INVESTIGATION REPORT

Embraer EMB-110-P1
Bandeirante DQ-AFN

24 July 1999

Delailasakau
Republic of the Fiji Islands

FOREWORD

This report completes the investigation into the circumstances of the accident involving an Embraer Bandeirante aircraft, registered DQ-AFN, operated by Air Fiji. The accident occurred 41 kilometres west of Nausori Airport, Fiji Islands on 24 July 1999, with the loss of 17 lives.

The Republic of the Fiji Islands is a Member State of the International Civil Aviation Organisation (ICAO). Therefore, the investigation was conducted and this report prepared in accordance with international standards and recommended practices as published in Annex 13 to the Convention on International Civil Aviation Aircraft Accident and Incident Investigation. The investigation was carried out by staff from the Australian Transport Safety Bureau, formally the Bureau of Air Safety Investigation, on behalf of the Civil Aviation Authority of the Fiji Islands.

The investigation team wishes to thank all those who provided assistance and cooperation during the investigation, especially those of the Fiji Islands, without whose help our task would have been immeasurably more difficult.

16 December 1999

CONTENTS

TERMS AND ABBREVIATIONS

ATC	Air Traffic Control
CAAF	Civil Aviation Authority of Fiji
CPL	Commercial Pilot's Licence
CRM	Crew Resource Management
ELT	Emergency Locator Transmitter
GPS	Global Positioning System (a satellite-based navigation system)
ICAO	International Civil Aviation Organisation
SAR	Search And Rescue

INTRODUCTION

The main purpose of air safety investigation is to prevent aircraft accidents by determining the significant contributing factors and then taking measures to prevent a recurrence by improving safety defences. Experience has shown that occurrences are rarely the result of a single failure, but are most likely to be due to a combination of a number of factors, any one of which by itself being 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, this sequence of factors may be sufficient to result in a safety hazard. Should the safety defences be inadequate, a safety incident or accident 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 in 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

The crew was conducting a regular public transport flight, PC121, in an Embraer Bandeirante aircraft. They departed Nausori for Nadi at 0525 on 24 July 1999, Fiji time. At 0533, the crew advised Nausori Air Traffic Control (ATC) that they were maintaining 6,000 feet and on the direct track. Nausori ATC instructed the crew to contact Nadi ATC at 0535. When the crew did not contact Nadi ATC at 0535, Nadi ATC attempted to contact the crew, discussed the issue with Nausori ATC, and asked another aircraft to attempt to contact PC121.

A resident of Delailasakau village reported observing an aircraft and hearing the sound of an explosion shortly after 0530. At 0700, Nausori ATC advised Nadi ATC that a witness had reported that an aircraft had crashed about 3 kilometres from Delailasakau. The police were advised at 0731. During the preceding two hours ATC had attempted to contact the crew but did not initiate a distress phase. At 0758, an an Air Fiji pilot instigated a search for PC121 and located the aircraft wreckage, at 0816, on the south-eastern slope of a ridge about 41 kilometres west of Nausori.

The aircraft had broken up and impacted the eastern and western sides of the ridge. Subsequent investigation revealed that the aircraft was operated within its weight-and-balance limitations and was being maintained in accordance with the manufacturer's requirements. No evidence was found of any fault in the aircraft that may have contributed to the accident.

It was subsequently established that the pilot-in-command had insufficient rest prior to the flight and had taken medication, which may have further degraded his ability to safely pilot the aircraft.

Examination of company documentation indicated that check-and-training records were not appropriately maintained. Air Fiji pilots interviewed during the investigation demonstrated a low level of skills and knowledge regarding the operation of the Bandeirante aircraft type and a lack of adherence to standard operating procedures. Deficiencies were also found with the level of surveillance conducted by the Civil Aviation Authority of Fiji.

1. FACTUAL INFORMATION

1.1 History of the flight

On Saturday 24 July 1999, at 0525 hours Fiji time, an Embraer Bandeirante, PC121, departed Nausori for Nadi with a planned flight time of 25 minutes. A witness at the airport reported that after departure, the aircraft initially diverged to the right of the direct Nausori–Nadi track, but was later seen to make an apparent correction. At 0526, Nausori Air Traffic Control (ATC) advised Nadi ATC of the departure of PC121, and to expect the crew to contact them at 0535. At 0532, the crew advised Nausori ATC that they were 14 nautical miles from Nausori and passing through 5,500 feet. At 0533, the crew advised Nausori ATC that they were maintaining 6,000 feet and on the direct track. Nausori ATC responded and instructed the crew to contact Nadi ATC at 0535.

When the crew of PC121 did not contact Nadi ATC at 0535, Nadi ATC contacted Nausori ATC to ascertain if there had been any further contact with the crew and were advised that there had not been.

Nadi ATC attempted to contact the crew at 0543. However, the crew of PC123, who had departed Nausori for Nadi at 0535, responded. At the request of Nadi ATC, the crew of PC123 attempted unsuccessfully to contact PC121. Nadi ATC then requested that the crew of PC123 monitor transmissions on the emergency frequency, which would include emergency locator transmissions. No transmission was received. The ATC staff at Nausori later commented that because a transmission from an emergency beacon was not received by the crew of PC123, the ATC staff assumed that the aircraft had not crashed but was either continuing onto Nadi or returning to Nausori.

A resident located 1 kilometre north of the direct Nausori–Nadi track and about 13 kilometres east of Delailasakau village reported seeing an aircraft at 0529. He estimated that the aircraft was probably at an altitude of about 4,000–5,000 feet and flying in a north-westerly direction. Although he considered the engines to be very noisy, the aircraft appeared to be flying normally.

Shortly after 0530, a resident of Delailasakau village reported hearing an aircraft that sounded closer than normal, with an unusual engine sound. The resident then went outside and observed an aircraft until it disappeared from her field of view. Several seconds later, she

observed a bright flash and then heard the sound of an explosion. The resident began to wake people in the village and ran to the next village to wake the radio operator to report the aircraft accident.

ATC records show that at 0700, a telephone call was received by Nadi ATC from Nausori ATC stating that a witness had reported, by radio telephone, an aircraft crash about 3 kilometres from Delailasakau. Police records indicate that an airport security guard advised the police of the accident report at 0731. At 0758, an Air Fiji pilot instigated a search for PC121. At 0816, the crew of the search aircraft reported that they had located aircraft wreckage.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	2	15	-

1.3 Damage to aircraft

The aircraft was destroyed.

