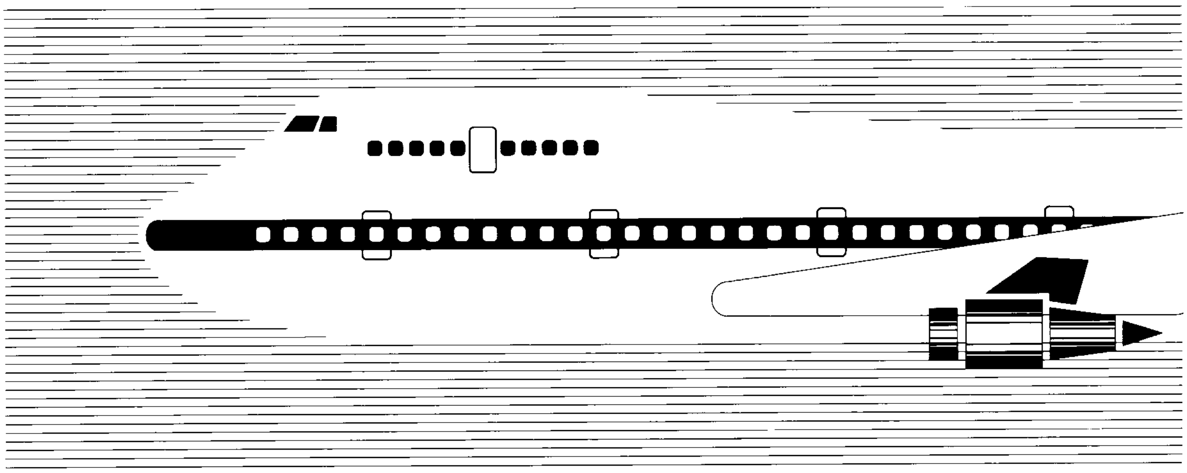
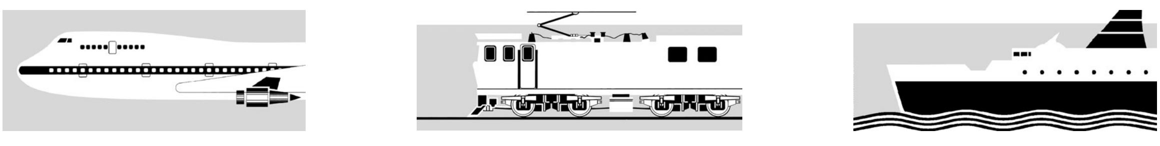


# AVIATION OCCURRENCE REPORT

**03-004** **Piper PA 31-350 Navajo Chieftain ZK-NCA, controlled flight into terrain, near Christchurch Aerodrome** **6 June 2003**



**TRANSPORT ACCIDENT INVESTIGATION COMMISSION**
**NEW ZEALAND**

# Report 03-004

# Piper PA 31-350 Navajo Chieftain

# ZK-NCA

# controlled flight into terrain

# near Christchurch Aerodrome

# 6 June 2003

## Abstract

On Friday 6 June 2003, Air Adventures New Zealand Limited Piper PA 31-350 Navajo Chieftain aeroplane ZK-NCA, was on an air transport charter flight from Palmerston North to Christchurch with one pilot and 9 passengers. At 1907 it was on an instrument approach to Christchurch Aerodrome at night in instrument meteorological conditions when it descended below minimum altitude, in a position where reduced visibility prevented runway or approach lights from being seen, to collide with trees and terrain 1.2 nm short of the runway. The pilot and 7 passengers were killed, and 2 passengers received serious injury. The aircraft was destroyed.

The accident probably resulted from the pilot becoming distracted from monitoring his altitude at a critical stage of the approach. The possibility of pilot incapacitation is considered unlikely, but cannot be ruled out.

Safety issues identified included:

- the desirability of adoption of TAWS equipment for smaller IFR air transport aircraft
- the need for VFR/IFR operators to have practical procedures for observing cellphone rules during flight
- the need for pilots on single-pilot IFR operations to use optimum procedures during instrument approaches.

Three safety recommendations to address these issues were made to the Director of Civil Aviation.

photograph courtesy of Christchurch Police Photography Section

**Figure 1**
**ZK-NCA accident site, looking south towards Christchurch Aerodrome runway 20**

# Contents



# Figures

## Abbreviations

| | |
|---|---|
| °M | degrees magnetic |
| ADF | automatic direction finder |
| ATIS | aerodrome terminal information service |
| AVGAS | aviation gasoline |
| CAA | Civil Aviation Authority |
| CDI | course deviation indicator |
| CFIT | controlled flight into terrain |
| cm | centimetre |
| DA | decision altitude |
| DME | distance measuring equipment |
| EGPWS | enhanced ground proximity warning system |
| ELT | emergency locator transmitter |
| G/S | glide slope |
| gph | gallons per hour |
| GPS | global positioning system |
| GPWS | ground proximity warning system |
| HSI | horizontal situation indicator |
| IFR | instrument flight rules |
| ILS | instrument landing system |
| kg | kilogramme |
| kt | knots |
| lb | pound |
| LOC | localiser |
| m | metre |
| MDA | minimum descent altitude |
| MEL | minimum equipment list |
| NDB | non-directional beacon |
| nm | nautical mile |
| PAPI | precision approach path indicator |
| psi | pounds per square inch |
| QNH | altimeter subscale setting to obtain elevation when on the ground |
| RMI | radio magnetic indicator |
| SPAR | special aerodrome report |
| SPECI | special weather report |
| TAF | aerodrome forecast |
| TAWS | terrain awareness warning system |
| VFR | visual flight rules |
| VHF | very high frequency |
| VOR | very high frequency omni-directional range |

## Data Summary

| | |
|---|---|
| **Aircraft registration:** | ZK-NCA |
| **Type and serial number:** | Piper PA 31-350 Navajo Chieftain |
| **Number and type of engines:** | two Lycoming TIO-540-J2BD piston engines |
| **Year of manufacture:** | 1974 |
| **Operator:** | Air Adventures New Zealand Limited |
| **Date and time:** | 6 June 2003, 1907[1] |
| **Location:** | near Christchurch Aerodrome<br>latitude: 43° 27′south<br>longitude: 172° 34′east |
| **Type of flight:** | Air Transport<br>(charter) |
| **Persons on board:** | crew: 1<br>passengers: 9 |
| **Injuries:** | crew: 1 fatal<br>passengers: 7 fatal, 2 serious |
| **Nature of damage:** | aircraft destroyed |
| **Pilot's licence:** | commercial pilot licence |
| **Pilot's age:** | 52 |
| **Pilot's total flying experience:** | 4321 hours; approximately 820 hours on type |
| **Investigator-in-charge:** | J J Goddard |

[1] All times in this report are in New Zealand Standard Time (UTC+12) and are expressed in the 24-hour mode

# 1 Factual Information

## 1.1 History of the flight

1.1.1 Piper PA31-350 Navajo Chieftain ZK-NCA was chartered from Air Adventures New Zealand Limited (Air Adventures) by an agricultural research company to fly a group of senior staff from Christchurch to Palmerston North and return on Friday 6 June 2003. On the evening before, the pilot obtained a routine pre-flight briefing, and filed standard instrument flight rules (IFR) flight plans for both legs. The flight up was planned at 9 000 feet, and the return at 10 000 feet, each with an elapsed time of 1 hour 30 minutes. The flight to Palmerston North departed from Christchurch Aerodrome at 0749, carrying 8 passengers, and was flown by the chief pilot of Air Adventures. The flight proceeded without incident, and arrived at Palmerston North Aerodrome at 0930.

1.1.2 During the day the pilot remained at Palmerston North Aerodrome, to await the passengers' return for the flight back to Christchurch, which was planned to depart at 1730. At about 1430, the pilot refuelled the aircraft with 350 litres of Avgas from the installation on the aerodrome. At 1702, he obtained by telephone an updated weather briefing on Christchurch.

1.1.3 The group of 9 passengers arrived at Palmerston North by taxi van shortly after 1700 for the return flight to Christchurch. They were met by the pilot, who led them to the aircraft, seated them and closed the aircraft door. He gave them a routine passenger briefing, which included advising that they could use their cellphones and computers during the flight.

1.1.4 At 1723 the pilot made radio contact with Palmerston North Tower, requesting clearance to start engines, advising 10 persons on board, and nominating Woodbourne as the alternate aerodrome for the flight to Christchurch. Palmerston North Tower acknowledged this, and advised that Radar had amended the flight plan for ZK-NCA. The route clearance issued was: to Christchurch via Foxton, Paraparaumu North, Tory, then flight planned route at 10000 feet, with a West 1 Delta departure. The previously filed flight plan was via Paraparaumu and Tory.

1.1.5 The pilot then spent a few minutes amending his navigation plan before starting the engines. During this time Tower advised him that a new Christchurch special aerodrome report (SPAR) had been issued. This reported visibility at 800 m, and cloud scattered at 200 feet, overcast at 400 feet.

1.1.6 At 1734, shortly after the end of daylight, the pilot requested taxi clearance, and was cleared to taxi and line up on runway 25. Palmerston North Tower also advised another new Christchurch SPAR and aerodrome forecast (TAF). This reported visibility at 800 m reducing to 500 m in drizzle, and cloud scattered at 100 feet, overcast at 400 feet. The TAF was for surface wind variable 3 knots, visibility 15 km in light drizzle, cloud scattered at 400 feet and broken at 1800 feet; temporarily between 1700 and 2200 visibility 500 m in fog, and cloud broken at 200 feet. The 2000-foot wind was variable at 5 knots becoming, after 1900, 180° magnetic at 15 knots.

1.1.7 ZK-NCA was cleared for take-off at 1739, and departed without incident. The pilot climbed the aircraft to 10 000 feet, and made routine radio contact on the appropriate frequencies with Ohakea Control, Wellington Control and Christchurch Control (Area and Approach) as the flight progressed. At 1826 Christchurch Control advised that another new Christchurch SPAR had been issued, reporting visibility at 500 m, scattered cloud at 200 feet and overcast at 700 feet.

1.1.8 During the cruise part of the flight, the passenger seated in the co-pilot seat, who was wearing a headset, had some conversation with the pilot. He subsequently recalled that the pilot had told him that the Christchurch weather was poor, and if it got worse they might end up in Woodbourne. The pilot had shown him their route on the map, and pointed out Blenheim and Kaikoura which were clearly visible on the way. The passenger said that the flight seemed smooth and uneventful, with the heater maintaining a comfortable temperature in the cabin.

