties.

(b) Aircraft overloading

The pilot in command did not ensure that the aircraft weight did not exceed the MTOW. Although he had some doubts concerning the total load, he did not obtain a load sheet, and the freight and passengers were not weighed. The weight of the spare parts, tools and drums of oil was not included when calculating the aircraft take-off weight. Consequently, he was not aware of the degree to which the aircraft was overloaded.

2.4 Preconditions (local factors)

Preconditions are task, situational or environmental factors which may promote the occurrence of active failures.

2.4.1 CAA environment

CAA Moorabbin expedited the commencement of the operation of VH-EDC by permitting operations before a check-and-training organisation had been approved, and sanctioning the operational and maintenance supervision by a chief pilot and an engineering manager, neither of whom had much experience relevant to the operation of DC-3 charter services.

The manner in which the AOC variation approval was granted (particularly with respect to Groupair having little relevant experience), the lack of inspection and surveillance, the minimal co-ordination between the Moorabbin and Bankstown CAA offices, and the provision of an FOI for the operator's check-and-training function, suggest that the CAA's focus may have been towards minimising delay in the commencement of operations rather than ensuring that the operation met, and would continue to meet, safety requirements.

2.4.2 CAA manuals and procedures

The MAOC procedures did not provide adequate guidance for CAA officers when dealing with the proposed commercial operation of a single, transport category aircraft, based and maintained remote from Groupair. Consequently, CAA Moorabbin officers applied a measure of 'discretion' when assessing the inspection and surveillance requirements. However, the procedures used did not ensure that the operation of the aircraft complied with the intent of the MAOC. This is evidenced by the lack of CAA awareness of discrepancies in both maintenance and operational aspects of the DC-3 operation. The failure by CAA officers to conduct an inspection of either operational or airworthiness aspects of the proposed new operation indicates a lack of appreciation of the MAOC guidance in the application of discretion. Volume 1 part A chapter 1 paragraph 1.5 of the MAOC (General Information) stated in part:

> Situations may arise where the certification process can be expedited, based on the past experience of the applicant's personnel, type and scope of operation, and organisational capacities.
>
> However, the applicant must not be certificated under any circumstances, until the CAA is assured that the prospective certificate holder is fully capable of meeting the responsibility for safe operations, and that the company will comply with the Civil Aviation Regulations in a proper and continuing manner.

Inadequate communication and co-ordination within the CAA during development of the requirements for EROPS led to an unclear, conflicting, and poorly cross-referenced CAO and AD. The deficiencies in the presentation of the requirements for EROPS were such that both the operator and an FOI responsible for aspects of the oversight of the DC-3 operation were satisfied that the aircraft was not required to comply. Consequently, the aircraft was committed to a flight to which EROPS regulations applied and for which it was not approved.

2.4.3 Knowledge, skills and experience of CAA officers

(a) AOC assessment

The CAA Moorabbin officers involved in the approval of the variation to the AOC did not show sufficient awareness of the MAOC guidelines. They also appeared to lack knowledge of the requirements for the operation of the DC-3 aircraft type and for aircraft based remote from Groupair. This is evidenced by their acceptance of the proposed operation without inspection of either the aircraft, the aircraft documentation, or the Camden facilities. The incorrect identification of the DC-3 as a 'normal' category aircraft influenced the approach taken by the CAA in approving the variation to the AOC. This is an indication of the lack of appreciation by CAA Moorabbin of the safety implications of the operation of an aircraft of the capacity of the DC-3.

(b) Operations manual

The CAA Moorabbin's acceptance process for the operations manual did not identify the incorrect inclusions, specifically the incorrect performance charts and the contradictory crew procedures instructions. It is likely that the 'acceptance' of the manual rather than 'approval', led to a situation where CAA officers did not recognise the need for verification of the detail of the manual. Moreover, inspection of the manual during surveillance would have detected the incorrect charts and the contradictory procedures issued with the last amendment which had not been incorporated in the copy of the manual held by the CAA.

CAA Bankstown officers were aware that SPA was using incorrect performance charts and incorrect maintenance procedures. They instructed SPA to correct the discrepancies, but the instructions were not complied with. Having given the instructions, the CAA officers did not meet their responsibility to take action to ensure that SPA did comply.

(c) Inspection and monitoring

When assessing the level of inspection required, it is likely that the CAA officers were influenced by the extensive aircraft maintenance management experience of the principal of SPA. They were also aware that he was involved in the development of the manufacturer's DC-3 ageing aircraft program.

However, the CAA may not have recognised that the principal was frequently absent from Australia.

(d) Regulation and policy

The assigned AWI advised SPA that CAA policy precluded the granting of approval for the simultaneous operation, beyond the standard TBO, of both engines of a twin-engine aircraft. However, the CAA did not formally have such a policy, and had not published relevant information for the guidance of either their own staff or the industry.

CAA officers, including an FOI responsible for aspects of the oversight of the DC-3 operation, incorrectly interpreted the intent of a CAO relating to requirements for EROPS. The CAO was misleading, and failed to cross-reference the applicable AD. However, the misinterpretation of the CAO by CAA inspectors indicated a deficiency in the knowledge and experience of CAA staff.

When assessing the application for extension of the TBO for the left engine, senior CAA staff advised that the TBO for an R1830 engine should not be increased. The results of the SOAP analysis were also not supportive of extension of the TBO. However, CAA Central Office approved the application. The evidence indicated that this decision was based on an inadequate assessment of the supporting documentation.

2.4.4 Checking and supervision by the CAA

Although the CAA was asked to vary an existing AOC rather than to approve an additional AOC, the proposal was for the commencement of a new operation, with an aircraft type and certification category new to Groupair. This necessitated operational and maintenance procedures beyond the experience of Groupair.

The CAA had no relevant prior experience with SPA upon which to assess their capacity to meet the requirements for the approval of the variation to the AOC, or for continuing compliance. Groupair was also unable to demonstrate prior competence in the management of commercial operations of aircraft which weighed in excess of 5,700 kg. Further, the proposed DC-3 flight captain, although an experienced pilot generally, had only recently recommenced flying the DC-3 type after a break of about 13 years and required additional training to satisfy the requirements for approval as check-and-training captain. However, CAA Moorabbin did not consider that inspection of the aircraft, its documentation, or the operational base was required prior to approval of the variation to the AOC.

Attempts reportedly made by CAA Bankstown officers to liaise with SPA in order to conduct surveillance on the aircraft and the Camden facility were unsuccessful. However, these attempts were made only on the basis of telephone calls rather than formally addressed correspondence. Further, there is no indication that CAA Bankstown attempted to co-ordinate contact with SPA through Groupair.