1.4 Other damage

Damage was confined to natural vegetation.

1.5 Personnel

	Pilot-in-command	**Co-pilot**
Age	26	25
Licence category	Commercial pilot's licence	Commercial pilot's licence
Medical certificate	Current	Current
Instrument rating	Command (multi-engine)	Command (multi-engine)
Total hours	4,500	1,616
Total command	2,000	126
Total on type	1,000	400
Total command on type	1,026 (until April 99)	0 (not command endorsed)
Total last 364 days	900	930
Total last 28 days	80	80
Total last 7 days	18	20
Time off last 7 days	2	2
Last check on type	24 April 1999	10 March 1999

1.5.1 Previous 72-hour histories

Pilot-in-command

The pilot-in-command had driven to Nadi the day before the accident and rested at a relative's house from 1600 until meeting a friend arriving on an international flight at 2000. The two

returned to Suva by car, a drive of about 3 hours, and spent time together until 0200, on the morning of the accident.

A colleague drove the pilot to work shortly after 0430 and later advised that his colleague appeared quieter than usual. On arrival, the pilot did not attend to flight-planning duties but went straight to the aircraft.

Close relatives of the pilot reported that he appeared to be in good health. However, a toxicology test of the pilot revealed 0.03–0.05 milligrams/Litre (which is above therapeutic levels) of Chlorpheniramine, a potent antihistamine. Levels usually range from 0.004–0.01 milligrams/Litre.

Specialist medical advice to the investigation team reported that Chlorpheniramine is a sedating antihistamine which may exacerbate fatigue and affect concentration, alertness, vision, decision making, and psychomotor skills. The advice reported that the pilot would have been significantly sedated and probably suffered visual disturbances and a decreased mental alertness which may have affected his judgement.

Co-pilot

The co-pilot was reported to have been in good health and was not taking medication. The toxicology report did not reveal any abnormalities. He was enthusiastic about having recently achieved pilot-in-command status with the company. He had spent 2 days off and slept-in the day before the accident. The co-pilot retired at about 2200 on the previous evening and rose at about 0300 on the day of the accident.

1.5.2 Relevant operational experience

Pilot-in-command

The pilot-in-command commenced flight training in Fiji in January 1992. In August 1994 he was granted an instrument flight rating and in January 1995 he was issued with a commercial pilot's licence. He commenced flying with another Fijian airline in March 1995 as a co-pilot until gaining a position with Air Fiji in September 1995 as a co-pilot endorsed to fly the BN2A and DHC-6 aircraft type. In November 1995, after completing aircraft type endorsement training, he was assessed as suitable to fly the Bandeirante as co-pilot.

In May 1998, after completing pilot-in-command training, he was granted pilot-in-command status on the Bandeirante and in June 1999, was approved to conduct line training of other pilots in the Bandeirante.

Co-pilot

The co-pilot commenced flight training in Fiji in July 1995. In April 1997, he was issued with a commercial pilot's licence and in July 1997 he was granted an instrument flight rating. He commenced flying with Air Fiji in September 1997 as a co-pilot on the BN2A aircraft type. In April 1999, after completing aircraft type endorsement training, he was assessed as suitable to fly the Bandeirante as co-pilot. In July 1999, he was granted pilot-in-command status of another aircraft type, although he had not assumed these duties at the time of the accident.

The co-pilot training records included comments regarding his shyness and lack of confidence. A check-and-training captain had recorded the comment: 'Still has problem in communicating. Must overcome this'.

1.5.3 Crew resource management training

Crew resource management (CRM) involves the effective use of all available resources to achieve safe and efficient flight. Effective CRM involves many components, including enhanced leadership skills, situational awareness, improved communications and a clear definition of each person's role.

An Air Fiji staff member indicated that pilots in command used to receive CRM training which was conducted by a consultant from New Zealand. However, the training had ceased in 1996-97, therefore, many of the current Air Fiji pilots would not have received CRM training. At the time of the accident, Air Fiji was planning to reintroduce CRM training later in 1999.

Neither pilot had completed a CRM course.

1.6 Aircraft information

1.6.1 Significant particulars

Registration	DQ-AFN
Manufacturer	Embraer
Model	EMB-110-P1
Common name	Bandeirante
Serial number	110-416
Country of manufacture	Brazil
Year of manufacture	12 January 1983
Year acquired by Air Fiji	13 September 1994
Engines	Pratt & Whitney Turbo Prop, PT6A-34
Total airframe hours	13,563
Total cycles	22,411

The aircraft was being maintained in accordance with the manufacturer's procedures. No evidence was found of any fault in the aircraft that might have contributed to the accident.

1.6.2 Weight and balance

The aircraft weight-and-balance documentation indicated that the aircraft was operating within its weight-and-balance limitations.

1.6.3 Aircraft history

The Embraer Bandeirante aircraft type was introduced into civil service by the manufacturer in 1978. The accident aircraft was manufactured in 1983 and initially placed on the United States register. In 1985, the manufacturer issued an airworthiness directive that the autopilot and elevator electric trim systems fitted to the Bandeirante aircraft type were to be deactivated.

Although the airworthiness directive regarding the electric trim and autopilot was withdrawn in 1988, there is no record in the aircraft maintenance logbooks that the autopilot or electric trim was reinstated. Air Fiji advised pilots not to use the autopilot as it was unserviceable. However, the investigation team could not confirm that it was isolated in the correct manner (circuit breaker pulled and collared), or that it was placarded 'unserviceable' as is standard

practice. Examination of the elevator trim mechanism revealed no evidence that the trim system had malfunctioned or contributed to the accident.

The aircraft logbooks indicate that the aircraft had undergone routine maintenance and there was no record of previous accident damage.

1.7 Meteorological information

The weather report for Nausori at 0500 indicated nil wind, visibility of 40 kilometres and scattered cloud at 2,200 feet. The report for the accident area indicated a small shower band, which the National Weather Forecasting Centre at Nadi classed as not significant. The pilot of PC123, which departed Nausori about 10 minutes behind PC121, later commented that after takeoff he entered and climbed through broken cloud until 5,500 feet. This cloud extended for about 55 kilometres along the direct Nausori-Nadi flight path. The pilot of a rescue helicopter that departed Nadi at 0840, commented that although they flew under broken cloud with scattered light rain showers, the accident site was clear.