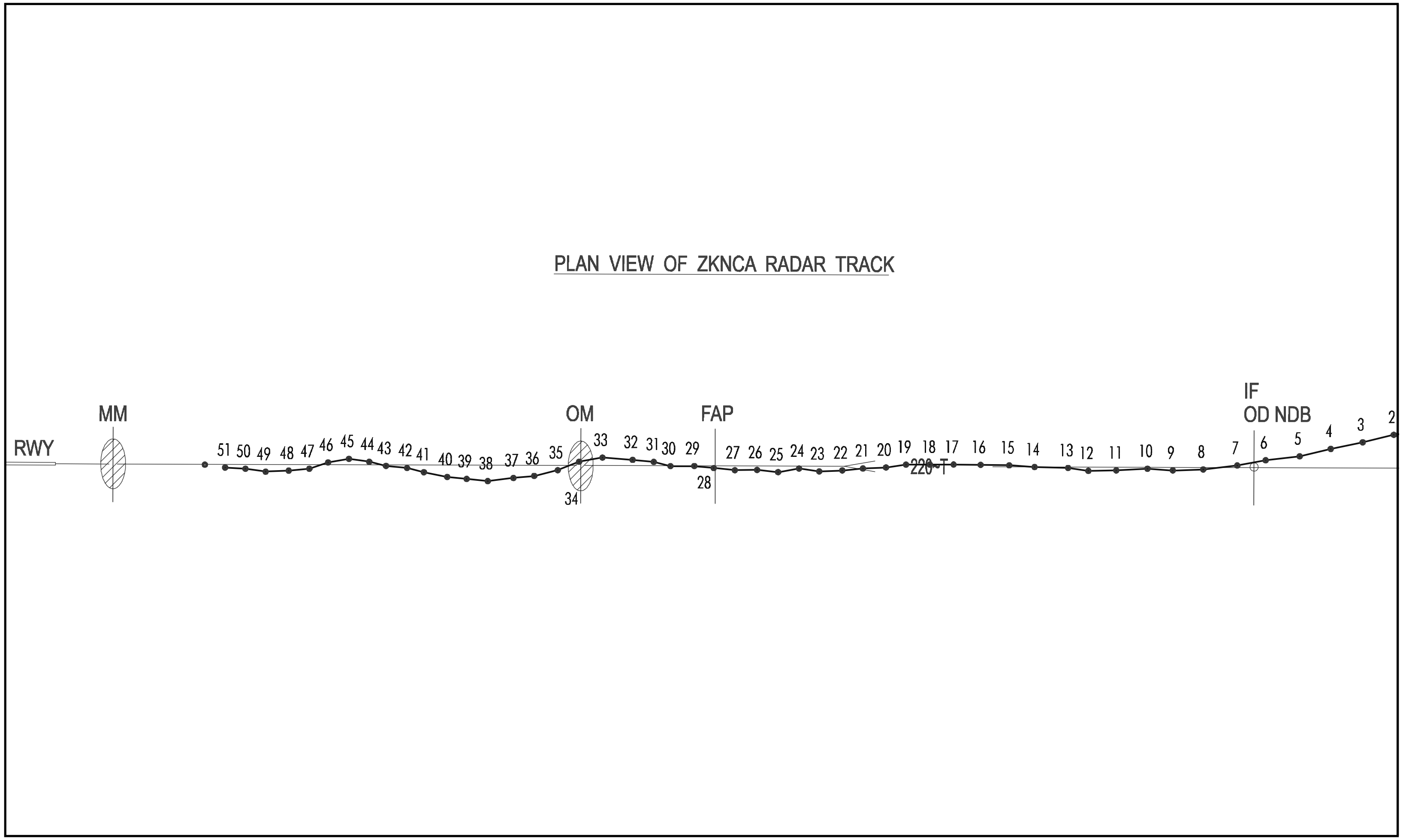



**Figure 2**
**Air Traffic Control radar track of ZK-NCA on the Christchurch 20 ILS approach**

The other passengers passed round some snacks and drinks, including wine and beer, but neither he nor the pilot had anything to drink. The autopilot was engaged until about where they crossed the coast north of Christchurch, where the pilot started to hand-fly the aircraft. At that stage he could see an area of low cloud ahead obscuring Christchurch and Christchurch Aerodrome, although Rangiora and Kaiapoi were clearly visible as they passed. He had no further recollection of the flight.

1.1.9 The passenger seated behind the co-pilot seat had similar limited recollections of the flight. He also remembered seeing the pilot use his cellphone fairly late on the flight, listening to it by pushing one earphone from his ear, as he had done on the flight up to Palmerston North. Some passengers had also used their cellphones and computers on both flights.

1.1.10 At 1844 Christchurch Control cleared ZK-NCA to descend when ready to 7 000 feet, followed by a further descent clearance to 6 000 feet, at 1851. ZK-NCA began descending from 10 000 feet at 1846, when the aircraft was about 64 nautical miles (nm) from Christchurch Aerodrome. At 1852 Christchurch Control advised ZK-NCA of a change of runway-in-use, to runway 20, and that a new aerodrome terminal information service (ATIS) was expected shortly.

1.1.11 At 1853 Christchurch Control cleared ZK-NCA to descend to 4000 feet, and advised that the ATIS was Information Whiskey, but runway 20 was now in use, and the altimeter setting (QNH) was 999 millibars. At 1855 ZK-NCA was cleared to track direct to Woodend (the non-directional radio beacon (NDB) marking the instrument landing system (ILS) approach to runway 20). The aircraft was 37 nm from the aerodrome at that time. ZK-NCA levelled at 4 000 feet at 1857, when it was 32 nm out.

1.1.12 At this stage of the flight ZK-NCA was following a Boeing 737 aircraft which commenced the ILS approach some 4 minutes ahead. Christchurch Tower reported to the Boeing a local visibility towards the runway threshold of at least 1400 m, and a southerly wind of 4 knots. The Boeing completed the ILS approach and landed at 1904.

1.1.13 At 1902 Christchurch Control cleared ZK-NCA to descend to 2 000 feet, and cleared the aircraft for the ILS approach for runway 20. The aircraft was 16 nm from the runway threshold at that time. At 1904 the aircraft was descending through 2400 feet with a ground speed of 202 knots when Christchurch Control requested ZK-NCA to reduce speed to less than 175 knots. The pilot acknowledged this, and reported established on the approach and slowing up. Control thanked him and instructed him to contact Christchurch Tower.

1.1.14 ZK-NCA reported to Christchurch Tower at 1904:52 that the aircraft was established on the ILS. Christchurch Tower replied "continue number one, (Boeing) 737 to roll ahead". ZK-NCA was 7 nm from the threshold at 2100 feet.

1.1.15 Christchurch Tower cleared ZK-NCA to land at 1907:01, and the pilot made a normal acknowledgement. The aircraft was 2.5 nm from the runway threshold and descending through 600 feet. No further transmissions were heard from ZK-NCA.

1.1.16 ZK-NCA continued descending, to collide with trees and flat pasture land 1.2 nm from the runway threshold. The last Air Traffic Control radar return from ZK-NCA was recorded at 1907:29, with the aircraft descending through 200 feet and 1.4 nm from the threshold.

1.1.17 The aerodrome controller saw that the radar return from ZK-NCA had ceased, and the aircraft did not arrive on the runway or make any radio call. At 1909 the controller called ZK-NCA several times without response, and confirmed with Christchurch Control that ZK-NCA was not back on their frequencies. At 1910:48 he telephoned the Aerodrome Fire Service to initiate the aircraft crash emergency response, reporting ZK-NCA missing on final approach. At 1914:17, in a telephone call from the Aerodrome Fire Chief, he advised that the aircraft appeared to be on short finals about 1 mile beyond the threshold of runway 20.

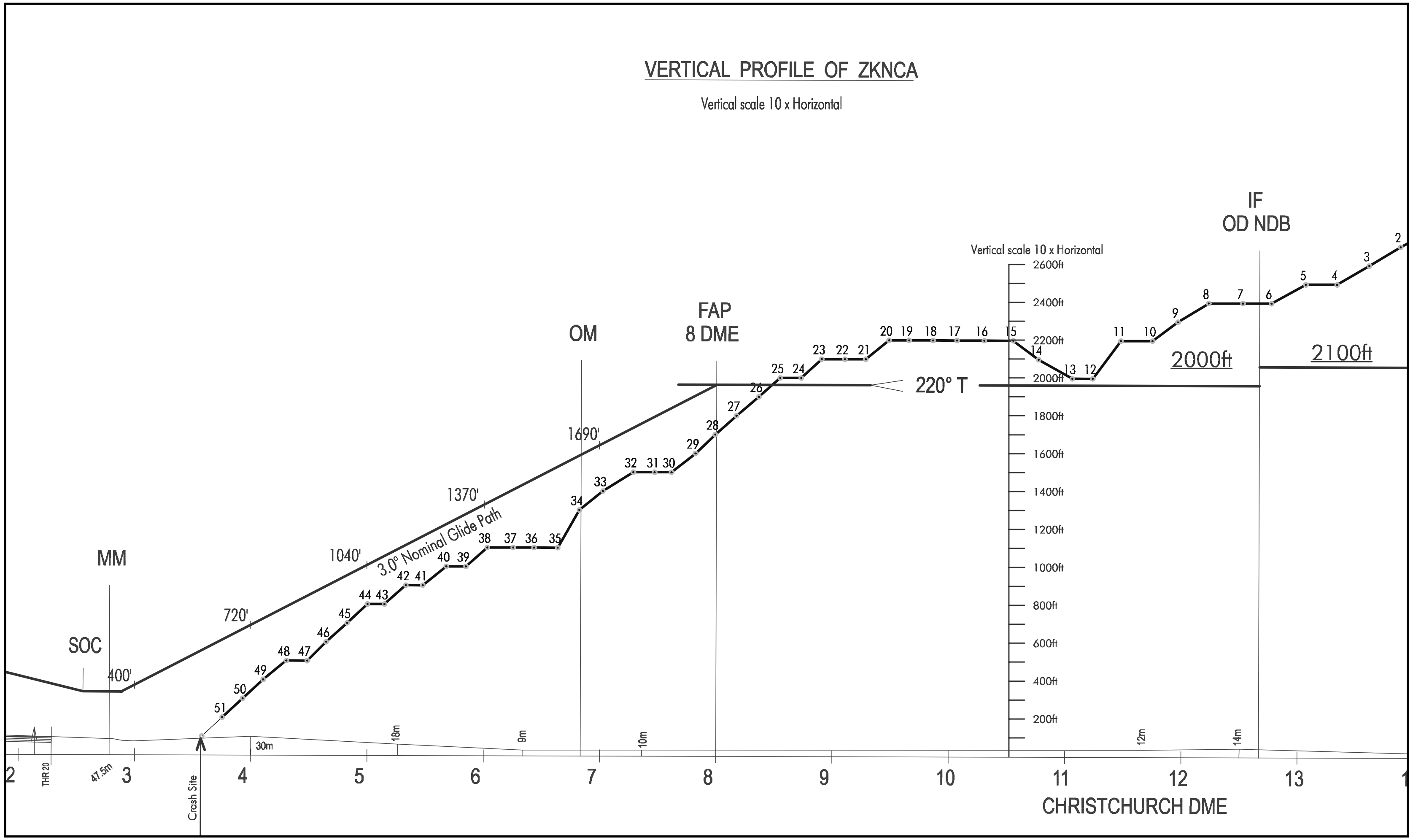



**Figure 3**
**Air Traffic Control radar vertical profile of ZK-NCA on the Christchurch 20 ILS approach**

| | TIME | ALT | GROUND SPEED |
|---|---|---|---|
| 1 | 19:03:26 | 2800' | 186 |
| 2 | 19:03:31 | 2700' | 191 |
| 3 | 19:03:36 | 2600' | 195 |
| 4 | 19:03:41 | 2500' | 197 |
| 5 | 19:03:46 | 2500' | 199 |
| 6 | 19:03:51 | 2400' | 200 |
| 7 | 19:03:55 | 2400' | 202 |
| 8 | 19:04:00 | 2400' | 202 |
| 9 | 19:04:05 | 2300' | 201 |
| 10 | 19:04:09 | 2200' | 199 |
| 11 | 19:04:14 | 2200' | 196 |
| 12 | 19:04:19 | 2000' | 194 |
| 13 | 19:04:24 | 2000' | 192 |
| 14 | 19:04:29 | 2100' | 191 |
| 15 | 19:04:34 | 2200' | 189 |
| 16 | 19:04:39 | 2200' | 186 |
| 17 | 19:04:43 | 2200' | 182 |
| 18 | 19:04:48 | 2200' | 177 |
| 19 | 19:04:53 | 2200' | 172 |
| 20 | 19:04:58 | 2200' | 167 |
| 21 | 19:05:03 | 2100' | 162 |
| 22 | 19:05:07 | 2100' | 159 |
| 23 | 19:05:12 | 2100' | 155 |
| 24 | 19:05:17 | 2000' | 152 |
| 25 | 19:05:22 | 2000' | 150 |