2.4.5 Knowledge, skills and experience of the AOC holder and SPA

(a) AOC holder

Groupair was responsible under the regulations for the safety of the DC-3 operation. The CAA established with Groupair and SPA systems for operational and maintenance management. These systems were intended to compensate for Groupair's lack of knowledge and experience in the operation and maintenance of aircraft weighing in excess of 5,700 kg, while ensuring compliance with the terms of the AOC. However, neither Groupair nor SPA ensured that the systems functioned as intended.

(b) SPA

SPA applied for a time extension beyond the TBO for the left engine, using information which indicated that the engine was operating in a distressed condition. The application suggests that SPA had not recognised the risk involved with the continued engine operation. This lack of understanding was further demonstrated when SPA indicated in correspondence to the CAA in March 1994 an intention to seek to have the TBO extended to 1,600 hours.

(c) Chief pilot

The monitoring of the DC-3 operation by the chief pilot was limited to his being advised by the DC-3 flight captain of intended tasks. His location remote from the aircraft's operational base and his exclusion by the executives of Groupair and SPA from the planning and operation of the DC-3 and from receiving advice by CAA Bankstown concerning regulatory deficiencies, contributed to the chief pilot's lack of awareness of the DC-3's operating environment. He did not maintain a copy of the DC-3 operations manual at his base and, as a consequence, was unable to become sufficiently familiar with the DC-3 operational procedures. This evidence indicates that the chief pilot did not recognise that although a DC-3 flight captain had been appointed to accept some operational responsibility, the ultimate responsibility for the safe operation of the DC-3 remained with the chief pilot.

(d) Chief engineer

The engineering manager of Groupair was not familiar with the maintenance requirements of DC-3 aircraft. He was neither included in the planning, nor made aware of the reporting procedure, for the maintenance of VH-EDC. Consequently, he did not exercise any control over, or monitoring of, the maintenance of the aircraft.

(e) Flight crew

The co-pilot's mishandling of the aircraft's flight controls after the engine was shut down is probably directly attributable to his lack of experience and training in similar situations. The pilot in command physically functioned as the support pilot, in accordance with one of the two available crew take-off procedures contained in the operations manual. However, the pilot in command had not ensured that the co-pilot was competent to operate the aircraft at high gross weights from the right control position. The appropriateness of the particular procedure adopted should therefore have been conditional upon the circumstances existing at the time.

Acceptance of the co-pilot's claimed endorsement training by the pilot in command in his role as DC-3 flight captain probably resulted from his perception of an apparently credible existing situation. The co-pilot, as the part-owner of VH-EDC, had been involved in the operation of the aircraft from the time of its purchase. He had flown the aircraft as pilot in command before the DC-3 flight captain became involved. This may have given the impression that he was qualified to fly the DC-3 as either the co-pilot or as the pilot in command.

The crew indicated that they had not received any formal CRM training. Appropriate CRM during the engine malfunction should have led to a more effective response to the malfunction by ensuring the best use of available resources. The use of the operations manual's alternative procedure during takeoff would have enabled the pilot in command to optimise the aircraft's performance, possibly avoiding the need to ditch the aircraft.

The crew displayed a lack of understanding of the link between aircraft weight increase beyond MTOW and increase in the required take-off safety speed. It could be expected that knowledge of this factor would have led the crew to confirm the actual aircraft weight. They would then have been able to properly assess the implications of operating the aircraft with a known overload.

(f) Flight attendant

The flight attendant had not fastened her shoulder harness, and was unable to recall the circumstances in which she had released her lap belt. She had received training which should have been sufficient to enable her to manage the situation with which she was faced. However, the flight attendant had not fully recognised the need to first ensure her own safety in order to be able to fulfil her passenger safety function.

2.4.6 Checking and supervision by the AOC holder and SPA

Groupair had been assessed by the CAA to be competent to ensure the continuing compliance by SPA with operational and maintenance requirements. However, there is no indication that Groupair recognised that under the terms of both the AOC and the maintenance certificate of approval, Groupair was ultimately responsible for safety compliance.

The evidence suggests that Groupair considered that SPA's considerable aviation experience was such that monitoring of the operation was not warranted.

The oversight of maintenance management by Groupair did not eventuate, and the chief pilot's involvement in the management of the DC-3 operation was limited to administrative functions. Groupair did not advise the CAA that the maintenance manager had resigned. Consequently, CAA Moorabbin was not aware that the maintenance management plan was no longer valid.

The use of the existing AOC was probably seen by SPA as a convenient and expeditious means of commencing the DC-3 operation. There was no evidence of a commitment by SPA to ensure that safety monitoring by Groupair was enabled through proper communication and documentation. Consequently, the chief pilot may have gained the impression that he was not expected to assume responsibility for the operation. This is evident from the lack of involvement by the chief pilot in the management of the DC-3 operation, despite being the responsible person designated by the CAA.

The lack of monitoring of the DC-3 operation by Groupair was compounded by the lack of CAA surveillance. Consequently, the CAA was not aware that there was no effective supervision of the DC-3 operation.

2.4.7 Record keeping by the operator

Groupair had not ensured that the DC-3 flight captain had established a formal recording system for DC-3 flight crew qualifications and check and training. Consequently, the investigation could not determine if the DC-3 flight captain established the credentials of pilots used by SPA. There was no evidence available to indicate that he verified the co-pilot's licences or endorsements, or that he was able to operate a DC-3 on one engine at representative weights following an engine failure on takeoff. Neither SPA nor the co-pilot provided documentary records to substantiate that the co-pilot had completed the training necessary to qualify as a DC-3 co-pilot or as a pilot in command.

SPA was operating the aircraft without ensuring that the aircraft maintenance history records were complete and accurate. Consequently, the investigation was unable to identify maintenance performed, or ADs and other requirements complied with during a period of more than 12,000 hours flight time. The available records reflected a lack of diligence in accurately recording maintenance required and maintenance performed.

2.4.8 Operator's manuals and procedures

The failure by the CAA to ensure that Groupair's operations manual was properly assessed for relevance and accuracy provided the opportunity for erroneous material to be used to justify operations of an unsafe nature and for conflicting information to remain in the manual. This is evidenced by the retention in the manual, up to the time of the accident, of non-approved take-off and landing performance charts, and the inclusion of conflicting instructions relating to flight crew procedures when the co-pilot is conducting the takeoff. The use of the approved performance charts would have shown that the proposed charter flight could not comply with either the landing weight or take-off weight requirements at Lord Howe Island.