PC121 departed Nausori at about 0525. The moon had already set and first light for Nadi occurred at 0625. Consequently, the planned flight would have been completed in darkness.

1.8 Aids to navigation

The aircraft was fitted with a Global Positioning System (GPS) navigation aid designed for instrument flight rules use. Although the data card was not current, the unit was operating and provided navigational information (including altitude) prior to impact. The GPS unit was not substantially damaged during the impact and was interrogated by the manufacturer. Only one waypoint, including a location about 300 metres to the south-west of the main wreckage site (adjacent to the horizontal stabiliser) and an altitude of 2,818 feet at time 0536, was stored. Records show that at the time of the accident, a constellation of nine GPS satellites were within view of the aircraft GPS receiver.

The flight crew also had access to ground-based navigation aids for the duration of the flight. Air traffic control records show that there were no faults recorded for the ground-based navigation aids for this time.

It was not possible to determine if the crew had utilised tracking information provided by the GPS or ground-based navigation aids.

1.9 Communications

Satisfactory two-way communications via very high frequency radio between the crew and local air traffic control units existed up until the last recorded transmission from PC121. The transmissions from the crew were conducted by the co-pilot.

1.10 Flight recorders

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

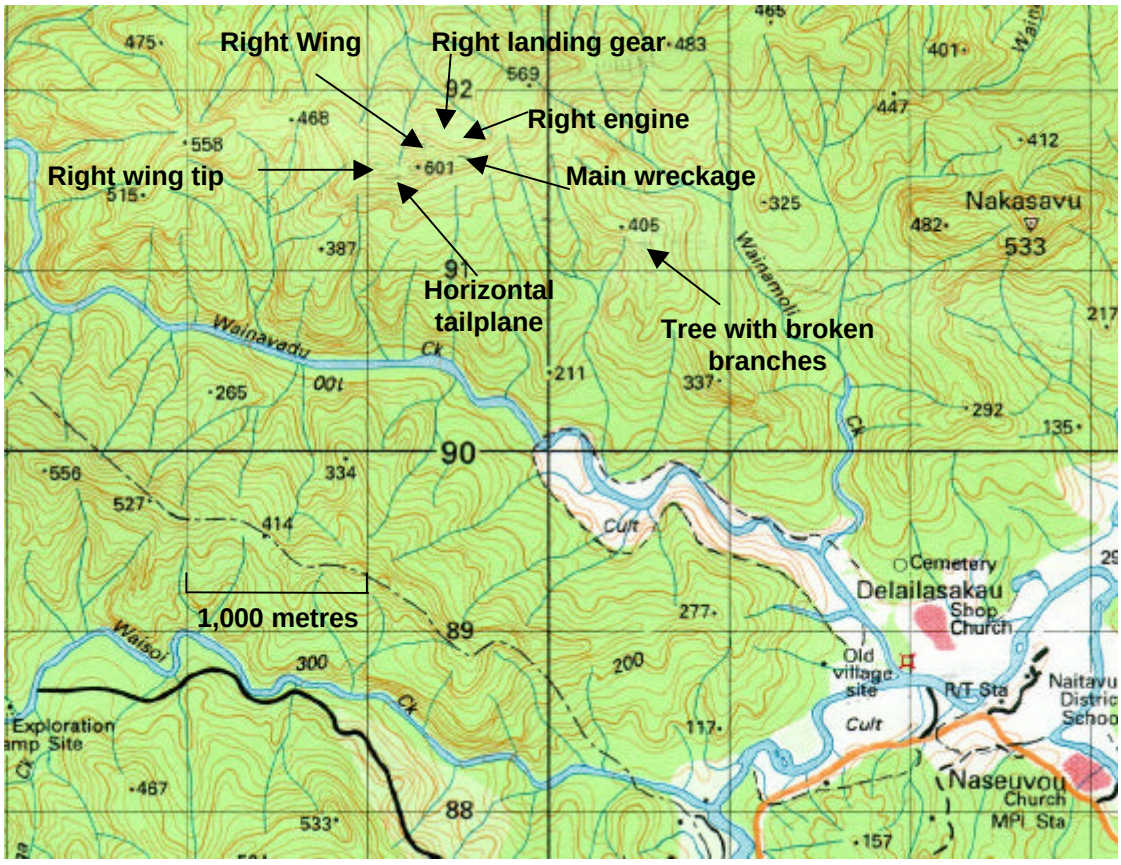
1.11 Wreckage and impact information

The main part of the wreckage, comprising most of the fuselage, the left wing, the left landing gear assembly, the left engine and propeller, and the nose landing gear assembly, was located on the south-eastern slope of a ridge about 41 kilometres west of Nausori. The position was about 3 kilometres to the south of the direct Nausori–Nadi track.

The horizontal stabiliser was located on the south-east side of a higher peak about 300 metres to the south-west of the main wreckage. The vertical stabiliser was not located. The rudder was located about 50 metres directly below the horizontal stabiliser. The outer section of the right wing, the right landing gear assembly and right engine and propeller were located on the north-western side of the peak, about 200 metres from where the horizontal stabiliser was found.

The locations in which the components were found suggested that the aircraft began to break up and separate shortly before impacting the trees and ridge. The aircraft's final flight path was in a north-easterly direction and descending at an angle of 40°.

The aircraft had sustained significant damage to the leading edge of the right wing, 2.2 metres inboard of the wingtip. About a metre of the leading edge was torn away and the main spar of the right wing had fractured 2.2 metres inboard of the wingtip and was deformed rearwards about 100 millimetres, at the fracture point. The deformation is consistent with a collision with a solid object. The main and rear spars had also fractured at three locations between the engine nacelle and immediately outboard of the wing attachment fittings. The fractures exhibited rearward and upward bending consistent with stresses that exceeded the structural strength of the wing.



A tree with large freshly broken branches was observed on a ridgeline at an altitude of 1,300 feet, and about 1.3 kilometres east from the main wreckage site. However, due to rugged steep terrain and dense vegetation it was not possible to confirm that the aircraft had collided with the tree.

Immediately prior to the final impact, the empennage (complete tail unit) had separated from the fuselage due to in-flight stresses resulting from the loss of the right wing. The stresses exceeded the aircraft's structural strength. It is possible that the right wing impacted the empennage as it separated from the aircraft.