| | TIME | ALT | GROUND SPEED |
|---|---|---|---|
| 26 | 19:05:27 | 1900' | 147 |
| 27 | 19:05:32 | 1800' | 145 |
| 28 | 19:05:37 | 1700' | 143 |
| 29 | 19:05:41 | 1600' | 142 |
| 30 | 19:05:46 | 1500' | 139 |
| 31 | 19:05:51 | 1500' | 137 |
| 32 | 19:05:56 | 1500' | 137 |
| 33 | 19:06:00 | 1400' | 149 |
| 34 | 19:06:05 | 1300' | 140 |
| 35 | 19:06:10 | 1100' | 139 |
| 36 | 19:06:15 | 1100' | 140 |
| 37 | 19:06:20 | 1100' | 146 |
| 38 | 19:06:25 | 1100' | 150 |
| 39 | 19:06:29 | 1000' | 147 |
| 40 | 19:06:34 | 1000' | 145 |
| 41 | 19:06:39 | 900' | 144 |
| 42 | 19:06:44 | 900' | 137 |
| 43 | 19:06:49 | 800' | 134 |
| 44 | 19:06:53 | 800' | 128 |
| 45 | 19:06:58 | 700' | 124 |
| 46 | 19:07:03 | 600' | 127 |
| 47 | 19:07:08 | 500' | 120 |
| 48 | 19:07:13 | 500' | 128 |
| 49 | 19:07:18 | 400' | 139 |
| 50 | 19:07:23 | 300' | 136 |
| 51 | 19:07:27 | 200' | 141 |

**Figure 4**
**Air Traffic Control radar data of ZK-NCA on the Christchurch 20 ILS approach as plotted in Figure 3**

1.1.18 The Aerodrome Fire Service promptly activated the emergency plan by notifying Police, Fire and Ambulance services. A search for the aircraft began, with several Police and Fire Service units in the area from 1915 onwards. Ground visibility in the area was poor in fog and darkness, and there was no additional position guidance such as witnesses or an emergency locator beacon (ELT) signal. A helicopter was on standby, but conditions were unsuitable for a helicopter search. The area was sparsely populated farmland with limited road access and no illumination. Some transient confusion occurred from incorrectly relayed or recorded geographical coordinates, which expanded the search area for a time. At 2124 foot searchers found the aircraft wreckage, and first aid and ambulance assistance was provided for 2 surviving passengers. The other 8 occupants had been killed in the accident.

## 1.2 Injuries to persons

1.2.1

| Injuries | Crew | Passengers | Others |
|---|---|---|---|
| Fatal | 1 | 7 | - |
| Serious | - | 2 | - |
| Minor/nil | - | - | - |

## 1.3 Damage to aircraft

1.3.1 ZK-NCA was destroyed by collision with trees and the ground.

## 1.4 Other damage

1.4.1 Three poplar trees were severed by the collision.

## 1.5 Personnel information

1.5.1

| | |
|---|---|
| pilot: | male, aged 52 years |
| licence and ratings: | commercial pilot licence (aeroplane), instrument rating, D category instructor rating. |
| aircraft type ratings: | Piper PA 34, PA 23-250, PA 31-350; various single-engine aeroplane types. |
| medical certificate: | class 1, valid to 22 June 2003 |
| last IFR operational competency assessment: | 16 April 2003 |
| last instrument rating renewal: | 21 October 2002 |
| last biennial flight review: | 20 September 2001 |
| flying experience: | total, aeroplane 4325 hours<br>total, multi-engine 1191 hours<br>total, PA31 type 820 hours<br>total, last 90 days 82 hours<br>total, instrument flight 151 hours<br>total, night flight 24 hours |
| duty time: | about 12 hours |
| rest before duty: | about 12 hours |

1.5.2 The pilot was one of 2 principals of Air Adventures, and was also chief executive, director of operations, chief pilot and instructor of the company.

1.5.3 He had trained and qualified for his private pilot licence in 1971. In 1992 he qualified for his commercial pilot licence (aeroplane), and shortly thereafter started flying single-engine aircraft as a commercial pilot on charter operations with a new company in Christchurch.

1.5.4 For some years before he completed his commercial pilot licence the pilot had been the marketing manager of a cellphone company.

1.5.5 In 1994 he and another person started Air Adventures, initially operating a PA32 6-seat single-engine aircraft. His principal activity, as chief pilot, was flying this and other single-engine aircraft on visual flight rules (VFR) scenic charter flights around South Island. In 1998 Air Adventures purchased another Christchurch company which operated twin-engine aircraft, and in 1999 he began to fly PA34 and PA23 types on VFR charter flights. Other company pilots flew these aircraft on IFR operations.

1.5.6 In May 2000 the company acquired ZK-NCA for a period of about one year, and the pilot began flying the PA31 type. He also started Instrument Rating training, which he completed in December 2000. Following this, he flew the company twin-engine aircraft on IFR operations as one of a 2-pilot crew, in addition to VFR operations as a single pilot. In September 2001 he completed a routine operational competency assessment on the PA23 aircraft as a single pilot on

IFR operations, and thereafter flew the twin-engine aircraft on IFR operations as a single pilot, as well as VFR operations on the other company aircraft.

1.5.7 The company operated a PA31-310 Navajo aircraft, ZK-WHW from December 2001 until July 2002 when it was replaced by ZK-NCA. In October 2002 the company phased out its single-engine aircraft operations, and thereafter the pilot flew only ZK-NCA, on a mixture of IFR and VFR operations.

1.5.8 Typical flights in ZK-NCA were from Christchurch to various scenic destinations such as Milford Sound, Mount Cook or Kaikoura, and return; some flights had a short IFR segment to facilitate departure from or return to Christchurch, but were mostly VFR. For the 90 days before 6 June the pilot's logbook recorded a total of 3.30 hours of instrument flight time, with 7 instrument approaches. In the same period he had logged 3.15 hours of night flying, which was not also recorded as instrument flight time. He had flown ILS approaches at Christchurch on 22 March and 17 April. He had made night landings, at Christchurch, on 14 April, 11 May and 23 May.

1.5.9 The pilot had completed routine operational competency assessments in ZK-NCA for single-pilot IFR operations at 180-day intervals, as required, the last on 17 April 2003. The assessment records were unremarkable, with average marks.

1.5.10 The pilot had last flown on 30 May 2003, in ZK-NCA, from Christchurch to Westport, Greymouth, and return. He had been on duty on 5 June, without flying. His partner reported that he had a normal night's sleep, and was his normal self on the morning of 6 June, before departing on the flight to Palmerston North.

1.5.11 The last routine medical for the renewal of the pilot's class 1 medical certificate was on 23 December 2002. The only endorsement on his medical certificate was that half-spectacles must be readily available. The only abnormality found on his routine medicals had been a hearing loss in his left ear in 1992, which had required a more frequent audiogram. The last Civil Aviation Authority (CAA) assessment, made in December 2001, of his cardiovascular incapacitation risk over a 5-year period was 2.5%. The corresponding risk within the New Zealand population, for age and gender, was 3.8%.

## 1.6 Aircraft information

1.6.1 ZK-NCA was a Piper PA31-350 Navajo Chieftain twin-engine aeroplane, serial number 31-7405203, manufactured in 1974. It was imported into New Zealand from the United States in 1990, at which time it had flown 2446 hours. It was issued with a non-terminating Certificate of Airworthiness in the standard category. After operating in North Island until 1998 it was registered to Air Adventures in May 2000, when it had flown a total of 12547 hours. It was subsequently re-registered to Air Adventures in July 2002.

1.6.2 An approved aerodynamic modification had been made to the aircraft in 2000. This involved fitting vortex generators to the wings, designed to improve stalling characteristics and asymmetric handling. The main effect was to allow an increased take-off weight, of 3342 kg (7368 lb), up from 3175 kg (7000 lb). Other weights were unchanged.

1.6.3 ZK-NCA was maintained in accordance with the Air Adventures operator's maintenance manual by a principal maintenance contractor based in Nelson. The last scheduled maintenance, an Event 2 inspection and an Annual Review of Airworthiness, was completed on 18 March 2003 at a total time in service of 13123 hours. The next scheduled maintenance, an Event 3 inspection, was due at 13173 hours total time in service, or on 7 January 2004, whichever came first. The aircraft had been booked in for this maintenance in the second week of June 2003.

1.6.4 The aircraft had accumulated a total time in service of 13175 hours, as at 30 May 2003.

1.6.5 Two Lycoming engines were fitted; a TIO-540-J2BD type on the left, and a LTIO-540-J2BD type on the right. The left engine, serial number L-3801-61A, had run 16596 hours since new, and 617 hours since overhaul. The right engine, serial number L-2200-68A, had run 7281 hours since new, and 1580 hours since overhaul.

1.6.6 The engines were fitted with Hartzell propellers, types HC-E3YR-ATF (left), and HC-E3YR-ALTF (right). The left propeller was serial number DJ7798, and the right propeller was serial number DJ8241A. Both propellers had run 858 hours since overhaul. Both propellers had been dismantled and inspected in accordance with their 4-yearly inspection requirement on 22 May 2003.

1.6.7 A review of maintenance documents showed that all scheduled maintenance had been recorded. The only outstanding item recorded on the aircraft technical log was the cabin heater, which was signed off on 18 March 2003 as "unserviceable" and "deferred" by the maintenance engineer. The engineer had disabled the heater pending the completion of a repetitive pressure test required by Airworthiness Directive DCA/GEN/26, which he planned to do during the next maintenance visit in June. However, other pilots who had flown ZK-NCA in May reported the heater to be serviceable. The overhauled heater had been installed in 1996, and had since run 463 hours, recorded on its Hobbs meter.