The inclusion in the operations manual of the procedure adopted by the pilot in command, which permitted the co-pilot to continue to handle the aircraft while the pilot in command performed the support function, was inappropriate. The right control position instrument panel was not provided with flight attitude instruments. Consequently, accurate control of the aircraft in all circumstances when flown from the right control position could not be assured. The pilot in command's use of the procedure on this occasion was also inappropriate, as he had not confirmed that the co-pilot was capable of correctly handling the aircraft from the right control position following engine failure on takeoff with the aircraft at high gross weight.

A proper appraisal of the operations manual should have identified and resolved the conflicting flight crew procedures. The pilot in command would then have been better placed to assess the effect of the engine malfunction on the aircraft performance.

2.4.9 Task performance by SPA

The use of the DC-3 for the charter flight was inappropriate. Had the hirer been quoted a correct load capability, the task should not have been awarded. Use of the correct take-off performance chart clearly precluded operations at Lord Howe Island. However, invalid performance charts were used to justify the operation. In addition, the aircraft did not comply with EROPS requirements.

The load capability quoted by SPA for the flight was significantly overstated. As well as not including the weight of SPA equipment, it also did not include the weights of required emergency equipment, including life rafts. The omission of these items from the aircraft load calculations may have been an oversight. It is also possible that the declared load capability was intentionally overstated.

The operations manual required that the pilot in command should review the weight of any item if there was doubt about the accuracy of the declared weight. Both pilots expressed concern when the passengers and their equipment arrived, and, although a load manifest was not provided, they did not attempt to confirm the weight of the load.

The flight crew may not have been aware of the extent to which the aircraft weight exceeded the MTOW. This is evidenced by their lack of recognition of the need to confirm the aircraft weight or to change their operating procedures during the takeoff. Apparently unaware of the need to increase the take-off safety speed linearly with increase in aircraft weight beyond MTOW, the crew did not recognise that confirmation of the actual aircraft weight was critical. Consequently, the standard take-off safety speed of 81 kts adopted by the crew was not appropriate for the overloaded condition of the aircraft.

The pre-takeoff briefing was general in nature, again indicating that the crew were not aware of the need for an emphasis on particular procedures relating to the effect of high gross weight on aircraft performance.

The investigation team was unable to determine why SPA had not complied with EROPS requirements nor attempted to clarify the intent of the applicable CAO and AD.

2.5 Organisational factors

Organisational factors are weaknesses or inadequacies which are not readily apparent, and which may remain dormant in organisations for extended periods. These latent failures become apparent when combined with active failures, resulting in a breakdown of safety.

2.5.1 CAA procedures (operations and airworthiness)

When assessing operators for approval of variations to AOCs and to certificates of approval, CAA officers were permitted to apply discretionary judgement, and were expected to ‘act in a reasonably flexible manner’ when considering the extent to which the MAOC guidelines should be complied with. CAA Moorabbin established procedures which were intended to ensure that the DC-3 operation complied with regulatory requirements. However, as the officers were not sufficiently familiar with the regulatory requirements for the operation of DC-3 type aircraft, the approach adopted was inadequate.

The CAA management’s monitoring of the performance of officers in the exercise of their regulatory responsibilities was inadequate. CAA management did not ensure that the discretionary powers were appropriately applied and that the intent of the MAOC was achieved.

The CAA failed to restrict use of the information contained on the computerised aircraft register until that information had been audited. Consequently, there was no procedure in place to prevent the CAA Moorabbin Office from using incorrect information to ascertain the maintenance category for VH-EDC.

Groupair submitted, and the CAA ‘accepted’, an operations manual which contained significant errors. These included omissions, inappropriate inclusions (notably aircraft performance charts), and potentially misleading duplications. These deficiencies were either directly related to the justification for the planning of the flight, or were critical to the circumstances of the response to the emergency. At the time of accepting the manual, however, the CAA did not identify these errors.

The CAA procedures or standards for the approval of overhaul time extension of this type of engine were inadequate to ensure that engines approved to continue in service were in fact safe to do so. This is evident by the failure of the CAA to recognise the implications for engine integrity of the SOAP analysis information supplied by SPA, and the limited operational period during which SPA had been monitoring the engine.

2.5.2 Control and monitoring of the AOC holder and SPA

Prior to approval of the addition of the DC-3 type aircraft to the AOC, the CAA was required to establish that the operator had the capability to maintain an acceptable standard of compliance with the regulatory requirements. The MAOC-recommended inspections were not conducted, nor was the NASS applied to the operation to ensure the operator's continuing compliance with required airworthiness standards.

Consequently, CAA Moorabbin did not recognise that the proposed Groupair/SPA structure and facilities were not appropriate for the DC-3 operation. The requirement to ensure that the operator was capable of operating and maintaining the aircraft in the transport category was therefore not met.

The surveillance procedures established by CAA Moorabbin were dependent upon the chief pilot and the engineering manager of Groupair being responsible to the CAA for the operational and maintenance management, although neither had experience relevant to this category of aircraft. These procedures failed when the CAA was not advised that the engineering manager had resigned, and when it remained unaware that the chief pilot was not involved by SPA in other than an administrative capacity.

The low priority afforded by the CAA for surveillance of the operation of VH-EDC was due, at least in part, to there being only one operational aircraft. However, the investigation has been unable to determine why CAA Bankstown, over a period of about 13 months following acceptance of responsibility for airworthiness surveillance, failed to plan any surveillance of SPA's base, even though it was aware of operational and maintenance discrepancies.

The MAOC-recommended inspection of the operator prior to approval of the variation to the AOC would have enabled CAA officers to be sufficiently aware of the proposed operation. This awareness should have identified deficiencies both in the proposed maintenance management structure and in operational aspects. The lack of a surveillance program suggests that CAA management had not ensured that officers recognised the level of responsibility associated with the exercise of discretionary powers.

2.5.3 Communications

(a) Communication and co-ordination between the CAA offices and between the CAA functional branches

This was not effective, as evidenced by the following:

- CAA Central Office did not ensure that all staff were fully aware of limitations on the use of the aircraft register until after an audit could be conducted to qualify and validate the data. They were not aware of the extent to which staff were accessing and applying the unaudited data.
- The CAA had implemented systems and protocols, including the MAOC. However, these systems were not always provided with the means necessary to ensure their effectiveness. This is evidenced by the failure of the officers concerned, and their management, to recognise the potential consequences resulting from the lack of a MOU between the Moorabbin and Bankstown offices.
- There is no record of CAA Bankstown being consulted by CAA Moorabbin concerning the request for the DC-3 Camden-based operation to be included on the AOC of a Melbourne-based company. This was despite the aircraft file being held at Bankstown.