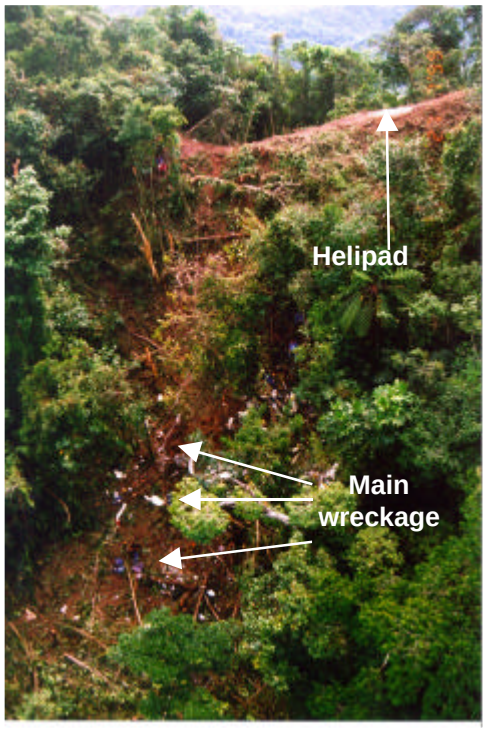
During the final impact sequence, most of the aircraft, including the fuselage and left wing, collided with a number of trees before impacting the ground inverted on its right side.

The left-wing forward and rear spars fractured immediately outboard of the wing attachment fittings. The fractures were consistent with excessive stresses generated during the final impact sequence on the ridge. No other significant damage was found on the left wing. The wing carry-through section forward and rear spars had fractured due to excessive impact-induced stresses during the final impact sequence.

The left engine and propeller were found with the main wreckage. Both were substantially damaged during the final impact. The right engine and propeller had separated from the aircraft prior to the final impact. The right engine was substantially damaged by impact forces. Damage sustained by the right propeller was consistent with the propeller blades having collided with one or more objects while operating under power.

Examination of the engines and propellers indicated that both engines had been operating under power during a collision with one or more objects.

Although the witnesses reported an unusual engine sound while observing the aircraft, no evidence of a pre-existing defect with the aircraft or its systems, that may have influenced the circumstances of the accident, was found.



1.12 Medical information

The occupants of the aircraft died as a result of impact forces. Samples from the crew for toxicological study were not taken until 4 days after the accident. The tests revealed low levels of alcohol in the pilot-in-command and co-pilot. Specialist advice indicated that this was a result of natural processes during decomposition, which were exacerbated due to the delay in obtaining and preserving the samples. However, the delay was not considered to have adversely affected the higher than therapeutic levels of antihistamine in the pilot-in-command.

1.13 Fire

The witness at Delailasakau reported that as the aircraft disappeared from view, she observed a bright flash. This report is consistent with a possible air burst of fuel vapour as sections of the right wing, incorporating fuel tanks and electrical cables, separated from the fuselage. However, no evidence of an explosion or fire was found at the wreckage site.

1.14 Search and rescue

1.14.1 Air traffic control

Air Traffic Control (ATC) in Fiji is provided by Strategic Air Services Ltd. The crew of PC121 was required to contact Nadi ATC at 0535. However, Nadi and Nausori ATC records do not contain any details of an attempted contact at that time from the crew. At 0543, Nadi ATC attempted to contact the crew, but there was no response. Nadi ATC then contacted Nausori ATC to advise that there had been no contact at any time.

Both Nadi and Nausori ATC attempted to contact the crew of PC121, including by asking other aircraft crews to broadcast on the Air Fiji frequency. There was no response. At 0655, a Nausori airport security guard received a telephone call from a villager, reporting an aircraft accident. Five minutes later, the call was transferred to the Nausori control tower. The security guard subsequently contacted the police at 0731.

No record was found to indicate that the ATC staff implemented procedures from their Manual of Air Traffic Services. The procedures required ATC staff to declare an uncertainty phase (INCERFA) should the pilot fail to report within 15 minutes after a pre-arranged frequency change. An alert phase (ALERFA) was to be declared if ‘during INCERFA, subsequent communication checks or enquires to other relevant sources fail to reveal any news of the aircraft’ or ‘the duration of the INCERFA has exceeded 30 minutes’. ATC declared a distress phase (DETRESFA) at 0755.

When questioned regarding the delay in implementing search and rescue (SAR) phases and initiating action, the ATC officers responded that they thought that the aircraft may have sustained a radio equipment failure and was either returning to Nausori or continuing onto Nadi, a flight time of about 25 minutes. ATC had requested that other aircraft monitor the emergency frequency. However, as an emergency beacon or other transmission was not received, they believed that the aircraft had not crashed even though their records indicated that the aircraft’s fuel supply would have been exhausted at about 0705.

The aircraft was equipped with an emergency locator transmitter, which could not be found amongst the wreckage. An ATC officer commented that had the beacon activated upon impact, the aircraft wreckage may have been located earlier.

1.14.2 The operator

A number of airlines require that if one of their aircraft is overdue, clearly defined procedures be implemented to ascertain the status of the aircraft. These are designed to operate in conjunction with the state’s ATC and SAR systems.

Air Fiji personnel became concerned that the aircraft was overdue. However, no action was taken until a company pilot returning from a scheduled flight decided to instigate a search for

the aircraft. The pilot departed Nausori at 0758 for the search area and located the wreckage at about 0815.

1.14.3 The regulator

An officer from the Civil Aviation Authority of Fiji (CAAF) waiting for a flight at Nadi learned that the aircraft was overdue. He immediately phoned other CAAF officers and asked them to proceed to the CAAF office and organise helicopters and medical personnel. The helicopter with the CAAF officer and a doctor on board departed Nadi at 0850. Shortly before their arrival in the search area, ATC advised them that the wreckage had been located. The officer then coordinated access activities, including having a local villager clear a helicopter landing pad.

1.14.4 The police

Records show that at 0731 the police were notified of the message from the villager. The first police officer arrived at the village at about 1130. Additional police officers arrived at about 1400 to take control of the site.

1.14.5 Site access

Initial access to the site by rescuers was hampered by the difficult terrain. Although construction of a helipad improved access to an area adjacent to the main wreckage, the steepness of the terrain and the thick vegetation continued to hinder the recovery operations.