1.6.8 Maximum take-off weight for the aircraft was 3342 kg, and maximum landing (and zero fuel) weight was 3175 kg. The empty weight was 2160 kg. The centre of gravity limits at 3342 kg were between 126 inches (320 cm) and 135 inches (343 cm) aft of datum.

1.6.9 The computer-generated loadsheet calculated the take-off weight as 3337 kg and the landing weight as 3157 kg. The centre of gravity in each case was calculated at 133 inches aft of datum. Standard weights of 77 kg per occupant were used, and the total fuel weight was 377 kg. Differing fuel burn figures for the flight had been generated, however, with 180 kg on the loadsheet and 235 kg on the navigation log. The 350 litres of fuel loaded at Palmerston North weighed 252 kg.

1.6.10 The aircraft was equipped and approved for single-pilot IFR operations. Standard flight instruments were fitted to both the pilot and co-pilot panels. Avionics items were Bendix or King equipment, and consisted of 3 very high frequency (VHF) communications radios, 2 VHF navigation receivers (NAV 1 and 2), marker beacon receiver, one distance measuring equipment (DME) system, 2 automatic direction finder (ADF) receivers, audio and intercom systems, one radio altimeter, one global positioning system (GPS) and one ELT. VHF navigation information was presented to the pilot on a horizontal situation indicator (HSI), by a flight director on the attitude director indicator, and by a secondary course deviation indicator (CDI). ADF or VOR bearings were presented on a radio magnetic indicator (RMI). A Bendix Altimatic V autopilot was fitted, with altitude hold, heading, navigation, approach and go-around modes available. The pilot also had a portable Garmin Pilot III GPS mounted on the instrument panel.

1.6.11 Reports from other pilots who had flown ZK-NCA recently, and from the avionics engineer who maintained the equipment, indicated that NAV 1 was serviceable, producing normal indications on the HSI for VOR navigation and for ILS approaches; however the flight director was unserviceable. NAV 2 was reported to be unsatisfactory or unserviceable; it was not normally used for instrument approaches. The radio altimeter was unserviceable and disconnected, but remained on the instrument panel. The autopilot was reported to be serviceable, with its modes functioning normally. The normal company practice on an ILS approach was to hand-fly the aircraft, using raw ILS data from the HSI.

1.6.12 CAA Rule part 135 required that the instruments and equipment installed in the aircraft were in operable condition, except as provided for by a minimum equipment list (MEL) approved under part 91 for that aircraft. Air Adventures had no MEL approved for ZK-NCA.

## 1.7 Meteorological information

1.7.1 A complex low covered New Zealand on 6 June 2003. An associated rain band crossed South Island during the afternoon with patches of moderate rain or drizzle in many places in Canterbury. High dew point temperatures were maintained during the afternoon. Late afternoon satellite imagery indicated that the cloud started to clear the region, which instigated the development of fog in the evening.

1.7.2 During the afternoon Christchurch Aerodrome reported drizzle with visibilities between 1000 and 5000 m, and cloud generally overcast at 200 to 400 feet, except between 1400 and 1500, when cloud was scattered at 500 feet and broken at 1500 feet. At 1730 visibility fell to 500 m in drizzle, and thereafter was reported between 400 and 1000 m. The wind remained light and variable.

1.7.3 The 1700 special weather report (SPECI) for Christchurch Aerodrome, which the pilot received before departure from Palmerston North, was:

> surface wind variable 3 kt, visibility 1000 m in light drizzle, cloud overcast at 400 feet, temperature 10°, dewpoint 9°, QNH 999; temporarily visibility 15 km, cloud scattered at 600 feet and broken at 2000 feet; temporarily visibility 1500 m in drizzle.

1.7.4 The 1900 SPECI for Christchurch Aerodrome was:

> surface wind variable 3 kt, visibility 500 m in light drizzle, cloud scattered at 100 feet, overcast at 500 feet, temperature 10°, dewpoint 10°,QNH 999; temporarily visibility 15 km, cloud scattered at 400 feet and broken at 1800 feet; temporarily fog with cloud broken at 200 feet.

1.7.5 The Christchurch ATIS, Information Whiskey issued at 1811, which the pilot was referred to at 1853, with the change to runway 20 was:

> runway-in-use 20, runway wet; expect ILS approach; surface wind 030º/3kt;
> visibility 500m in drizzle; cloud scattered at 200 feet, overcast at 700 feet;
> temperature 9º, dewpoint 9º; reported 2000 foot wind 320º/29kt; QNH 999.

1.7.6 The TAF for Woodbourne, the nominated alternate aerodrome, was:

> surface wind 260°/8 kt, visibility 20 km, light rain showers, cloud few at 1500 feet, broken at 3000 feet, 2000 foot wind 300°/20 kt.

1.7.7 The crew of the Boeing 737 aircraft which flew the Christchurch 20 ILS approach about 4 minutes before ZK-NCA reported that they had descended through a layer of cloud at about 4000 feet, which made the evening dark. There was a local layer of cloud over the Christchurch area which they descended into at about 600 feet on the approach. They had no problem with the ILS approach, and were able to see the runway approach lights from about 200 feet above the decision altitude (DA) for the approach, and estimated the visibility at DA to have been 1000 to 1500 m.

1.7.8 Ground visibility around Christchurch Aerodrome and in the search area north of runway 20 was limited by fog and drizzle all night, and was estimated to vary between 50 and 400 m.

## 1.8 Aids to navigation

1.8.1 Christchurch Aerodrome was equipped with an ILS for each end of the main runway 02/20. Middle and outer marker beacons were included. Two co-sited very high frequency omni-directional range/distance measuring equipment (VOR/DME) served the aerodrome. Christchurch VOR/DME was located 0.5 nm south of runway 02, and Eyrewell VOR/DME was located 8 nm north-west. NDBs were located at Woodend (262) and Burnham (374), to provide intermediate fixes for each ILS approach (see Figure 5).

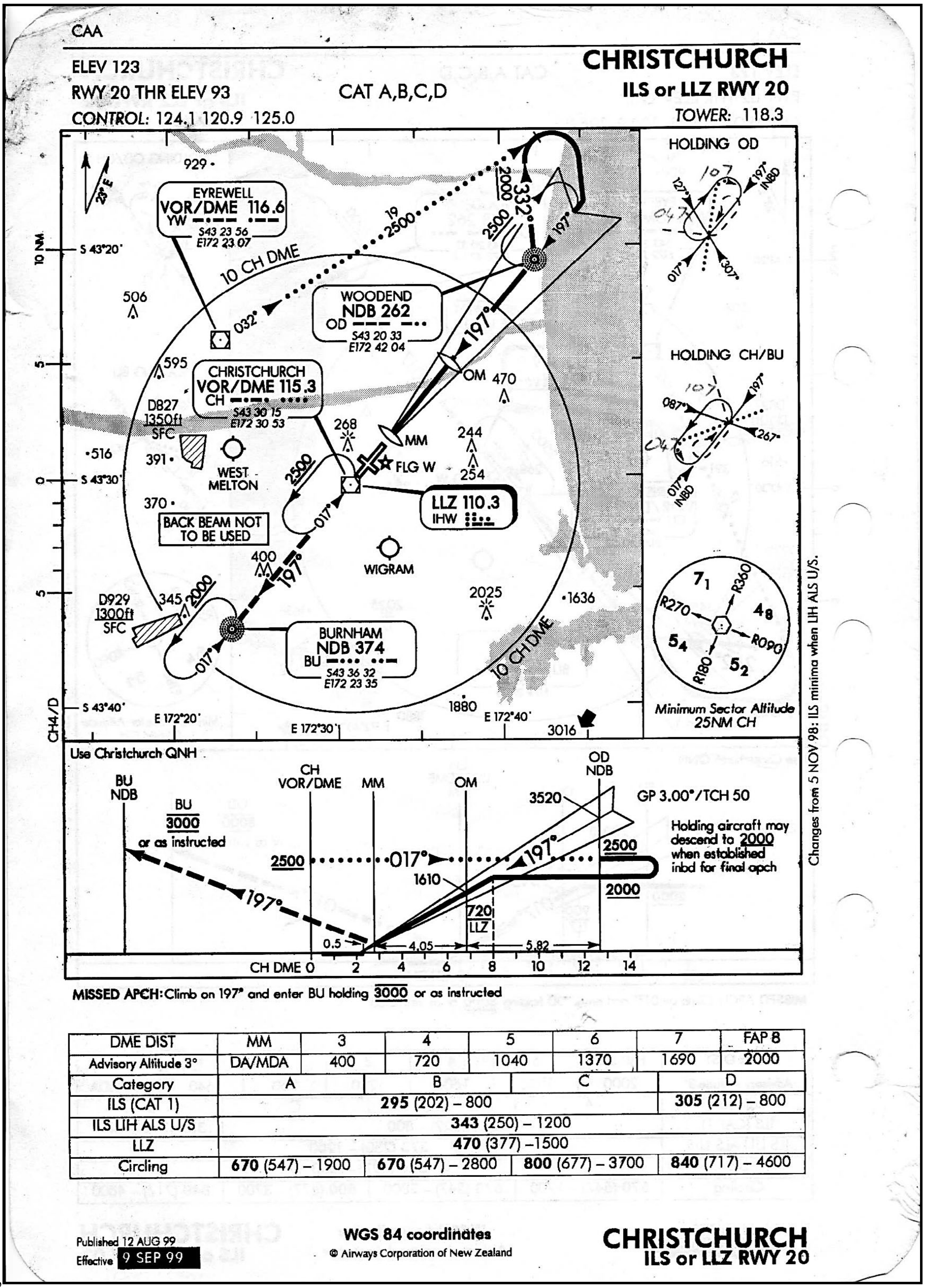



**Figure 5**
**Christchurch 20 ILS approach chart from ZK-NCA**

1.8.2 Air traffic control radar information was sourced from a primary radar located on Christchurch Aerodrome and a secondary radar on Cass Peak, 9.5 nm south-east. This location enabled radar coverage of approaching aircraft down to ground level at Christchurch. Christchurch Approach was the air traffic control facility providing radar control service to ZK-NCA until the pilot reported established on the ILS and changed radio frequency to Christchurch Tower. Christchurch Tower was also equipped with a radar display to assist the aerodrome controller with his visual control task, such as for sequencing traffic, but not for radar control purposes.

1.8.3 Airways Corporation made available air traffic control radar recordings containing the position and altitude of ZK-NCA on descent and approach to Christchurch Aerodrome. The derived plan view of the radar track shows the aircraft intercepting the 20 localiser normally, then flying a slightly erratic track until the last radar return (Figure 2). The derived vertical profile (Figure 3) shows the aircraft levelling briefly at 2000 feet, climbing some 200 feet while slowing, then commencing descent about 0.5 nm before reaching the glide path, and continuing to descend 200 to 300 feet below the glide path until the last radar return. The table (Figure 4) shows the time, radar altitude and derived ground speed (knots) for each plotted point.

1.8.4 A similar vertical profile for the Boeing aircraft immediately preceding ZK-NCA, which had flown an autopilot-coupled approach, showed close correlation with the nominal ILS glide path.