Had this information been provided, CAA Bankstown should have advised CAA Moorabbin of its contact with SPA regarding the maintenance management classification of the aircraft.

- There was a lack of co-ordination between the CAA airworthiness and CAA operational areas when developing or modifying CAOs. This is evidenced by the inadequate cross referencing between CAO 20.7.1B Issue 2 and AD /Gen /69 Amdt 1, 3/90, relating to EROPS, current at the time of the accident. This lack of cross-referencing suggests that there was inadequate communication between the CAA branches during development or modification of operational and airworthiness requirements.

(b) Communications between the CAA and the AOC holder

- The CAA was not aware of the departure of Groupair's engineering manager, without whom the CAA's required DC-3 maintenance management structure was not functional.
- When advising SPA concerning the requirement to use the correct performance charts and maintenance procedures, the CAA did not ensure that Groupair was also advised of the requirements.
- CAA Bankstown experienced difficulty when attempting to co-ordinate, with SPA, surveillance of the Camden facility. This was due, in part, to an inability to communicate with the principal of SPA, who was frequently engaged in aircraft maintenance management commitments overseas. However, there was no record of any formalised communication procedure, or of any attempts by CAA district offices to communicate with Groupair to facilitate access to SPA.

(c) Communications between the AOC holder and SPA

Groupair was unable to meet its responsibilities to the CAA due to an inadequate level of communication with SPA.

- SPA did not advise the chief pilot concerning the CAA requirement to remove the invalid performance charts from the operations manual and to use only the correct charts. Also, Groupair was not aware that the CAA had required that SPA should maintain the aircraft to the transport category standard.

2.5.4 Training of CAA staff

Inadequate training of staff had led to differences in the understanding of, and approach by, CAA officers to industry situations. Consequently, the degree of discretion in the conduct of their duties afforded officers by the Authority, had led to variations in the safety standards applied to industry. This was evidenced by the following:

- A lack of familiarity by CAA staff with requirements both for the commercial operation of DC-3 aircraft and the AOC approval procedures in general, was evident. CAA Moorabbin staff were not sufficiently familiar with the definition and implications of transport-category and normal-category aircraft.
- The CAA had not ensured that staff were adequately trained in the use of the computerised aircraft register database before it became possible to access and use information from the database.
- CAA staff did not recognise the need to refer to available information regarding the aircraft, the facilities, and the operator during the certificate of approval and AOC approval processes.
- The approval process for the variation to the AOC, and the subsequent inadequate monitoring of the operation, suggested that management had not ensured that staff recognised the critical safety function of inspection and surveillance.

- The failure to recognise the safety implications of the left engine SOAP analysis report when approving the engine for a TBO extension, suggested that the CAA staff concerned did not have the appropriate knowledge or experience.
- Individual CAA officers were attempting to apply a more stringent interpretation of CAA policy in the absence of clear guidelines. An example was the lack of guidance on the granting of concessions to concurrently exceed the TBO of both engines on an aircraft.
- CAA Bankstown staff were inadequately trained to assess pilots' qualifications for issue of aircraft ratings. This is evidenced by the issue of a DC-3 type rating to the co-pilot without his production of adequate substantiation of the required training.

2.5.5 CAA regulation and standard setting

- Although the intent of CAO 20.11.5.1.1 may be that only one type of life jacket should be used, this was not specified by the CAO. By not ensuring clarity of intent in the CAO, the CAA had apparently not recognised the potential consequences for passenger safety.
- The published CAA requirements for EROPS, applicable to DC-3 type aircraft, were inadequately presented. This was evidenced by the confusion experienced by both operators and CAA staff in attempting to determine their applicability to the DC-3.
- Acceptance by the CAA of the operations manual failed to identify the incorrect and invalid data and instructions included in the manual. Further, the inclusion in the operations manual, without CAA 'approval', of the flight manual requirements which are normally subject to a CAA 'approval' process, could have directly contributed to the use by SPA of non-approved performance charts to plan the flight.
- The way in which the CAA assessed applications for engine TBO extension was deficient. This was evidenced by the apparent lack of recognition by the CAA of the importance of the SOAP report, and of the limited time during which SPA had been monitoring the engine.

2.5.6 SPA's training

SPA did not maintain adequate check-and-training records. Consequently, the actual training conducted could not be verified.

Since becoming a DC-3 crew member, the co-pilot had not been required by the pilot in command, as DC-3 flight captain, to demonstrate aircraft handling ability other than during a command instrument rating test, reported to have been conducted about four months prior to the accident. There was no evidence that the co-pilot had previously experienced asymmetric operations in DC-3 aircraft at high gross weight, or when operating the aircraft from the right control position.

Following the engine malfunction, the co-pilot handled the aircraft controls inappropriately, suggesting a misunderstanding of DC-3 aircraft asymmetric handling technique. He was unable to substantiate completion of the training required by the CAA to qualify for issue of a DC-3 rating.

2.5.7 Operator's maintenance management

When the maintenance management structure notified by Groupair to the CAA failed, due to the resignation of the Groupair chief engineer, no apparent attempt was made by either SPA or Groupair to rectify the deficiency.

SPA's procedures were inadequate to ensure that maintenance records were correctly annotated and maintained. The aircraft logbooks did not adequately reflect the maintenance status of the aircraft. The logbooks contained certifications for procedures which had not been completed, and some maintenance procedures reported by SPA to have been performed were not recorded. Further, SPA had not ensured that the aircraft maintenance history was properly verified, as it was unable to substantiate maintenance certification for the period June 1977 to May 1988.

The overrun of the left engine TBO also reflected SPA's inadequate maintenance management procedures. The current maintenance release was not annotated to indicate to flight crew the aircraft hours to which the engine was life limited. Consequently, the flight crew were not alerted as to when the engine had reached its approved life.

The identified deficiencies in the maintenance and installation of seat belts and seat fittings indicated inadequate qualified supervision by both SPA and Groupair. The failure of the maintenance management structure and the lack of maintenance supervision by Groupair suggested that Groupair considered that all it was expected to do was to facilitate the CAA approval of the DC-3 operation.

2.5.8 Operator's procedures (operations and maintenance)

Groupair may not have fully understood the implications for the management of a commercial DC-3 operation remote from its main base. They did not implement procedures to ensure that the nominated managers, despite lacking DC-3 experience, could exercise an effective monitoring role. That this did not occur is evident from the virtual isolation of Groupair's nominated managers from the operational and maintenance control of the DC-3 operation.