When the investigation team arrived at the accident site helipad, police prevented them from commencing their investigation. The team presented a senior police officer with a letter of authorisation from the Minister of Communication and Civil Aviation of Fiji. The investigation team leader then travelled to the base camp and again explained the situation to the police site commander, and access was granted after further consultation.

Two days later local villagers denied the team access to the site. After several requests by the investigators to government officials and representation to the villagers by government ministers, the team was given full access to the wreckage site 5 days after arriving in Fiji.

Throughout this period there was a substantial amount of rain that severely hampered access and retrieval activities over the ensuing days. It is possible that the rain also contributed to the loss of evidence.

1.15 The operator

Air Fiji operated three other Bandeirante aircraft and a number of turbo-prop and piston engine aircraft. Inductees initially began as co-pilots on the less sophisticated aircraft before progressing to the Bandeirante. On promotion to pilot-in-command (captain), they returned to piston-engine aircraft and progressed through the aircraft types as pilot-in-command.

1.15.1 Check and training

Examination of recent crew records indicated that the crew of PC121 achieved a perfect score at each line check. Recent instrument renewals, currency and recency records and base check reports did not include comments as to whether there were any concerns regarding the ability of the crew to continue acting in their assigned role or if promoted to higher duties.

During the investigation, an Air Fiji staff member made the following comment:

> When commencing employment with the company, a staff member encountered poor procedures such as line pilots being promoted to checking and training responsibilities and management positions without formal assessment. He commented that no one has ever failed a check ride as the examiner doesn't want to embarrass the candidate with a fail…

1.15.2 Standard operating procedures

Four days after the accident, a company representative indicated that as a result of the accident, they could roster 35 pilots for duty. During the preceding 18 months, 16 pilots joined the company. This meant that an additional 40% of pilots over the preceding 18 months would have required training and supervision, with many of them requiring aircraft type endorsement training as well as routine checks.

During the investigation, a number of Air Fiji personnel were interviewed. These included staff from flight operations and maintenance. Their comments include the following:

> A staff member commented that to his knowledge there are no records kept of personnel who have completed weight and balance training nor was there a centralised comprehensive record detailing the aircraft types on which flight crew were endorsed or current.
>
> A pilot commented that when he began flight duties with Air Fiji, which was his first position as a pilot-in-command in a multi-crew environment, he received no training in multi-crew procedures. Nor was he aware of his responsibilities as a pilot-in-command or that of his co-pilot in a multi-crew environment. When questioned regarding Crew Resource Management (CRM) training, the pilot was unfamiliar with the concept and practice of CRM. He commented that he had not yet sighted a company operations manual. The pilot stated that other pilots with the rank of captain had warned him to watch his co-pilots closely as they do not cope with high workloads or unusual situations.
>
> A Bandeirante pilot-in-command commented that there were no company standard operating procedures for the aircraft. The investigation team spoke to a number of pilots who all related different climb power settings and airspeeds for the Bandeirante aircraft.
>
> Comment was made by a CAAF officer regarding crew smoking on the tarmac and lack of a fuel check for water after refuelling in the rain. The officer also commented on the inappropriate loading of passengers while an aircraft engine was running without ground personnel stationed at critical locations to direct passengers.

Several company operations manuals were checked. The manuals had not been amended to reflect the changing structure of the company since 1995.

1.16 The regulator

Under Fiji Islands legislation, the Civil Aviation Authority of Fiji (CAAF) is tasked with the responsibility of regulating civil aviation in Fiji. This includes issuing the appropriate licences and certificates to allow an airline to conduct a commercial air service. CAAF delegates the renewal of instrument ratings and other recurrent flight reviews to company check-and training-pilots.

To fulfil these requirements CAAF is required to conduct programmed surveillance checks to ensure the maintenance of aviation standards and regulations. These checks allow CAAF to monitor the safety health of the industry and allow industry personnel to provide formal and informal feedback and thus engender trust between the regulator and the industry. Ultimately, this level of regulatory involvement should provide a positive influence on the safety culture in which the industry operates. At the time of the accident, no formal mechanism existed to allow aviation personnel to confidentially report air safety incidents.

A CAAF officer commented that the Authority's flight safety department had conducted surveillance visits since the beginning of 1999. However, prior to the accident, there had only been one flight operations inspector available to conduct surveillance visits. He indicated that while industry information days had been conducted in the past these had ceased due to inadequate resources. The officer believed that more resources should be made available to establish a permanent presence in Nausori.

A CAAF officer highlighted a number of aviation safety issues including;

- selection and promotion of aircrew based on ethnic origins rather than ability and experience;
- generally low standard of flying skills and airmanship;
- lack of communication between multi-national crews while in the cockpit;
- lack of a responsible attitude by aviation personnel across the industry including pilots, ground staff and engineers, towards their work; and
- reticence of pilots to seek assistance or clarification from senior management or the government authorities.

CAAF is also responsible for conducting investigations in the event of an accident occurring within Fiji.

During the investigation, it was found that the legislation which empowered the relevant minister under section 4 to make regulations for the investigation of accidents by an inspector, made no provision for complying with investigation requests submitted by the investigation team. Additionally there was no power available to the inspector to delegate authority to nominated individuals to assist with an investigation.

1.17 The Nausori–Nadi route

The crew of PC121 planned to fly the direct Nausori–Nadi route, a distance of 124 kilometres. This route, which required tracking 270°, crosses a number of ranges which extend to 3,900 feet. The published lowest safe altitude for the route is 5,400 feet.

1.18 Other aspects

1.18.1 Prior accidents

During the 1980s, a number of accidents and serious incidents occurred in Fiji which prompted the Fiji Government to invite the New Zealand Office of Air Accidents to conduct an inquiry into *The safety of Air Transport within Fiji*. The investigation team published a number of findings, which identified:

- inadequate supervision, standard operating procedures and training of flight crews; and
- inadequate resources and consequently surveillance of the industry by CAAF.

During the investigation by CAAF of a series of aircraft accidents in Fiji in the 1990s, findings included:

- inadequate supervision, standard operating procedures, and inexperience of flight crew; and
- the need for CAAF to increase surveillance of the aviation industry.

1.18.2 Air traffic monitoring

In March 1995, the GPS Harris Aries system was introduced in Fiji as a prototype on a trial basis by the Harris Corporation of the USA.