1.8.5 Shortly after the accident, at 1925, the runway 20 ILS was declared unserviceable, as a routine precaution. Other aircraft arrivals continued, using runway 02 ILS. A technical investigation and check of the equipment was promptly carried out by Airways Corporation personnel. No anomalies were found with the 20 ILS or other navigation aids. The 20 ILS was returned to service on the following morning, after visual checks were made.

## 1.9 Communication

1.9.1 Normal radio communications between ZK-NCA and various appropriate air traffic control facilities were made during the flight. Electronic recordings disclosed only routine exchanges, and nothing of significance to the accident.

1.9.2 Electronic recordings of telephone communications from Christchurch Tower established the actions taken and the timing of the aircraft crash emergency response, and the subsequent progress of the ground search for ZK-NCA.

## 1.10 Aerodrome information

1.10.1 Christchurch Aerodrome had a main instrument runway, 02/20, oriented 017°/197° magnetic (M), with a landing distance of 3288 m. Runway 20 had a threshold elevation of 93 feet, and sloped up at 0.28°. The terrain north-east of the aerodrome was substantially flat, with a slight downslope to the Waimakariri River 4 nm away. Runway 20 was equipped with high intensity white edge lights, green threshold and wingbar lights, and red end lights. An array of high intensity white approach lights, comprising 5 crossbars and a coded centre line extended 600 m from the runway 20 threshold. A precision approach path indicator (PAPI) light system gave visual guidance of a 3° approach to the touchdown zone. All of these lights were in operation at the time of the ZK-NCA accident.

1.10.2 The ILS approach procedure to runway 20 commenced from Woodend NDB, not below 2000 feet, on the localiser track of 197°M. The 3° glide path was intercepted at 2000 feet, at 8 nm DME (5.7 nm from the threshold). The relevant procedure minima (category 1 ILS) were: DA 295 feet (202 feet above the runway), and a flight visibility of 800 m. The position of the normal DA corresponded with the middle marker beacon. The missed approach procedure was to climb straight ahead to Burnham NDB at 3000 feet (see Figure 5).

## 1.11 Flight recorders

1.11.1 No flight recorders were fitted, or required to be fitted to this aircraft.

1.11.2 The portable Garmin Pilot III GPS mounted in ZK-NCA recorded a track plot of both flights, without altitude information. These data were used to confirm times of events, and to correlate with the Airways radar recordings of the approach to Christchurch. The Garmin GPS 100 which was part of the aircraft equipment did not contain any track memory.

## 1.12 Wreckage and impact information

1.12.1 The first point of impact in the accident sequence was between the right wingtip of ZK-NCA and a poplar tree about 10 feet above ground. This was followed closely by 2 more tree impacts on the left side of the aircraft. One of these was severe, on the fuselage side and left wing root area, leading to separation of the left wing. The relative heights of the 3 tree strikes indicated that the aircraft had been banked about 5° left, while the distance to the first ground scar, and the shallowness of the scar indicated that the aircraft had been descending slightly or in nearly level flight at moderately high speed. The first tree impact was 1.27 nm from the runway 20 threshold, on a bearing of 013°M.

1.12.2 The first ground scar from the aircraft commenced 30 m past the first tree, and was followed by a series of ground marks and a trail of separated aircraft wreckage across a level pasture for a further 160 m. These marks were consistent with the aircraft having rolled left, to arrive on the ground inverted, and then sliding on the cabin roof across the paddock, gyrating to trail the right wing as it went.

1.12.3 At the southern side of the paddock, the aircraft fuselage had collided heavily, left side first, with a substantial willow tree. The impact separated the tail section and empennage, and further collapsed the cabin area. The remaining cabin section of the fuselage and the right wing slid a further 27 m, crossing a small stream before coming to rest. The pilot's Instrument Flight Guide was found nearby, open at the Christchurch runway 20 ILS approach chart. The distance the main wreckage travelled from the first tree strike was 207 m, on a track of 204° magnetic. Some items, such as the aircraft battery, had travelled a further 40 m.

1.12.4 Propeller slash marks in the ground at 40 m and 105 m along the trail, and matching rotational damage to the blades were consistent with both propellers turning under some engine power. Little fuel was found in the ruptured wing fuel tanks, but appreciable grass staining along the wreckage trail was consistent with fuel spillage.

1.12.5 The extremities of all aircraft components were accounted for around the site, and all control surfaces were present. There was no evidence of any bird strike on the aircraft. Verification of primary and secondary control cable systems was not possible because of disruption. All 3 undercarriage legs were extended, and the flaps were set to about 15° down. All 10 occupied seats had separated from the cabin floor tracks during the final disruption of the cabin, but the seats, with restrained occupants, remained in close proximity to the main wreckage.

1.12.6 Significant readings and settings from the pilot's instrument panel were:

HSI heading 202°, course set to 197°, heading bug 192°, NAV, HDG and G/S OFF flags showing, CDI centred, G/S pointer full down.

Secondary ILS indicator heading set to 195°, CDI centred, G/S pointer 1 dot down, LOC and G/S flags showing.

Altimeter subscale set to 998, setting knob broken off.

RMI heading 194°, both selectors to ADF; ADF 1 034°, ADF 2 190°, no flags.

Clock stopped at 7.52:28.

Other instruments were broken or read zero.

1.12.7 The only significant readings from the co-pilot's instrument panel were:

Altimeter subscale set to 1010.

Directional gyro 222°.

1.12.8 Significant settings from the radio panel were:

COMM 1 on, 130.30.

COMM 2 on, 127.20.

COMM 3 on, broken and unreadable.

NAV 1 on, 110.30.

NAV 2 on, 115.30.

ADF 1 on, 262 (on both tuning heads), ADF selected.

ADF 2 on, 286, ADF selected.

DME on, frequency unreadable.

Transponder on, ALT selected, code 5527.

Audio panel COMM 3 selected, COMM 3 to phone, marker beacon set to LOW.

1.12.9 Significant engine instrument readings were:

Manifold pressure: number 1 25 inches, number 2 43 inches.

Fuel flow: number 1 30gph, number 2 22gph.

Hobbs meter 3704.35.

1.12.10 Significant secondary control settings were:

Cabin heater inlet open, temperature mid position, defrost off.

Cabin air off, cabin exhaust partly open.

Fuel selector: both selected to inboard, crossfeed off, firewall shutoffs open.

Fuel gauges: left tank 60%, right tank 40 %.

Cowl flaps both closed.

1.12.11 Overhead panel switch positions were:

Magneto switches all on.

All lights on, panel lights mid-brightness.

Windscreen heat: left on, right missing; pitot heats off; prop de-ice off; surface de-ice marked U/S.

Ground vent fan off; seat belts on; air control on.

## 1.13 Medical and pathological information

1.13.1 Post mortem examination of the deceased passengers and crew found that each suffered multiple injuries which would have been immediately fatal.

1.13.2 Post mortem examination of the pilot found evidence of long-standing moderately severe coronary artery disease affecting the left anterior descending and right coronary arteries. There was no evidence of acute ischaemic change to the myocardium, and no indication of a previous or recent coronary artery occlusion causing acute myocardial infarction. No symptoms of coronary disease had been recorded on his CAA medical file, and none had been reported to his family medical advisers.

1.13.3 Toxicological examination showed that 5 of the 7 deceased passengers had a carbon monoxide saturation of blood haemoglobin of 6 to 8 %, while the other 2 passengers had levels of 2% and 3%. Some passengers had low to moderate levels of blood alcohol, consistent with the beverages consumed on the flight.

1.13.4 Toxicological examination of the pilot for medicinal and other common drugs, and for alcohol, found none present. His carbon monoxide level was 1%.

1.13.5 Normal levels of carbon monoxide saturation of blood haemoglobin are up to 1% to 2% for non-smokers, and 5% to 6% for smokers. A level above 15% may cause some cognitive impairment, while levels exceeding 50% are considered life-threatening.

## 1.14 Fire

1.14.1 Fire did not occur.

## 1.15 Survival aspects

1.15.1 The shallow angle of impact which the aircraft made with the ground, and the long ground slide across the paddock should have generated only moderate vertical and longitudinal deceleration forces, probably within the tolerance of the occupants and their seat restraint systems. Two lateral tree impacts, however, did intrude into the cabin and destroy its integrity. The first of these was while the aircraft was still flying, and caused substantial intrusion to the left front cabin area. The second tree impact, still at high speed after the inverted aircraft had slid 160 m across the paddock, was also on the left side of the cabin, further to the rear. This separated the rear fuselage and tail section completely, and led to the detachment of the cabin roof, separation of the seats from their rails, and disruption of the cabin as protective space for the occupants.

1.15.2 The blunt object trauma from these tree impacts probably caused fatal injuries to the occupants directly, rather than flailing or deceleration injuries while restrained within the cabin. Some injuries may have resulted from the detachment of the cabin roof. The two survivors, seated in the co-pilot and front passenger seat on the right, were both outside the intrusive path of the trees, and received lesser, but serious injuries.

1.15.3 Although the Aerodrome emergency response was begun promptly, with a good initial search position, the search was hampered by the lack of any ELT signal to provide guidance. The ELT had been triggered by the impact, but failed because its aerial cable was separated by the detachment of the aircraft tail section. There were no witnesses, and nothing for searchers to see, hear or smell until close to the accident site in the fog and darkness.

1.15.4 A large search effort by Police and Fire Service units was underway quickly, but the environmental conditions at the time made a foot search inevitable, and likely to be slow.

1.15.5 As the search progressed, Airways Corporation developed further information on the last radar return, after the radar record was reviewed. The geographical coordinates produced were incorrectly relayed or recorded at one stage, resulting in some additional Police units being deployed in an incorrectly expanded search area. This did not take searchers away from the correct area, however, and probably did not lengthen the search time before the site was found.

1.15.6 The post mortem examinations indicated that the severity of injuries to the deceased occupants would have been immediately fatal, and that if the search and rescue had taken less time, no increased potential for their survival would have ensued. The 2 survivors, however, probably would have benefited from an earlier rescue.

## 1.16 Tests and research

1.16.1 The pilot's altimeter was tested in an approved avionics facility. This was a Smiths encoding altimeter, part number 001-200-193, serial number 0575004. A comparison test in a pressure chamber, with a standard altimeter on the same subscale setting, 998, demonstrated close correlation and smooth needle movements, both climbing and descending, between zero and 2000 feet, in 100 foot increments. The encoder function was tested on an electronic test rig, between zero and 1000 feet, in 100-foot increments. The code displayed was within 100 feet at each test point, i.e. within the resolution of the transponder code system.

1.16.2 The Bendix HSI, type IN-831A, serial number 2669, was examined, and components tested, at an approved avionics facility. Impact forces had caused some internal damage and distortion, with a bearing race broken and its parts jamming several mechanical functions. These broken parts were removed, allowing assessment of the mechanism. The electrical connections and meter movements, which operated flags and indicator pointers, were tested. With the exception of one wire to the heading flag which had detached in a manner consistent with accident damage, all tested normally. The opinion of the test engineer was that the HSI was working correctly prior to impact.

1.16.3 The glide slope receiver, which provided the ILS glide slope signal to the HSI and secondary ILS indicator, could not be tested because of severe accident damage.