The lack of an effective DC-3 operational safety and supervisory structure within Groupair was responsible for a number of the operational failures identified by the investigation. The appointment of a DC-3 flight and check-and-training captain, of itself, was not sufficient. The chief pilot, in order to meet his responsibilities, needed to be more closely involved in the operational planning for the DC-3. Similarly, the CAA-approved maintenance management structure was not recognised by Groupair to be essential to meeting its maintenance management responsibilities.

SPA was aware that the aircraft maintenance procedures were required to comply with transport category standards. It was also aware that the operations manual contained invalid data. However, SPA had not corrected either deficiency prior to the accident.

The adoption by the pilot in command of the operations manual procedure which permitted the co-pilot to continue as the handling pilot following an engine failure during takeoff, was not sound. The pilot in command was significantly more experienced than the co-pilot, and the right control position was not equipped with flight attitude instruments. The alternative procedure ensured the best use of available crew resources and was therefore more appropriate to the circumstances of the takeoff on the accident flight.

2.6 Summary

The origin of the defect determined to have most likely caused the left engine malfunction could not be established. However, an appropriate response by the CAA to the left engine condition information should have prevented further operation of the engine.

As the aircraft was heavily loaded, the pilot in command had the option of conducting the takeoff himself to ensure that the aircraft performance was maximised. However, he not only permitted the inexperienced co-pilot to conduct the takeoff, but also chose not to follow through on the controls. Consequently, when the engine malfunction occurred, the pilot in command did not immediately take over control of the aircraft. He assessed that the engine should be shut down and carried out the appropriate checklist actions. Further, following the engine shutdown, the pilot in command did not respond to the inadequate aircraft handling by the co-pilot until the only option available was to ditch the aircraft.

The success of the subsequent ditching by the pilot in command resulted in minimal injuries to the passengers and crew. Preventable injuries were sustained by some crew members who chose to not use the full restraint harnesses provided.

The timely rescue of the aircraft occupants was facilitated by the calm waters of the bay and the presence nearby of a number of small pleasure craft and a volunteer coastal patrol vessel.

3. CONCLUSIONS

3.1 Findings

1. The pilot in command was correctly licensed and endorsed.
2. The aircraft part-owner/co-pilot applied for and was granted a DC-3 type rating, despite not being able to substantiate completion of the required training.
3. The pilot in command, as check-and-training captain, had not adequately confirmed the status or capabilities of the co-pilot in the response to an EFATO at high weights or as the pilot flying from the right control position.
4. The chief pilot did not adequately supervise the DC-3 operation.
5. The DC-3 operations manual contained conflicting instructions relating to crew procedures when the co-pilot was the handling pilot during takeoff.
6. SPA was aware that the operations manual contained a non-approved performance chart. Although directed to do so by the CAA, SPA had not removed the chart.
7. The invalid take-off performance chart was used by SPA to successfully bid for a task for which the DC-3 was not suited.
8. SPA provided the charterer with an incorrect load capability.
9. The pilot in command did not verify the weight of the load prior to departure.
10. The flight crew were not aware that if the aircraft weight exceeded the MTOW, the take-off safety speed would need to be increased.
11. The pilot in command did not initially take over the controls following the engine malfunction.
12. The co-pilot was inadequately trained to respond appropriately to the loss of aircraft performance following the engine malfunction.
13. The left propeller did not fully feather; however, the blade angle achieved was sufficient to stop rotation of the engine.
14. Degradation of the aircraft's performance was consistent with the overloaded condition of the aircraft, mishandling of the flight controls, and the inability of the propeller to feather fully.
15. The pilot in command resumed control and ditched the aircraft adjacent to the southern end of the third runway.
16. The CAA documentation on EROPS was unclear and ambiguous.
17. The CAA did not ensure that the aircraft was maintained in accordance with the requirements of the transport category.
18. Compliance with relevant airworthiness directives could not be verified due to missing aircraft maintenance records.
19. The left engine malfunction was most likely due to the incorrect assembly of the no. 3 cylinder inlet valve rocker mechanism which allowed a thrust washer to jam the valve open.
20. SPA applied for, and was granted, an extension of the TBO for the left engine based, in part, on test results that indicated that further engine inspection was warranted.
21. The flight attendant was qualified for the operation.

22. At the time of impact, the flight attendant was not wearing a restraint harness, and the pilot in command and co-pilot were not wearing shoulder restraints.
23. The flight attendant was unable to direct the evacuation of the aircraft due to the severity of her injuries.
24. All three flight crew members received minor head injuries.
25. Three seat rows detached from the outboard seat rail during the impact. All were inadequately secured prior to the flight.
26. One seat belt detached from the seat structure and three further belts were not correctly secured.
27. Five different types of life jacket were carried on the aircraft.
28. The co-pilot egressed through the cockpit overhead hatch and all other occupants egressed through the main rear door.
29. The operations manual did not detail the duties to be undertaken by the flight attendant in an emergency and did not adequately address the evacuation of passengers.
30. The ATC, RFFS, FAC, NSW Ambulance, NSW Fire Brigade and NSW Police response was satisfactory and in accordance with the AEP.
31. Passengers and crew were transferred to two separate locations on land by some of the many pleasure craft using Botany Bay at the time of the accident.
32. Following the accident, confirmation of the actual number of persons onboard the aircraft took approximately one hour.

3.2 Significant factors

The following factors were considered significant in the accident sequence.

1. Compliance with the correct performance charts would have precluded the flight.
2. Clear and unambiguous presentation of CAA EROPs documentation should have precluded the flight.
3. The aircraft weight at takeoff exceeded the MTOW, the extent of which was unknown to the crew.
4. An engine malfunction and resultant loss of performance occurred soon after takeoff.
5. The operations manual take-off safety speed used by the crew was inappropriate for the overloaded condition of the aircraft.
6. The available single-engine aircraft performance was degraded when the co-pilot mishandled the aircraft controls.
7. The pilot in command delayed taking over control of the aircraft until the only remaining option was to conduct a controlled ditching.
8. There were organisational deficiencies in the management and operation of the DC-3 involving both Groupair and SPA.
9. There were organisational deficiencies in the safety regulation of both Groupair and SPA by the CAA district offices at Moorabbin and Bankstown.
10. There were organisational deficiencies relating to safety regulation of EROPS by the CAA.

4. SAFETY ACTIONS

Classification of responses

The Civil Aviation Safety Authority and Airservices Australia respond to the Bureau's formal recommendations in accordance with a memorandum of understanding. Although no formal procedures are in place for other respondents to Bureau recommendations, the expectation is that responses will be received from all recipients.