The GPS Harris Aries system was an aircraft and ground-based ATC facility that utilised the GPS unit in the aircraft to transmit positional data, derived from GPS satellites, on a real-time basis to ATC. This enabled ATC to monitor an aircraft's position and altitude without a radar infrastructure.

At the time of the accident, the system was unserviceable.

1.18.3 Pacific search and rescue special implementation project

Between November 1992 and February 1993, the International Civil Aviation Organisation (ICAO) undertook a project to 'assist selected Pacific States and Territories to provide the most efficient Search and Rescue services and, in particular:

a) Review, in consultation with the relevant authorities in each state within the Pacific Region, the existing machinery of the Search and Rescue services with a view to reorganising them and restoring them to maximum efficiency;

b) Assist in the preparation of formal agreements between States for mutual assistance and cooperation to which the States concerned can subscribe and;

c) Identify and foster the implementation of those aspects of the Regional Air Navigation plan which have not been implemented within the region.'

Fiji was one of the Pacific States that participated in the project and agreed to host the Regional Rescue Coordination Centre.

A recommendation resulting from the project was:

> Each country should establish a National SAR Plan and an appropriate coordinating committee for:
>
> - Overall coordination of national SAR;
> - Preparing for regional committee meetings and projects and;
> - Implementing regional committee actions and recommendations within their own states.

At the time of the accident, the National SAR Plan had not been implemented.

2. ANALYSIS

2.1 Introduction

The circumstances of the accident were found to be consistent with an in-flight collision with solid objects. The aircraft began to break up prior to impacting the side of a ridge. The aircraft was capable of normal operation prior to the in-flight break up. However, the circumstances of the collision could not be established.

The investigation identified a number of factors that influenced the organisational environment, that is, the regulatory and company systems, and the operational environment in which the flight was conducted. These factors included inadequate surveillance by the regulator, inadequate check-and-training procedures, standard operating procedures, and record keeping by the operator.

2.2 The regulator

Operational surveillance by the Civil Aviation Authority Fiji (CAAF) was ineffective due to inadequate allocation of qualified resources. This is evidenced by only one flying operations inspector being available to carry out field surveillance prior to mid-1999. In order to ensure a safe environment, it was essential that CAAF allocate adequate resources to enable it to conduct essential scheduled and unannounced visits including line-flying with crews. This would have served to promote a working relationship with the industry, ensured that the industry was fully complying with the regulations and highlighted deficiencies in the regulations and their interpretation by the industry.

However, despite prior accident investigations conducted by CAAF and New Zealand indicating problems with standard operating procedures, flight crew inexperience and training and regulatory surveillance, subsequent surveillance had not been effective in addressing these problems.

An effective surveillance program would have ensured an awareness of the safety health of the industry and encouraged industry personnel to be sufficiently confident in CAAF's ability to respond to their concerns.

2.3 Air traffic control

Air traffic control (ATC) officers on duty during the flight of PC121 did not follow their published standard operating procedures. The delay of 2 hours and 20 minutes from the time at which the aircraft became overdue to the declaration of a distress phase by ATC directly resulted from staff not adhering to procedures. The reason for this non-adherence could not be positively established. However, ATC officers apparently relied on the activation of the emergency locator transmitter (ELT) to prompt them to initiate a search and rescue (SAR) phase. The ELT was not recovered as it is probable that it was destroyed during the impact sequence or buried beneath wreckage, which would have prevented it from operating satisfactorily due to shielding. Because ATC had requested that other aircraft monitor the emergency frequency and as no emergency transmission or signal was received, this reinforced their belief that the aircraft had not crashed. ATC apparently did not realise that the aircraft's fuel supply would have been exhausted at about 0705 even though their own records indicated a fuel endurance of 102 minutes.

The initiation of a SAR phase 15 minutes after the crew failed to report by radio, would have commenced an escalating series of events culminating in the early search and location of the missing aircraft. However, ATC officers were prompted to act only after they received the message from the villager reporting an aircraft crash.

In the absence of a radar service it, was not possible for ATC to monitor an aircraft's location other than by flight crew position reports. An operational GPS Harris Aries system or a similar system would have alerted ATC almost immediately that a significant event had occurred to PC121. Such an alert would have enabled a rapid response which would be critical in the circumstances of a survivable accident.

Timely SAR response is dependent on affective SAR coordination, ATC notification and company flight following. A national SAR coordinator would or should have coordinated SAR resources on receipt of a report from the villager, ATC or police.

2.4 The operator

The environment in which Air Fiji operated should have been strongly influenced by an effective regulatory oversight. However, the environment was characterised by infrequent and superficial surveillance visits by CAAF, which resulted in Air Fiji determining their own responses to safety issues within the company. This is evidenced by inadequate management of operational documentation and standard operating procedures.

2.4.1 Check and training

Operational management was deficient in that pilots had been cleared to current positions or promoted to positions of higher responsibility, including check and training, without appropriate assessment of their ability to perform at that level. Consequently, some check-and-training pilots did not possess the required skills to properly assess flight-crew competencies, but instead applied superficial procedures to provide an apparent compliance with the regulations. Consequently, superficial application to flight assessment and training records, particularly the absence of substantiating comments, meant that the records were inadequate. Therefore, it was not possible to accurately assess the relevant skill and experience level of the PC121 crew, based on their training records. Inadequate records also denied company management accurate information to sufficiently monitor a pilot's skill and experience level.

The number of new pilots joining the company in the previous 18 months would have constituted a significant task for the check-and-training pilots. Without adequate records or standard operating procedures, the check-and-training pilots and hence management would have found it difficult to accurately track the progress of the new pilots

2.4.2 Standard operating procedures

The general lack of adherence to procedures demonstrated by crews, including inadequate published standard operating procedures on the Bandeirante aircraft, led the pilots to improvise their own procedures. This was evident in the lack of adherence to standardised speed and power settings for Bandeirante aircraft for the climb sequence. It was also evident in a lack of professionalism by the crews, (e.g. smoking in the vicinity of aircraft, inappropriate procedures for the loading of passengers with an engine operating, and inadequate fuel checking practices)

Inadequate standard operating procedures and lack of CRM training and procedures may have resulted in the pilot-in-command of PC121 being unsure of his responsibilities and those of his co-pilot. The co-pilot may have adapted his operating procedures to suit the pilot-in-command with whom he was rostered. In an emergency situation, this adaptation could have led to confusion and inaction on the part of the crew.