1.16.4 The engines were stripped and inspected at an approved engine overhaul facility. Both were found to have been in good condition, showing good lubrication and normal wear patterns consistent with hours run. They were considered to have been serviceable until the accident stoppage, but did not show any evidence to quantify the power being developed at the time.

1.16.5 The propellers were stripped and inspected at an approved propeller shop. Both were found to have been in good condition before the substantial damage resulting from the accident occurred. Blade damage on each propeller was fairly uniform, consistent with a medium engine power and low pitch setting when the blades struck the ground.

1.16.6 The Janitrol cabin heater, model B 4050, serial number 7771440, was tested in accordance with DCA/GEN/26, which required a pressure leakdown test of the combustion tube every 2 years. The combustion tube was pressurised to 6 pounds per square inch (psi), and the pressure drop timed. In 2 minutes it had dropped to 5 psi. The maximum allowable pressure drop for the heater to remain in service was from 6 psi down to 1 psi in 45 seconds.

1.16.7 AVGAS fuel samples from the dispenser at Palmerston North aerodrome, used to refuel ZK-NCA before the accident flight, were analysed. The fuel was found to be uncontaminated, bright and clear, and within specifications for AVGAS.

1.16.8 Cellphones carried by the passengers and pilot on the aircraft were recovered, and the timing and details of their use during the flight was discovered from the telephone companies. A number of calls to and from these cellphones were made during the flight. The only call that was made during the time of the ILS approach, after 1904, was from the pilot's cellphone to his home. This call started at 1904:36, and continued for 3 minutes and 9 seconds. The call was initiated through a cell site in Belfast, 4 nm north-east of Christchurch Aerodrome, and was terminated through a cell site 0.6 nm east of the accident site. During the flight the only other call on the pilot's cellphone was one received at 1752, of 16 seconds duration.

## 1.17 Organisational and management information

1.17.1 Air Adventures New Zealand Limited was formed in 1994 by the pilot and one other person, to operate VFR single-engine aeroplanes principally on tourist scenic charter flights around South Island. The pilot initially held the position of chief pilot, with the other principal as chief executive and maintenance controller. The company expanded over the next few years, to operate 4 single-engine aircraft and to employ 3 pilots.

1.17.2 In 1998 Air Adventures purchased another Christchurch-based company which operated twin-engine aircraft on a mixture of VFR scenic and IFR charter and freight operations. Since the pilot was not appropriately qualified, he continued as chief pilot, VFR, with another pilot as chief pilot, IFR. The company manual and procedures were expanded for IFR operations, and in 1999 CAA issued a Part 119 Transitional Air Operator Certificate, in accordance with the Civil Aviation Rule part then coming into effect.

1.17.3 In 2000, ZK-NCA was added to the company fleet, then of 6 aircraft, enabling 9 passengers to be carried in one aircraft. The previous largest aircraft carried 5 passengers. During 1999 and 2000, the company had frequent turnover of chief pilots, IFR. The pilot completed his instrument rating in December 2000, and was then able to combine the chief pilot roles for IFR and VFR operations.

1.17.4 In March 2001 CAA certificated Air Adventures under Rule Parts 119 and 135 as a general aviation air transport operator, after approval of the company's new exposition. The aircraft fleet was then 3 aircraft.

1.17.5 In August 2002 the chief executive, the other founding principal in the company resigned, and this role was adopted by the pilot in addition to his other roles of chief pilot and instructor. At that time the pilot's partner was approved as maintenance controller and quality assurance person. Single-engine aircraft operations were curtailed at that time. The fleet was further reduced to one aircraft, ZK-NCA, in January 2003, with one other part-time pilot employed.

1.17.6 CAA carried out routine audits on Air Adventures, the last on 30 January 2003. Seven findings notices were issued, principally non-conformances with the company exposition, of which 4 were closed promptly. Previous audits were unexceptional.

1.17.7 CAA additionally carried out spot checks on Air Adventures. One of these, in May 2000, had been triggered by company pilots or ex-pilots complaining to CAA, mostly about being pressured to conduct VFR flights in unsuitable weather. CAA analysed the company operational risk as "high" at that time. A spot check a year later found improvements, and a subsequent risk assessment was "moderate".

## 1.18 Additional information

1.18.1 The call made from the pilot's cellphone to his home while the aircraft was on the ILS approach was not answered, but was connected to his voicemail instead. His partner listened to the first minute of it shortly afterwards, and heard only the steady noise of aircraft engines. She deleted the recording without listening further. She reported that a similar previous call had resulted from an unintended speed dial selection while the pilot was flying.

1.18.2 The use of cellphones on board aircraft has been identified from numerous occurrence reports overseas as a cause of random interference to the proper functioning of aircraft avionics such as navigation equipment and autopilots. New Zealand Civil Aviation Rule part 91.7(a) stated:

> No person may operate, nor may any operator or pilot-in-command of an aircraft allow the operation of, any cellphone or other portable electronic device that is designed to transmit electromagnetic energy, on any aircraft while that aircraft is operating under IFR.

1.18.3 The United Kingdom CAA in October 2002 conducted a series of laboratory tests which exposed general aviation avionic equipment to simulated cellphone transmissions. A VHF radio, a VOR/ILS receiver with HSI and secondary indicators, and a remote gyro compass system were used. At high signal levels, similar to that attainable from a cellphone 30 cm from the equipment or its wiring, anomalies were produced on all equipment readings except the glide slope indication. These tests confirmed onboard cellphones as an interference source, and endorsed current legislation restricting their use on aircraft.

1.18.4 The Air Adventures passenger briefing cards on ZK-NCA stated, "The use of electronic devices is not permitted unless approved by the Captain".

1.18.5 The standard wake turbulence separation prescribed between a light aircraft following a medium (such as a Boeing 737) aircraft is 3 minutes, or 5nm if under radar control. ZK-NCA was 3 minutes 50 seconds, or about 9nm behind the preceding aircraft.

1.18.6 The pilot had 3 incidents logged in CAA records involving IFR operations in ZK-NCA or ZK-WHW. Two of these involved a transition to IFR on VFR flights returning to Christchurch, and the third, in January 2002, involved the pilot twice failing to establish the aircraft on the Christchurch 20 ILS approach, with radar intervention being required each time. A visual approach was subsequently successful. The pilot was flying ZK-WHW for the first time and was unfamiliar with the avionics fit, which led to his difficulty with systems management during the approach.

1.18.7 CAA has proposed an amendment to CA Rule Part 125, which will require by 2005 a terrain awareness warning system (TAWS) to be fitted to Part 125 aircraft. This will include piston engine aircraft over 5700 kg with 10 or more passenger seats; in this case TAWS class B is intended. No such rule is proposed for Part 135 aircraft, below 5700 kg and 10 passengers. An assessment was made of the probable warnings which would be given by such equipment in the circumstances of this accident. Two warnings would have been made during the late stages of the ILS approach, and possibly a third. The first warning would have been a routine "500" call when descending through 500 feet above the runway (about 40 seconds before the first impact); the second, a possible "sink rate" call if the rate of descent increased above computed criteria; and the third warning, a continuous "pull up" call starting about 9 seconds before impact.

1.18.8 TAWS is a development of ground proximity warning systems (GPWS), and is also known as Enhanced GPWS (EGPWS); it uses a terrain database and GPS information to enable earlier warnings than GPWS provides. TAWS class B is a simplified and less costly version more suitable for older and GA aircraft. Several other States have rules in place requiring TAWS, and the International Civil Aviation Organisation has developed standards and recommendations for its use.

# 2 Analysis

2.1 The circumstances in which this accident occurred, in particular the shallow, almost wings-level descent; the position near the end of an instrument approach; the descent below the glide slope on the ILS approach, and the darkness and poor weather conditions are all common ingredients of a controlled-flight-into-terrain (CFIT) type of accident. CFIT accidents have been highlighted as the major serious accident risk in air transport operations worldwide.

2.2 For this accident to fall into the CFIT category, consideration must be made of whether or not the aircraft was in controlled flight. Evidence from the wreckage indicates that engine performance was normal, so probably no loss of engine power had occurred to cause an uncommanded descent. While the pre-impact integrity of the flight control systems could not be verified because of disruption, the nature of the aircraft's track as recorded by radar indicates that the pilot was making a series of lateral corrections in response to his ILS localiser guidance. These lateral corrections, involving small banked turns each way to bring the aircraft back to the centreline, were slightly erratic, but they do show that the aircraft was controllable, and under the control of the pilot.

2.3 The possibility of ZK-NCA being affected by wake turbulence from the preceding Boeing 737 was considered. The separation between the aircraft was substantially more than the specified minima of 3 minutes or 5 nm. These minima have been long established internationally, and proven reliable. It is unlikely that wake turbulence affected the flight path of ZK-NCA at all, and the impact evidence from the accident site was inconsistent with a wake turbulence upset.

2.4 The post-mortem evidence that the pilot had long-standing moderately severe coronary artery disease raises the question of whether he was suffering some level of incapacitation, and thus not able to control the aircraft. However, the post-mortem examination also showed no evidence of any cardiac damage, either recent or previous. Because of this, sudden incapacitation from any cardiac insufficiency is considered unlikely. The surviving passengers' accounts of the pilot's activities at the beginning of the approach also indicate that he was not incapacitated at that stage. However it is not possible to entirely exclude the possibility of a heart attack or transient ischaemia during the instrument approach, because any such evidence would have been precluded by his death shortly afterwards from accident injuries.

2.5 The toxicological evidence showed the absence from the pilot of any common drugs, alcohol or elevated carbon monoxide, so his ability to control the aircraft should not have been so impaired.

2.6 On an ILS approach, the normal procedure is for a pilot to intercept and then fly down the glide slope by first flying level inbound on the localiser track while monitoring the G/S indicator on the HSI for movement towards the centre, and also the DME to anticipate intercepting the G/S, expected at 8 DME in this case. As the G/S indicator centres, descent is started by reducing power and/or increasing drag by lowering landing gear, to achieve an appropriate rate of descent. With a ground speed of about 150 knots, as ZK-NCA had, a good target rate of descent would be 750 feet/minute (as indicated on the vertical speed indicator). Maintaining the aircraft on the G/S is done, in response to G/S indicator movement away from centre, by adjusting the descent rate by pitching the aircraft slightly, and if necessary maintaining the airspeed by engine power changes. The correctness of the G/S is monitored by cross-checking (a couple of times) the aircraft's DME and altitude against the advisory altitude table on the approach chart. At the same time the pilot maintains the aircraft on the approach centre line by making small heading changes in response to localiser indicator movements away from centre.

2.7 This process of continual changes in descent rate and heading in response to respective indicator movements away from centre becomes more demanding as the aircraft closes with the runway because the indicators move further from centre for a given aircraft displacement. This increasing sensitivity requires pilot accuracy and timeliness of control response, and substantial concentration on the task. As the aircraft descends towards DA, the pilot must be prepared also to decide whether he can make a visual landing or whether to make a missed approach. The missed approach must be commenced on reaching DA unless visual contact with runway or approach lights is made.