Responses are considered against the occurrence report and/or the recommendation text and an assessment is made as to the acceptability of the response. These assessments do not necessarily indicate whether or not a particular recommendation has been accepted by the action agency, either fully or in part, but that the agency has:

- considered the implications of the recommendation;
- correctly recognised the recommendation's intent without misinterpretation;
- offered, if applicable, acceptable counter-arguments against implementation; or
- offered an alternate means of compliance; and
- identified, if appropriate, a timetable for implementation.

Responses are classified as follows:

(i) CLOSED – ACCEPTED. The response is accepted by the Bureau without qualification.

(ii) CLOSED – PARTIALLY ACCEPTED. The response, in part, is accepted by the Bureau. The unacceptable part is not worthy, by itself, of further correspondence.

(iii) CLOSED – NOT ACCEPTED. The unacceptable response has been closed by the Bureau as not worthy, by itself, of further correspondence.

(iv) OPEN. The response does not meet some, or all, of the criteria for acceptability to a recommendation which BASI considers safety significant and further correspondence will be entered into.

Safety advisory notices do not require a response. Any received by the Bureau are published but not classified.

Safety outputs

Bureau safety outputs appear in bold. They are reproduced from original Bureau documents and may vary in textual layout.

Response text

Response text appears in italics and is reproduced as received by the Bureau.

4.1 Interim recommendations

During the course of this investigation a number of interim recommendations (IRs) were made to the then CAA. The IR documents included a 'Summary of Deficiency' section in addition to the actual interim recommendation. The text of the interim recommendations is detailed below, with each IR commencing with its BASI reference number. The pertinent comments from the CAA in response to the recommendations are also reproduced.

IR940186 The Bureau of Air Safety Investigation recommends that the CAA review its procedures with respect to the notification of people on board to ensure that the information supplied is timely, accurate and credible.

CAA response:

The current wording of AIP OPS FPLAN-6 provides the trigger for pilots to supply amended persons on board (POB) numbers to ATS.

To modify the requirement for all flights from "should notify" to "must notify" changes to the previously supplied POB figures would impose a number of practical difficulties and workload considerations on both the industry and the Authority. Whilst it would impose an increase in workload for departures from a control zone, it would impose additional reporting and equipment requirements on VFR flights departing aerodromes outside controlled airspace who have notified details but which may or may not carry radio.

IFR flights currently have a requirement to notify ATS of their movements for traffic and SAR alerting purposes. The additional notification of POB carried by IFR operations for each flight stage would probably not have a marked effect on ATS workload.

In recognition of the Bureau's concerns regarding the notification of POB, the Authority is processing an amendment to AIP OPS FPLAN-6 to reflect the notification of POB by altering the table at paragraph 4.1 to delete (j) and to substitute alternate text in lieu as a new paragraph 3.5.

"3.5 In addition to including POB numbers with the flight notification, pilots of IFR flights operating as other than RPT must notify ATS, on first radio contact, of the number of persons on board for each flight stage.

3.5.1 Pilots of flights operating as RPT must ensure a suitable passenger manifest is held by the company, detailing POB for each flight stage. Notification of changes may be made to ATS where it is impracticable for the pilot to provide notification of amendments to the company.

3.5.2 Pilots of VFR flights must include POB when submitting flight notification or when leaving a flight note and are encouraged to notify ATS of any subsequent changes."

Response classification: CLOSED – ACCEPTED

IR940256 That the Civil Aviation Authority review the accuracy of the Aircraft Register computer database and the procedures for issuing duplicate Certificates of Airworthiness or other information from that source.

CAA response:

This Authority has considered the Interim Recommendation and a review of the Aircraft Register data base and procedures for issuing information will be conducted.

Response classification: CLOSED – ACCEPTED

IR940258 That the Civil Aviation Authority ensure that the procedures of the ASSP surveillance system are specific enough to ensure that:

(a) the areas of responsibility and surveillance control between regional offices, for Certificate of Approval holders who operate interstate are defined; and

(b) the responsibilities for initiating the surveillance plan and process are conducted in a timely manner when it becomes apparent that the surveillance task for a particular Certificate of Approval holder crosses 'state or jurisdiction boundaries'.

CAA response:

I refer to BASI Interim Recommendation R940258 regarding surveillance of a "new" operator.

Under the Aviation Safety Surveillance Program (ASSP), the controlling District Office (Moorabbin) is required to ensure a surveillance program has been prepared for the Camden location by the conducting office (Bankstown).

The conducting office would have final responsibility for planning and conducting the surveillance at the Camden location and would be required to provide a copy of their surveillance plans and a copy of their surveillance results to the controlling office.

As part of the ongoing improvement to ASSP, the latest amendment due to be incorporated in the ASSP Manual in November 1994 will specify the requirements and responsibilities outlined above in more detail via a memorandum of understanding between the controlling and conducting office.

Response classification: CLOSED – ACCEPTED

IR940260 That the Civil Aviation Authority:

(a) consider the mandatory, phased introduction of the loose leaf logbook to replace those older logbooks which, due to the passage of time, have become obsolete and provide inadequate records of a continuing airworthiness and history audit trail;

(b) ensure that future recipients of an aircraft coming from airline type service are required to address the issue of continuity of records, prior certifications for ADs and component changes, establish the time-in-service of lifed components and provide a compliance statement for the logbooks which can be easily verified during the surveillance process; and

(c) ensure that current owners of aircraft which were previously in airline service, or which had previously been maintained to an approved system of maintenance which did not require the use of the aircraft and component logbooks, review their maintenance records to ensure continuity and validity with respect to mandatory requirements.

CAA response:

The Authority shares your concerns regarding the record keeping and retention aspects associated with the maintenance of VH-EDC. Shortcomings in the style of logbooks for various classes of aircraft are also recognised.

It is not intended at present, however, to mandate the use of the "loose leaf" log book in that it is not suitable in all respects for all aircraft. A new light aircraft log book is being developed to be used for light aircraft.

Legislation is being developed to strengthen the requirement for better airworthiness record control which will include consideration of continuity from one type of service to another.

Response classification: CLOSED – ACCEPTED

IR940296 The Bureau of Air Safety Investigation recommends that the Civil Aviation Authority ensure that Company Operations Manuals, in addition to meeting the requirements of CAO 40.1.0, contain procedures which will ensure that co-pilots being tasked with flying sectors have attained a recognised proficiency level to conduct take-off and landings, including practice engine failure and handling, prior to them flying aircraft on passenger carrying operations.

Note: This could well be addressed by review and amendment to CAO 40.1.0 such that co-pilots, prior to conducting sector flying, must comply with the training requirements of appendix 3 (d).