The inadequate multi-crew training including CRM training and standard operating procedures could also have negated the advantage of PC121 crews operating as a team.

2.4.3 Flight following

Regular public transport operators have a responsibility to ensure that their passengers are not exposed to preventable hazards.

An appropriate flight-following system would ensure that in the event of an accident, the earliest possible response would be initiated to minimise the consequences.

A flight following system with clearly defined procedures to be adhered to in the event of an aircraft encountering difficulties or becoming overdue, would have enabled Air Fiji to initiate the SAR activities sooner.

2.5 The crew

The crew operated in an environment which was strongly influenced by the cultures of the company, the regulator and the Fijian community. This environment conditioned the attitude of pilots to:

1) adherence to standard operating procedures;
2) reference to the company documentation, including the company operations manual, for guidance;
3) compliance with regulations; and
4) self assessment as to fitness to fly.

2.5.1 The flight

Information provided to the investigation team suggests that the pilot-in-command had had minimal rest during the preceding 24 hours. Additionally, specialist medical assessment determined that his above therapeutic levels of antihistamine may have exacerbated the effect of fatigue. The pilot-in-command's apparently out of character behaviour immediately prior to the flight, and the report of the aircraft initially turning right after take-off suggest that the pilot was experiencing difficulty. This apparent difficulty may have been the result of fatigue, compounded by the medication or an illness. As the co-pilot was making all of the recorded radio transmissions, it is likely that the pilot-in-command was the handling pilot for that sector. If he was experiencing difficulty controlling the aircraft under instrument meteorological conditions, he may have become disorientated. Additionally if the pilot was suffering from a respiratory ailment that necessitated the administering of the antihistamine, he may have experienced sinus or ear pain due to air pressure changes.

The co-pilot was apparently well rested and healthy. However, if the pilot-in-command was experiencing a degree of incapacitation, the co-pilot may have been required to manipulate the controls and conduct radio transmissions. This may not have been critical depending on the condition of the pilot-in-command and provided that the co-pilot was adequately trained.

2.5.2 Crew resource management

Effective Crew resource management (CRM) requires the co-pilot to be assertive when the situation warrants it, without usurping the authority of the pilot-in-command. The co-pilot was also reported on previous check rides as being shy and lacking confidence (‘Still has a problem communicating. Must overcome this’). It is likely that due to a lack of CRM training, the co-pilot would not have responded in an adequately assertive manner had the need arisen. In the circumstances of this accident, it is possible that early intervention by the co-pilot may have prevented the accident.

3 SUMMARY

The weather, other than reduced visibility in cloud, is not considered to have played a part in this accident. The combination of a dark night, cloud, and limited ground lights, would have provided the crew with few external visual cues. This would have required that they constantly scan their flight instruments to achieve the desired aircraft performance and flight profile. This is a demanding task and it is possible that the crew became disorientated and lost control of the aircraft with insufficient altitude remaining to regain control of the aircraft.

The evidence is consistent with the aircraft colliding with one or more objects prior to breaking up and impacting the ridge. However, it was not possible to determine the exact sequence of events during the in-flight break-up.

It is possible that the crew did not climb the aircraft to the reported altitude. However, there is no evidence to support this.

4. CONCLUSIONS

4.1 Findings

4.1.1 The aircraft

1. The aircraft was certified and registered on the Fiji civil register, and operated by Air Fiji.

2. The aircraft had been maintained in accordance with the required procedures, and was functioning normally at the time of the accident.

3. There were no reported aircraft unserviceabilities that may have contributed to the accident.

4. There was no evidence to suggest that the aircraft or ground-based navigation aids were not serviceable at the time of the accident.

4.1.2 The flight

1. The co-pilot submitted a standard flight plan for a direct track at 6,000 feet to Nadi.

2. The co-pilot performed all of the recorded radio transmissions.

3. After departure, the aircraft initially diverged to the right of the direct Nausori–Nadi track, but was later seen to make an apparent correction.

4. At 0532, the co-pilot reported by radio to Nausori ATC that they were 14 nautical miles from Nausori and climbing through 5,500 feet.

5. At 0533, the crew advised Nausori ATC that they were maintaining 6,000 feet and on the direct track.

6. The crew were instructed by Nausori ATC to contact Nadi ATC at 0535.

7. At 0535, the crew did not contact Nadi ATC as previously instructed by Nausori ATC.

8. The locations in which the wreckage, including major aircraft components were found, suggest that the aircraft began to break up in-flight before impacting the ridge. The damage to the right wing was consistent with an in-flight collision with a solid object or objects.

9. The main part of the wreckage was located on the south-eastern slope of a ridge about 41 kilometres west of Nausori and about 3 kilometres to the south of the direct Nausori–Nadi track.

10. The horizontal stabiliser was located about 150 metres to the south of the main wreckage on the side of a higher peak. The rudder was located about 50 metres downhill from the horizontal stabiliser.

11. Heavier components such as the outer section of the right wing, the right landing gear assembly and right engine and propeller were located on the western side of the peak, about 150 metres from where the horizontal stabiliser was found.

4.1.3 The crew

1. The crew were correctly licensed and qualified to perform the flight.

2. The pilot-in-command had insufficient rest prior to the flight.

3. The pilot-in-command had consumed an above-therapeutic level of antihistamine prior to the flight, which would have degraded his ability to safely pilot the aircraft.

4. Training records indicate that the co-pilot may not have asserted himself if he recognised that the pilot-in-command was having difficulties.

5. Neither crew member had received CRM training.

4.1.4 The weather

1. The weather report for Nausori at 0500 was nil wind, visibility of 40 kilometres and scattered cloud at 2,200 feet.

2. A pilot of the following aircraft, which was about 10 minutes behind PC121, later commented that after takeoff they entered and climbed through broken cloud until 5,500 feet. This cloud extended for about 55 kilometres along the intended flight path.

3. A pilot of a search helicopter reported that they flew under broken cloud and encountered light rain showers at a few locations while transiting to the search area.

4.1.5 Organisational

1. Air Fiji's company operations manual had not been amended since 1995 and consequently did not reflect the company structure or procedures at the time of the accident.

2. Air Fiji's published standard operating procedures were inadequate for the Bandeirante aircraft.

3. Air Fiji had not kept records of personnel having completed weight-and-balance training or comprehensive records of crew's check and training, currency and recency reports and instrument renewals.