2.8 The process is optimised and simplified, and is in keeping with normal good airmanship by flying the aircraft on a stabilised approach. This means the airspeed is settled soon after intercepting the G/S, the aircraft configuration (flaps and landing gear) is made, the aircraft is trimmed, and appropriate power settings are established.

2.9 The advantages of the stabilised approach are many:

- the approach will take a little longer, giving the pilot more time to monitor and respond to different information
- the aircraft will have a steady lower descent rate for the pilot to adjust as needed, rather than a descent rate varying substantially as energy is exchanged between speed and height
- the aircraft will remain trimmed and will tend to remain at a steady airspeed by itself
- required engine power changes will be fewer and smaller, if any
- the pilot will have more time, and a lower descent rate, when approaching DA, to look and decide whether he can see to land or must make a missed approach
- overall, the pilot has fewer parameters affecting the aircraft's descent, or adjustments to make, so his manual flying task is easier and allows for more monitoring of other information.

2.10 One further measure which can significantly assist a single-pilot crew in flying an instrument approach in poor weather conditions is to use the autopilot to fly a coupled approach. This relieves the pilot from the detailed skilled task of hand-flying, allowing him more management time to better monitor the approach and prepare for decision-making at minimum altitude. ZK-NCA was capable of flying a coupled approach, following the localiser and G/S automatically, probably more accurately than a human pilot can. The pilot had used the autopilot in the en-route phase of the flight, but had disengaged it shortly before beginning the instrument approach. While hand-flying approaches may have become his normal practice, and some hand flying is necessary for maintenance of skill, a coupled approach would have been very helpful in the prevailing weather conditions. It is noteworthy that the preceding Boeing crew, with 2 pilots to share flying and monitoring tasks, elected to fly a coupled approach on that night.

2.11 The ILS approach has proved over some 50 years of operational service to be a safe and reliable procedure when flown as described. It has useful safety features to allow the pilot to identify any mis-guidance, but it requires as much rigour and method in its execution as any other instrument approach.

2.12 Approaches to busy aerodromes often involve aircraft being sequenced by air traffic control, and differing aircraft approach speeds can make the task more difficult and delay faster traffic. Pilots of slower aircraft are often asked by approach control to maintain higher than optimum speeds until partway through an instrument approach procedure to facilitate the traffic flow. This can lead to pilots of aircraft such as the PA 31 becoming habituated to fly fast unstabilised approaches, whether requested or not. A fast approach flown in a PA31 may be acceptable in good weather where visual conditions are established early, and where runway length is ample. An unnecessarily fast approach flown in poor or marginal weather is likely to produce extra difficulty and increased workload for the pilot to cope with. A good stabilised approach speed for a PA 31-350 is about 110 to 120 knots.

2.13 On the accident approach, ZK-NCA was not asked by air traffic control to fly a fast approach; in fact when about 12 miles out, Christchurch Control asked for its speed to be reduced to below 175 knots, presumably because ZK-NCA was closing with the Boeing 737 ahead.

2.14 The accuracy and serviceability of the navigation aids used on the instrument approach were considered, because of the possibility of the aircraft being under control, but misguided by erroneous information. The Christchurch runway 20 ILS system was obviously functioning normally shortly before ZK-NCA's approach, from the account of the Boeing 737 crew, and from the radar plot of their normal and successful approach. The equipment was investigated and checked after the accident, before being used again, and was found normal. Any deficiency in the performance of the ground ILS equipment was unlikely.

2.15 The ILS receivers and indicators in ZK-NCA could not be checked completely because of accident damage, particularly to the glide slope receiver. The HSI, however, which the pilot customarily used, was examined and checked, and was probably working correctly before the accident. The localiser receiver was probably working normally, again because the radar plot of the aircraft's track was consistent with the aircraft manoeuvring in response to normal guidance. The radar plot of the vertical profile flown by ZK-NCA does show that the aircraft began descending before reaching the glide slope, and continued the descent some 200 to 300 feet below the glide slope, increasing to 400 feet low at the last radar return.

2.16 This deviation of the flown vertical profile from the glide slope could have resulted from a number of causes:

- a faulty glide slope indication being presented to the pilot
- the pilot electing to fly a localiser approach (ILS without glide slope) or, less likely, a VOR or NDB/DME approach, all less precise alternatives at Christchurch
- some level of incapacitation or impairment, or substantial distraction of the pilot.

2.17 The possibility of a faulty G/S indication is unlikely to be resolved. While the aircraft was reportedly serviceable, some defect could have occurred since the last use of the ILS equipment in ZK-NCA. Normally a failure of the G/S receiver or indicator would produce a "G/S OFF" flag, so the pilot would know to follow a different approach procedure, such as a localiser approach. A possibility must remain that even with a serviceable G/S system, interference from the pilot's own cellphone might have caused erroneous indications, perhaps without activating the "G/S OFF" flag. The pilot's cellphone was the closest to the aircraft equipment, and was the only one operating during the approach. The potential for electronic interference increases with the closeness of the cellphone to the G/S receiver, indicator and associated wiring. The susceptibility of the system to interference is not quantifiable, and logically will vary with the condition of the wiring and screening in individual aircraft. Although the UK CAA tests did not demonstrate interference with the G/S, they did not rule out the possibility; they did confirm cellphones as an interference source to this general class of avionics equipment.

2.18 If the pilot had known of a G/S fault, as indicated by the "G/S OFF" flag, he might well have continued with a runway 20 localiser approach. This would have required flying a similar descent path to the ILS approach, but monitoring the DME and altitude by reference to the advisory altitude table. The descent would have had to stop at the minimum descent altitude (MDA) of 470 feet, and a missed approach carried out at the middle marker beacon if visual contact was not made. The radar plot could be seen as consistent with such a descent, except that it did not stop at 470 feet. It would be normal practice for a pilot to advise air traffic control if he was flying an approach differing from his clearance, and the pilot of ZK-NCA did not do so. A 20 localiser approach, in the weather conditions prevailing, probably would not have been successful because of the higher MDA, and a missed approach would have been required.

2.19 A 20 VOR or NDB/DME approach would have been even less likely to succeed because the track guidance was less precise, and the MDAs were higher than for the localiser approach. The NAV 1 receiver was found tuned to the ILS frequency anyway, not the VOR frequency, effectively ruling out a VOR approach. Similarly, ADF 2 was tuned to 286 (Cape Campbell NDB), making a NDB/DME approach improbable.

2.20 Whichever approach was flown by the pilot of ZK-NCA, either an ILS or a localiser approach for runway 20, there were two significant features in common. These are:

- the vertical profile of the descent was below the optimum path; for an ILS by a large amount, which should have produced a full scale fly-up indication; or for a localiser approach by a moderate amount, sufficient to be noticeable while monitoring the DME and altitude against the advisory altitude table, but not enough to compromise the approach
- the descent did not stop, either at the DA of 295 feet for the ILS, or at the MDA of 470 feet for the localiser approach.

2.21 On an instrument approach the aircraft's descent must be stopped at the minimum altitude unless the pilot can continue visually. With a precision approach such as an ILS, the minimum is a DA, where the pilot must decide either to continue visually or to make a missed approach procedure straight away. With a non-precision approach such as a localiser approach, the minimum is an MDA, where the pilot flies level until reaching the missed approach point (the middle marker in this case) and then, unless visual, makes a missed approach.

2.22 The co-pilot altimeter was found with its subscale set to 1010, 12 hectoPascals above the pilot's altimeter setting, which would have caused it to read some 400 feet high. The probable inference is that the pilot had not reset it, or referred to it, during that flight. Normal good practice is to set both altimeter subscales correctly, to provide a cross-check on altimeter indications.

2.23 It is noteworthy that neither ADF in ZK-NCA was appropriately tuned for the missed approach, which specified a climb to Burnham NDB at 3000 feet. Normal good practice on any instrument approach would be to make this selection, possibly on the standby tuning head for ADF 1, before the approach. A missed approach can occur for reasons other than below-minima weather, and relevant navigation guidance is necessary. That the pilot had not made this selection indicated some lack of method in his procedures, or distraction, or possibly an intention to persevere to land from the approach without regard to weather conditions

2.24 The vertical profile of ZK-NCA on the 20 approach shows that when the aircraft passed either the ILS DA of 295 feet, or the localiser approach MDA of 470 feet, it was too far from the runway and approach lights for them to be in sight in the reduced visibility at the time. At 295 feet, it was 1.7 nm (3.2 km) from the runway threshold and 1.4 nm (2.6 km) from the approach lights. The Boeing 737 crew immediately ahead of ZK-NCA had first sighted the approach lights when they were about 0.85 nm (1.6 km) from them. There would have been no other ground features visible from anywhere over the approach area in the dark cloud conditions.

2.25 The tests on the pilot's altimeter showed that it was working normally, in calibration, and its subscale was correctly set. Further, because it was an encoding altimeter, and tests showed the encoder to be in calibration and working, it follows that the encoder-derived radar altitudes recorded on the vertical profile were each within 100 feet of the altimeter indications presented to the pilot at the time.

2.26 The pilot's altimeter was a standard barometric/mechanical instrument, and was not susceptible to electronic interference from his cellphone or any other source. The possibility of an altimeter error arising from a fault in a pneumatic line to the static ports on the aircraft was also eliminated by the close correlation of the recorded radar altitudes from its encoder with the accident site altitude, and at earlier stages of the flight.

2.27 The conclusion from this is that the pilot allowed the aircraft to continue descent below the prescribed minimum altitude when he had accurate altimeter information, and when visual reference with the runway or approach lights was not available to him.

2.28 The only possible explanations for the pilot allowing the descent to continue in these circumstances are:

- some major distraction, which led the pilot to overlook monitoring the aircraft's altitude
- an intention to persevere with the approach below minima
- some partial level of incapacitation or impairment of the pilot, so that he was unable to either comprehend the aircraft's altitude, or to arrest its descent.

2.29 There is no evidence of the pilot's level of fitness in the late stages of the approach, other than the radar track of the aircraft, which indicates that he was continuing to manoeuvre the aircraft in the last 30 seconds of flight. Whether he had suffered some very recent incapacity, so that this activity was all he could cope with, is not known. The possibility is remote, but present.

2.30 The way in which the pilot set up and conducted the instrument approach was conducive to a high workload at best, and potential overload and distraction if any complicating factor arose. The significant events were:

- the high speed descent leading into the unstabilised approach
- the late reversion from autopilot to hand-flying, with little time to settle in before intercepting the ILS approach
- not leaving the autopilot engaged and not selecting it for a coupled approach, and
- his cellphone call, initiated just before commencing the approach.

2.31 The pilot's cellphone call was probably made intentionally, to report home. The passenger seated behind the co-pilot seat had seen the pilot hold his cellphone to his ear fairly late in the flight, and the records showed that the only other call on his cellphone was at 1752, 62 minutes earlier. A deliberate call made at that time, when about to intercept the ILS, and just after starting to hand-fly the aircraft would be irresponsible, with the high workload and concentration of the instrument approach about to start. The pilot had lived and worked with cellphones for years, however, and probably used one as an adjunct to his every activity. No cellphone conversation took place, however, and the call remained connected until the accident occurred. If the pilot had listened to his cellphone occasionally during the approach, it would have been a severe distraction.