CAA response:

See IR 940297

IR940297 The Bureau of Air Safety Investigation recommends that the Civil Aviation Authority review CAO 40.1.0 appendix III to require that asymmetric flight training, in aircraft above 5,700 kg and where a simulator is not available, include at least one takeoff, with a practice engine failure, at 90% of maximum take-off weight or equivalent simulated conditions.

CASA response:

I refer to Interim Recommendations IR940296 and IR 940297 regarding the accident involving VH-EDC Douglas Aircraft DC3 on 24 April 1994.

Summary

The Authority supports BASI Interim Recommendations IR940296 and IR940297. As a result, Flight Crew Licensing Section of the Branch has given utmost priority to a new project titled 'Review of Multi-engine Aeroplane Endorsement Training Requirements'.

Background to response

Briefly, some of the proposals under consideration as part of this review include (by way of amendments to CAO 40.1.0):

a. *requiring that an endorsement must be conducted with the endorsee in the seat s/he is expected to occupy in his/her duties;*

b. *define some limitations on the role of the pilot who has been trained in accordance with App V only, for example a pilot who has been endorsed in accordance with App V will not (except in the event of captain incapacitation) conduct the takeoff or landing if passengers are carried;*

c. *affirm that copilot endorsement training time (3 hours) cannot be used as a credit towards the 5 hours training time required for a command endorsement;*

   (It would follow that an operator would probably elect to give a new endorsee a command endorsement rather than a copilot. If the employer intended the pilot to fly as copilot, then the endorsement would be done in the RH Seat with the benefit of now having a copilot trained to the command syllabus. That pilot could subsequently be transferred to the LH Seat by way of ICUS. At the very least it would result in copilots that have at least seen and practised engine failures at the critical phase);

d. *provide guidance to training captains on requirements to demonstrate or train for near gross weight emergencies;*

   (This could be accomplished by either requiring the aircraft to be ballasted or to operate the aircraft at an established training (reduced) power that would demonstrate performance at or near the minimum requirements of CAO 27.1.b).

e. *amendment of CAO to impose the following limitation on the holder of a copilot endorsement 'prior to conducting takeoff or landing with passengers embarked, a copilot shall be trained in accordance with the requirements of CAO 40.1.0 App III' (As a compromise if needed, training to App III(d) may satisfy);*

f. *require training to be conducted in accordance with a flight test report form, which must be submitted to CASA on succesful completion lof training;*

g. *for aeroplanes less than 5,700 kg specify minimum hours requirements for training depending on aeroplane sophistication, speed, powerplant etc;*

h. *publish and require adherence a multi-engine endorsement syllabus of training for first multi-engine type endorsement.*

Response classification: CLOSED – ACCEPTED

IR940298 The Bureau of Air Safety Investigation recommends that the Civil Aviation Authority:

(i) Review the standard of operations manuals, in respect to CRM, to ensure that aircraft operating with two crew have crew resource management procedures established, and documented, for the type of aircraft being operated and that crews receive adequate training in CRM.

Note: This is particularly relevant to older/vintage type aircraft operations.

(ii)Consider an additional training requirement to enable takeoffs and landings to be carried out safely from the right seat of aircraft in which there is limited flight instrumentation on the co-pilot side.

CAA response:

I refer to Air Safety Interim Recommendation No IR940298 regarding the accident involving VH-EDC on 24 April 1994.

In response to the Bureau's recommendation, we offer the following comment:

(i) Crew Resource Management (CRM) procedures and training are not mandatory requirements for any operations by Australian flight crews. Consequently, operators are not required to have CRM procedures in their operations manuals.

Except for this incident, there have been no surveillance reports to indicate that existing multi-crew operating procedures are deficient. In view of this, a widespread review of multi-crew operating procedures is not considered justified at this stage. Nevertheless, action will be taken to review multi-crew operating procedures in older/vintage aircraft.

Recent overseas studies have identified CRM as being crucial to the safe operation of multi-crew aircraft. The CAA is reviewing these studies to determine whether CRM should be a mandatory training requirement.

(ii) The CAA will also review the training requirements for multi-crew aircraft where take-offs and landings are performed from the right seat, and where there are deficiencies in aircraft instrumentation on the co-pilot's side.

Response classification: OPEN

IR 940301 The Bureau of Air Safety Investigation recommends that the Civil Aviation Authority review CAO 20.11.14.1.3 with a view to ensuring that safety briefing cards present information to passengers in the most effective manner.

CAA response:

I refer to BASI Air Safety Interim Recommendation IR940301 regarding the accident involving

VH-EDC at Botany Bay on 24 April 1994.

The Bureau's recommendation that the Authority review CAO 20.11.14.1.3 in relation to the presentation of passenger briefing cards is supported.

CAO 20.11.14 is currently being reviewed and the required information and manner of presentation of the brace position on these cards will be updated to ensure that the cards provide the appropriate information to passengers.

Response classification: CLOSED – ACCEPTED

4.2 Safety advisory notices

The following safety advisory notices were issued:

SAN 940299 That the Civil Aviation Authority consider the publication of information to the industry identifying:

(i) details of this incident where abnormal wear of driving gear splines remained undetected;

(ii) the need for continued vigilance when carrying out magneto timing and synchronisation checks of P&W R1830 series engines;

(iii) the importance of magneto driving gear spline inspection and re-lubrication whenever magnetos are removed and splines exposed during in-service maintenance; and

(iv) the requirement to document and certify for component removal and replacement.

CAA response:

The Authority concurs with the suggestions contained in the Safety Advisory Notice.

Information will be issued to all operators of Pratt and Whitney R1830 engines concerning the technical aspects of the Bureau's findings as a result of the incident investigation.

A copy of this advice will be forwarded for your information.

SAN 940302 It is apparent that the orders relating to the carriage of life jackets are open to interpretation. As a result there is a potential to degrade the level of safety afforded to passengers.

CAA response:

It is considered that the carriage of numerous types of lifejackets in the one aircraft is undesirable and a potential safety hazard.

The Authority will review the Order relating to the carriage of lifejackets in order to rectify the problems encountered.

4.3 Safety action taken

Water rescue services

In November 1993, the CAA made the decision to introduce inflatable rubber dinghies in order to facilitate the first stage of rescue actions at RFFS-serviced aerodromes near water. The dinghies would be used to transport life rafts to survivors within 1 km of the runway. This would allow survivors to be removed from the water in the most expeditious manner possible. The second stage of the rescue would be performed by other agencies such as the Water Police, MSB and Coast Guard.