4. ATC staff did not adhere to procedures as published in their Manual of Air Traffic Services, specifically with regard to search and rescue.

5. Prior to mid-1999, CAAF flying operations department had not conducted adequate surveillance of the industry.

5. SAFETY ACTION

5.1 Recommendations

As a result of the investigation into this occurrence, the investigation team makes the following recommendations:

1. The government of Fiji should ensure that the Civil Aviation Authority of Fiji (CAAF) is adequately resourced with well qualified and experienced personnel to:

   (a) conduct frequent comprehensive scheduled and unscheduled surveillance audits of all commercial aircraft operators; and

   (b) conduct regular regional operational safety education meetings for line pilots and aircraft maintenance engineers. These meetings should target current safety concerns, such as adherence to standard operating procedures and crew resource management practices.

2. CAAF and the operator should ensure that the company operations manual properly reflects the organisational structure and operational function of the company. This should include the requirement that no personnel management changes likely to affect the operational safety and integrity of the company be implemented prior to approved amendment of the operations manual.

3. CAAF and commercial aircraft operators should develop appropriate recurrent crew resource management training programs. These programs should take account of the various cultural influences that may otherwise mitigate against successful implementation of such training.

4. The government of Fiji should engage the services of an internationally recognised emergency response specialist. The specialist should examine all aspects of the response capability of government and non-government agencies. The review should include an assessment of the adequacy of communication resources and procedures.

5. The government of Fiji should ensure that there are appropriate procedures in place to enable timely and accurate toxicological information to be obtained.

6. CAAF should ensure that procedures contained in the Manual of Air Traffic Services for the alerting of emergency response agencies adequately meet their intended purpose. Particular reference should be made to establishing appropriate time frames for the various response phases.

7. The operator should ensure that the position of chief pilot is accorded executive authority and support to enable full accountability for the safe operation of aircraft in accordance with the company operations manual.

8. The company should review its flight following procedures to ensure that aircraft flight progress is adequately monitored and that emergency response agencies are promptly advised when uncertainty exists as to the safety of an aircraft.

9. The government of Fiji should implement an air traffic control aircraft monitoring system using appropriate technology.

10. The government of Fiji and CAAF should examine the feasibility of requiring operators to fit and carry operative flight data and cockpit voice recorders on commercial aircraft of 15 or more passengers.

11. The government of Fiji should implement the recommendations contained in the *Pacific Search and Rescue Special Implementation Project* in conjunction with recommendation 4.

12. The government of Fiji should consider putting in place arrangements with countries that are able to assist with aircraft accident investigations.

13. CAAF should consider setting up a confidential reporting program.

5.2 Local safety actions

5.2.1 The regulator

During the course of the investigation, the Civil Aviation Safety Authority of Fiji wrote to the investigation team highlighting a number of steps that have been initiated including:

- an increase in surveillance of the industry;
- a review of the resourcing and structure of the Authority;
- appointment of a new controller of Air Safety;
- recruiting of additional staff to the flight safety unit;
- the training and placement into substantive positions of Fjiian nationals;
- re-activation of the regular regional operational safety education meetings with operators and pilots;
- notification to the industry of the availability of experts to train personnel in crew resource management;
- the seeking of approval from its board which would allow the authority to publish 'Mandatory Occurrence Reports' which would show general trends in aviation safety and highlight lapses in safety standards;
- the development of a 'Confidential Aviation Incident Reporting' system;
- review of *Air Navigation Regulation 72, sub-regulation 2* which deals with the use by air crews of intoxicating liquor and other substances;
- the development of 'Minimum Requirement Documents' specific to the local environment; and
- discussions with Airports Fiji Ltd, the commercial airport operator, regarding the re-instatement of the GPS Harris Aries system.

5.2.2 The operator

During the course of the investigation, Air Fiji wrote to the investigation team highlighting a number of steps that have been initiated which include:

- reviewing the pilots flight and duty times including additional allowances for taxi time;
- reviewing the record keeping of the flight and duty times;

- the limiting of pilots to 8 sectors per day and 8 hours flight time;
- mandating the minimum of 10 hours rest which must include the hours 2300–0400 and extended rest periods if the duty times exceed 11 hours;
- the requirement for each pilot to reside within 45 minutes driving time of Nausori airport; and
- the imposition by the operator of financial actions on company pilots for not adhering to procedures.

5.2.3 Air traffic control

During the course of the investigation, Strategic Air Services Ltd wrote to the investigation team highlighting a number of steps that have been initiated which include:

- requiring all controllers to ‘transfer/release’ aircraft at a specific time, position or level and to discontinue the practice of ‘transfer on contact’ or ‘release to be advised’;
- production of a notification flow chart which includes notification procedures for all internal and external agencies;
- amendment of their operations manual to include the activation of an appropriate SAR phase as a consequence of an en-route communication failure;
- introduction of a safety management system including a manual, handbooks, software and staff training which is consistent with international practice and will be fully implemented by March 2000; and
- refresher training for controllers, supervisors and managers in emergency procedures and timely activation of SAR phases.

6. REFERENCES

Civil Aviation Authority of Fiji, 1999, *Boeing 737-500: Nadi Airport,* Aircraft Accident Report, Nadi, Fiji.

Civil Aviation Authority of Fiji, 1999, *Harbin Y12: Mana Island,* Aircraft Accident Report, Nadi, Fiji.

Civil Aviation Authority of Fiji, 1999, *Pilatus Britten Norman BN-2A-27: Malololailai Airport,* Aircraft Accident Report, Nadi, Fiji.

Civil Aviation Authority of Fiji, 1999, *Pilatus Britten Norman BN-2A-26: Nadi Airport,* Aircraft Accident Report, Nadi, Fiji.

International Civil Aviation Organisation (ICAO), 1993, *Search and Rescue Special Implementation Project,* Project Report, Canberra ACT, Australia.

New Zealand Office of Air Accidents 1989, *The Safety of Air Transport within Fiji,* Special Study by Invitation from the Fiji Government, Wellington, New Zealand.

New Zealand Transport Accident Investigation Commission, 1993, *Britten Norman BN-2A-27 Islander: Nausori Airport,* Aircraft Accident Report, Wellington, New Zealand.

New Zealand Transport Accident Investigation Commission, 1994, *Aerospatiale AS 365 N2 Dauphin: 2 NM North-West of Ovelau,* Aircraft Accident Report, Wellington, New Zealand.