2.32 The pilot's cellphone call might have been inadvertent, because the passenger's recollection of its timing was approximate. If the call had been made by pressing a speed dial button unintentionally, then it should not have posed a distraction. It could, however, have potentially produced some electronic interference to the G/S indication, as discussed in paragraph 2.15.

2.33 The radar track plot showed a somewhat erratic track of ZK-NCA, which has been cited as indicating the pilot controlling the aircraft. The erratic and oscillatory nature of the track itself, while probably within limits, does show that the pilot was not coping easily with the approach. It was a calm night, so there would have been little turbulence or drift to complicate the task, and a steadier track should normally be achievable. It is likely that the pilot had to devote more attention to this part of his task than it should require, to the detriment of his monitoring the altitude.

2.34 The pilot had a moderate level of experience on the PA 31 type, some 820 hours, but most of this was VFR flying. The majority of his experience was on VFR cross-country or scenic operations. He had qualified for, and started IFR flying late in his career, in 2001. It was likely that his understanding of IFR operations was limited by his not having a peer group of other IFR pilots as he started. He became chief pilot, IFR, in his own operation from the outset. His logged instrument flight time in the last 90 days was 3.30 hours, but he had also completed an IFR operational competency assessment 6 weeks before the accident which complied with the recency requirements in Rule part 61. He had also logged 3.15 hours of night time in the last 90 days, much of which probably was instrument time. The incidents which CAA had logged on the pilot's IFR operations were unusual, but may reflect his learning on the job at the time.

2.35 The weather reports and forecast which the pilot had before departure from Palmerston North did indicate that conditions were likely to be temporarily below minima for an ILS approach at Christchurch. However, because this was a forecast of temporary weather, and the prevailing forecast was better, and also because the alternate aerodrome had suitable weather, it was appropriate for the flight to commence.

2.36 The pilot's knowledge of this marginal weather, and the possibility of having to divert to his alternate aerodrome would probably have caused him some anxiety. Apart from the demanding flying task and decision-making which would be required, the substantial extra cost to the company of diverting to Woodbourne would have been of concern. It was likely that the pilot was under some stress, and probably somewhat tired at the end of his duty period.

2.37 The maintenance records of ZK-NCA indicated that it was substantially in order, but the status of the cabin heater was unsatisfactory. The engineer had disabled it, and signed it off as "unserviceable" until the required test was done. However the operator, probably the pilot himself, had meantime put it back into service without the required test being done. The heater is a practical necessity for IFR operations, especially in winter, and should have had priority maintenance. Tests after the accident showed that it was in good condition, and therefore not a potential source of carbon monoxide poisoning.

2.38 While the post-mortem toxicology confirmed that the pilot was not affected by carbon monoxide, all the deceased passengers showed elevated levels; 2 were slightly and 5 were moderately elevated. This anomalous group result suggested that they might all have been exposed to carbon monoxide during their time together in Palmerston North. The most likely possible exposure was their travel in the taxi van to the Aerodrome before the flight. However, while undesirable, this could not have affected the events leading to the accident.

2.39 The unserviceable avionics in ZK-NCA did not comply with the requirement of Rule part 135 that all installed equipment was in operable condition, except as provided for by a MEL. No

MEL was approved for ZK-NCA. However there was sufficient serviceable equipment for the IFR flight to be made, though with reduced options in the event of further equipment failure during the flight. Shortcomings included the NAV 2 receiver, the radio altimeter and the flight director, which were reported unserviceable but not documented. These unserviceable items and ongoing avionics maintenance and rectifications may have been related to the age of the original installation 29 years earlier.

2.40 If the radio altimeter had been serviceable and set appropriately it would have had the potential to provide a minimum altitude warning light to the pilot, possibly preventing the continued descent and thus averting the accident.

2.41 More effective that a radio altimeter warning, and requiring no pilot setting, the recently developed TAWS equipment has much potential to prevent this type of accident. The assessment of warnings from a TAWS class B showed that as well as a routine 500 foot reminder, an audio "pull-up" warning would have started some 9 seconds before impact, which could have given a pilot in this situation enough time to respond and avert the collision with terrain. While CAA intend to make TAWS a requirement for larger aircraft, further development of the equipment is likely to make it more affordable and cost-effective for smaller Part 135 aircraft. A recommendation was made to CAA to monitor closely the future development of TAWS equipment with a view to amending Part 135 to require its installation in relevant aircraft.

2.42 The computer generated loadsheet and navigation log system used by the company automated much pre-flight work for the pilot, but it appeared to produce erroneous fuel burn figures, with differing figures on the loadsheet and navigation log. This had the potential, with longer sector flight times, to cause either inaccurate fuel endurance or total fuel load figures. It was surprising that the error had not been noticed and rectified by the company. However on this occasion the aircraft was probably loaded within limits during the flight.

2.43 The pilot's coronary artery disease revealed on autopsy was unexpected, because his routine CAA medicals had identified only minor cardiovascular risk factors, lower than the general population, for age and gender. These did not suggest that additional tests such as stress electrocardiogram or echocardiogram were appropriate; and such additional tests may also have been negative had they been undertaken.

2.44 The Civil Aviation Rule part which prohibits the use of cellphones on any aircraft operating under IFR is obviously appropriate. Since Air Adventures operations were commonly under VFR, where electronic interference is not critical, it may have become habitual for the pilot to permit cellphone use without discriminating between VFR and IFR. His own background of working with cellphones may also have led him to become unselective, perhaps cavalier, in using them. The practical implementation of cellphone rules on scheduled airline services appears to be well established, but this accident indicates that on a charter flight by a VFR/IFR operator, cellphone rules may not always be suitably administered. It was recommended to CAA that educational material be developed to raise operator and pilot awareness of the rules prohibiting cellphone use on IFR flights.

2.45 The search for the missing aircraft took 2 hours 13 minutes from notification to finding the wreckage. This may at first seem to be a long time to find an accident site 1.2 nm from the runway threshold, but the difficult environmental conditions of fog and darkness combined with the sparsely populated farmland with limited vehicle access made a foot search inevitable. There was no remote guidance from the wreckage to the site, either electronically or by sight, sound or smell, and there were no witnesses. The ELT was installed in the rear fuselage of the aircraft, the optimum position for it to be able to function after most accidents, but the unusual damage from the second tree impact disabled it. If the ELT had been able to transmit its signal, the search would have been greatly facilitated. The search by Police and Fire Service units was started promptly, and used sufficient resources to be effective. The search area was initially based on good information from Christchurch Tower, and its later expansion, based on incorrectly relayed or recorded coordinates, probably did not delay finding the accident site because no searchers were taken away from the correct area. While some improvement in search teams' procedures for communicating geographical coordinates is indicated, the search was probably completed as expeditiously as possible in the circumstances.

# 3 Findings

Findings and safety recommendations are listed in order of development and not in order of priority.

3.1 The pilot was appropriately licensed and rated for the flight.

3.2 The pilot's previously unknown heart disease probably would not have made him unfit to hold his class 1 medical certificate.

3.3 The pilot's ability to control the aircraft was probably not affected by the onset of any incapacitation associated with his heart condition.

3.4 Although the pilot was experienced on the PA 31 type on VFR operations, his experience of IFR operations was limited.

3.5 The pilot had completed a recent IFR competency assessment, which met regulatory requirements for recent instrument flight time.

3.6 The aircraft had a valid Certificate of Airworthiness, and the scheduled maintenance which had been recorded met its airworthiness requirements.

3.7 The return of the cabin heater to service by the operator, after the maintenance engineer had disabled it pending a required test, was not appropriate but was not a factor in the accident.

3.8 The cabin heater was a practical necessity for IFR operations in winter, and the required test should have been given priority to enable its safe use.

3.9 The 3 unserviceable avionics instruments in the aircraft did not comply with Rule part 135, and indicated a less than optimum status of avionics maintenance. However there was sufficient serviceable equipment for the IFR flight.

3.10 The use of cellphones and computers permitted by the pilot on the flight had the potential to cause electronic interference to the aircraft's avionics, and was unsafe.

3.11 The pilot's own cellphone was operating during the last 3 minutes of the flight, and could have interfered with his glide slope indication on the ILS approach.

3.12 The aircraft's continued descent below the minimum altitude could not have resulted from electronic interference of any kind.

3.13 The pilot's altimeter was correctly set and displayed correct altitude information throughout the approach.

3.14 There was no aircraft defect to cause its continued descent to the ground.

3.15 The aircraft's descent which began before reaching the glide slope, and continued below the glide slope, resulted either from a faulty glide slope indication or from the pilot flying a localiser approach instead of an ILS approach.

3.16 When the aircraft descended below the minimum altitude for either approach it was too far away for the pilot to be able to see the runway and approach lights ahead in the reduced visibility at the time.

3.17 The pilot allowed the aircraft to continue descending when he should have either commenced a missed approach or stopped the aircraft's descent.

3.18 The pilot's actions or technique in flying a high-speed unstabilised instrument approach; reverting to hand-flying the aircraft at a late stage; not using the autopilot to fly a coupled approach and, if intentional, his cellphone call, would have caused him a high workload and possibly overload and distraction.

3.19 The pilot's failure to stop the descent probably arose from distraction or overload, which led to his not monitoring the altimeter as the aircraft approached minimum altitude.

3.20 The possibility that the pilot suffered some late incapacity which reduced his ability to fly the aircraft is unlikely, but cannot be ruled out.

3.21 If TAWS equipment had been installed in this aircraft, it would have given warning in time for the pilot to avert the collision with terrain.

3.22 While some miscommunication of geographical coordinates caused an erroneous expansion of the search area, the search for the aircraft was probably completed as expeditiously as possible in difficult circumstances.

# 4 Safety Recommendations

4.1 On 19 February 2004 it was recommended to the Director of Civil Aviation that he:

4.1.1 monitor closely the future development of TAWS equipment with a view to amending Part 135 to require its installation in relevant aircraft (063/03).

4.1.2 develop educational material to raise awareness of the rules prohibiting cellphone use on IFR flights (064/03).

4.1.3 use the circumstances of this accident as educational material for single pilot IFR operators and pilots in the management of instrument approaches (065/03).

4.2 On 1 March 2004 the Director of Civil Aviation replied:

4.2.1 With regard to recommendation (063/03).
I accept this recommendation and will monitor closely the future development of TAWS equipment and if appropriate amend Part 135 to require its installation in relevant aircraft. No precise time frame can be stated.

4.2.2 With regard to recommendation (064/03).
I accept this recommendation and will publish an article in Vector magazine outlining the differences between VFR and IFR and the prohibition of cell phones whilst operating under IFR rules and reminding operators of their obligations under the current rules. This will be completed by July 2004.

4.2.3 With regard to recommendation (065/03).
I accept this recommendation and will use this accident as educational material in the forthcoming General Aviation Group projects specifically aimed at light twin multi engine training and operation. This will be completed by December 2004.

Approved for publication 25 February 2004

Hon W P Jeffries
Chief Commissioner

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