The first airport to be provided with such facilities was Hobart. This was intended to be followed by Sydney, with two boats expected to be operational by September 1994. Brisbane, Coolangatta, Mackay and Cairns were also proposed as possible sites. The RFFS initiated a project in November 1993 to provide water rescue services within 1 km of the end of runways near water at RFFS-serviced aerodromes.

The performance code to which the DC-3 operates is one which evolved over a number of years.

The performance code developed for Australian requirements considers a number of factors, including take-off distance, take-off climb with one engine inoperative, stalling speeds in various configurations, minimum control speeds and accelerate stop distances.

Accountable variables allowed for are aircraft gross weight, aerodrome pressure altitude, temperature, wind, runway effective operational length and runway slope.

To operate the aircraft to its best advantage, the crew must be aware of the performance code and its requirements and be able to manipulate the aircraft in such a manner as to comply with the procedures which are intended to ensure safety. To accomplish this, a list of emergency and normal procedures covering the various aspects of the code should be provided in the operations manual and these procedures must be well known and their relationship to the code appreciated.

The performance code: definitions

Critical or decision speed (V_1)
That speed during takeoff at which the critical point is reached on the runway where, in the event of a failure of one engine, the takeoff can be continued and a climb to 50 ft made by the end of the runway, or the takeoff abandoned and the aircraft brought to rest on the runway. The critical distance is reached with both engines developing full power.

Minimum control speed in flight (V_{MCA})
The minimum speed in flight at which control is available in the asymmetric take-off configuration, or when in this condition 180 lb of foot pressure on the rudder is reached. In the case of the DC-3, the latter applies and this speed is 73 KIAS at sea level.

Stalling speed in the configuration under consideration (V_{s1})
In the case of a DC-3 on takeoff, gear down flaps up, power off. This speed is 67 KIAS at MTOW (26,200 lb, 11,884 kg).

Take-off safety speed (V_2)
In the case of a twin-engine aircraft, $V_2 = 1.1\ V_{MCA}$ or $1.2\ V_{S1}$, whichever is the greater. This is a margin of safety above minimum control and stall speeds.

Because in the DC-3 the distance needed to climb to 50 ft is greater than the distance to stop, $V_1 = V_2$ and this value is 81 knots.

Stalling speed in the landing configuration (V_{so})
In the case of a DC-3, gear down, full flap, power off. This speed is 59 KIAS at MTOW.

Take-off climb
The climb profile from the point at which engine failure occurs to the point at which transition to either en-route climb or circuit is made.

The take-off climb is divided into four segments:

Segment 1
Conditions: One engine inoperative, propeller controls in take-off position, propeller windmilling, take-off power on operating engine, zero flap, gear extended, ISA, out of ground effect, speed not below V_2.

Requirements: 50 ft/min.

Segment 2

Conditions: One engine inoperative, propeller windmilling, gear retracted, take-off power on operating engine, speed not below V_2.

Requirements: $0.035V_{s1}^2$ ft/min.

Segment 3

Conditions: Propeller on inoperative engine feathered, take-off power on operating engine. Note: One-minute limit at take-off power on operating engine.

Requirements: Climb established. Speed not less than V_2 not more than best rate of climb speed.

Segment 4

Conditions: METO power on operating engine. Requirements: Climb established at best rate of climb speed. Accountable variables are aerodrome elevation and aircraft gross weight.

Takeoff

The performance code envisages that a full power failure of one engine may occur during any part of the takeoff in varying atmospheric conditions and that the critical engine may be the one which fails.

The performance chart shows the maximum weight which is allowable for takeoff under varying atmospheric conditions. The procedure covers the code in the event of a power failure occurring anywhere during the takeoff, and the code provides safety in allowing for an abandoned or continued takeoff with adequate field length and terrain clearance.

The concept for the DC-3 takeoff is that $V_1 = V_2$ for all weights, atmospheric conditions and runway EOLs as provided for in the P-chart. This means that at the critical point on takeoff, when V_1 is reached the take-off safety speed is also reached and the flight can safely proceed.

The correct procedure is clearly laid down and should be considered by every pilot before every takeoff, and his/her expected reaction firmly established in mind, so that in the event of a power failure on takeoff the correct procedure is adopted and the takeoff abandoned or continued safely.

Take-off climb

Inspection of the performance code conditions and requirements show that if these conditions are met the aircraft is required to perform to a certain minimum standard. It should also be appreciated that, if some of the conditions are not met, a serious doubt must exist as to whether the aircraft will climb at all. Two of the conditions which are most important are the retraction of the landing gear and control of airspeed. The importance of these two items cannot be overstated.

The procedure covers the code, and some techniques such as the instrument takeoff qualify it further. On an instrument asymmetric takeoff the technique of waiting until climb is indicated on the altimeter before selection of the landing gear up ensures that the climb is established as required in segment 1, and attention to the airspeed at this time ensures that the take-off climb is entered correctly. Feathering of the propeller and closing down the engine by moving the mixture control to idle cut-off completes the clean-up process and all that remains is selection of the correct speed for climb-out and reduction of power to METO.

The DC-3 is certified with a full power limit on the operating engine of five minutes. The only acceptable case where this limitation may be exceeded is where the safety of the flight depends on it.

In this code, all stall speeds are expressed in knots. Taking the stall speed V_{s1} for 11,884 kg MTOW as 67 KIAS, the rate of climb expected is 208 ft/min.

As the gross weight decreases, the climb requirement decreases but the aircraft climb capability increases and this automatically gives greater terrain clearance.

The climb immediately after takeoff is divided into four segments. The climb ability depends upon aerodrome elevation, temperature, aircraft weight and configuration. The climb requirements, however, are related to standard temperature capabilities which allow sufficient margin for performance variation due to other possible temperatures. The take-off chart ensures that at least the required 50 ft/min is available after takeoff and climb limitation on weight specifies the $0.035V_{s1}^2$ second segment requirement. If the DC-3 aircraft is operated by adhering to the 2.5% E.O.L. gradient in AIP/AGA and the climb weight limit delineated on the take-off weight chart, then take-off and en-route climb performance will be met.

Performance charts

A performance chart is a graphical representation of the performance of an aircraft, measured in terms of maximum gross weight for takeoff and landing, in varying aerodrome conditions and at varying aerodrome elevations.

In the original American code, some of the variables were not accounted for and this gave a false performance indication, particularly in the case of temperature as this is one factor in ambient conditions which has a considerable effect on the ability of the aircraft to perform. It was realised in this country that the standards as laid down by the American code were inadequate and amendments were made to it in the interest of a conservative approach to performance.