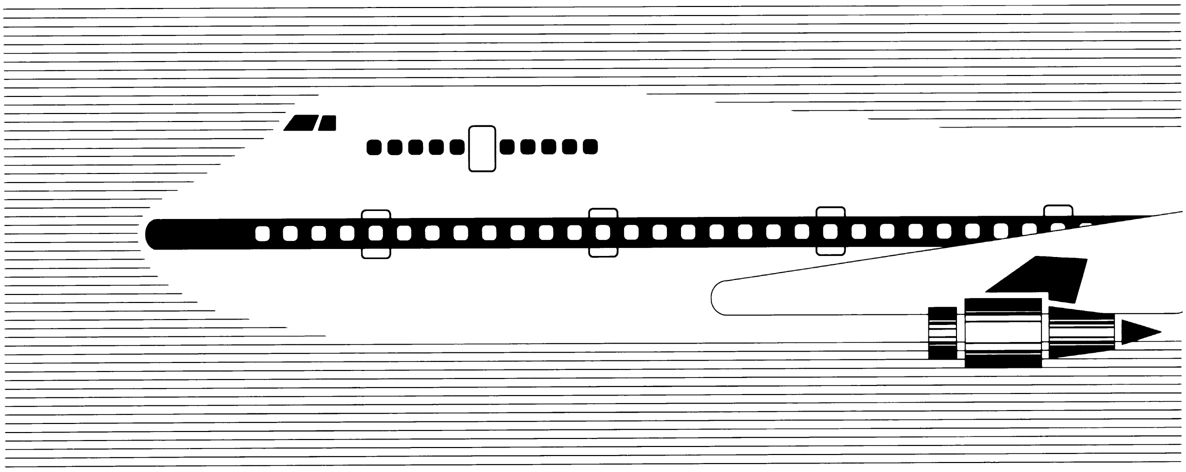

AVIATION OCCURRENCE REPORT

05-003 **Piper PA34-200T Seneca II, ZK-FMW, controlled flight into terrain, 8 km north-east of Taupo Aerodrome** **2 February 2005**

TRANSPORT ACCIDENT INVESTIGATION COMMISSION
NEW ZEALAND

Report 05-003

Piper PA34-200T Seneca II

ZK-FMW

controlled flight into terrain

8 km north-east of Taupo Aerodrome

2 February 2005

Abstract

On Wednesday 2 February 2005, ZK-FMW, a Piper PA34-200T Seneca, was on an air transport charter flight from Ardmore to Taupo with a pilot and 2 passengers on board. During the instrument approach to Taupo Aerodrome the aircraft deviated left of the published final approach track and at 1154 struck Mount Tauhara, 8 km from the aerodrome. The 3 occupants were killed on impact and the aircraft was destroyed.

No obvious cause for the accident could be determined. Autopsy reports showed the pilot had consumed cannabis, probably between 12 and 24 hours before the accident. While cannabis can adversely affect a person's ability to operate an aircraft, its effects can vary greatly so this could not be conclusively identified as a cause of this accident.

Safety issues identified included:

- the lack of a test regime to identify the use of illicit drugs and alcohol in the transport industry
- inadequate medical standards for pilots with an aortic valve replacement
- the urgent need to have terrain awareness warning systems installed in Part 135 aircraft

Safety actions were initiated by the Ministry of Transport and safety recommendations made to the Director of Civil Aviation to address these issues.

Accident Site, Mount Tauhara

Contents

Figures

Abbreviations

ACNZ	Airways Corporation of New Zealand
ADF	automatic direction-finder
amsl	above mean sea level
ATS	Air Traffic Services
ATSB	Australian Transport Safety Bureau
AWIB	aerodrome and weather information broadcast
º C	degrees Celsius
CAA	New Zealand Civil Aviation Authority
C of G	centre of gravity
CFIT	controlled flight into terrain
CO	carbon monoxide
DME	distance measuring equipment
EGPWS	enhanced ground proximity warning system
ELT	emergency locator transmitter
ESR	Institute of Environmental Science and Research Limited
º F	degrees Fahrenheit
ft	feet
GPS	global positioning system
GPWS	ground proximity warning system
(mm) Hg	mm of mercury
HV	high voltage
IFR	instrument flight rules
kg	kilogram(s)
kHz	kilohertz
km	kilometre(s)
kt	knot(s)
kV	kilovolt(s)
LOD	limit of detection
m	metre(s)
º M	degrees magnetic
MAPG	mean aortic pressure gradient
MetService	Meteorological Service of New Zealand

MHz	megahertz
mm	millimetre(s)
MoT	Ministry of Transport
NDB	non-directional beacon
ng/mL	nanogram per millilitre
nm	nautical miles
NPRM	Notice of Proposed Rule Making
PCP	phencyclidine
RBI	relative bearing indicator
RCCNZ	Rescue Coordination Centre New Zealand
SAR	search and rescue
SIG	Substance Impairment Group
SPECI	special aerodrome report
º T	degrees true
TAF	aerodrome forecast
TAWS	terrain awareness and warning system
THC	tetrahydrocannabinol
THC-COOH	carboxy-tetrahydrocannabinol
UNICOM	universal communications service
US	United States
UTC	coordinated universal time
VFR	visual flight rules
VHF	very high frequency
VOR	VHF omni-directional radio range

Glossary

CFIT	when an airworthy aircraft under the control of the crew is flown unintentionally into terrain, usually with no prior awareness by the crew. CFIT is more common during the approach and landing phase of flight, often under IFR and during a non-precision instrument approach.
cloud levels: -few	1 – 2 oktas of cloud, or covering 1 – 2 eighths of the sky.
-scattered	3 – 4 oktas of cloud, or covering 3 – 4 eighths of the sky.
-broken	5 – 7 oktas of cloud, or covering 5 – 7 eighths of the sky.
-overcast	8 oktas of cloud, or total cloud cover.
dew point	the temperature at which the air becomes saturated and condensation forms.
final approach fix	a predetermined position indicating the start of the final approach segment, in which alignment and descent for landing are accomplished.
non-precision approach	an instrument approach procedure that utilises lateral guidance but has no vertical guidance.
QNH	an altimeter subscale setting to obtain elevation above mean sea level.
track	either the desired or actual flightpath over the ground that accounts for any wind effect.
United States Rules Part 121	Domestic, Flag and Supplemental Operations
United States Rules Part 135	Commuter and On Demand Operations

Data Summary

Aircraft registration:	ZK-FMW
Type and serial number:	Piper PA34-200T Seneca, 34-8070181
Number and type of engines:	2 Teledyne Continental TSIO-360
Year of manufacture:	1980
Operator:	Christian Aviation (trading name)
Date and time:	2 February 2005, at 1154[1]
Location:	8 km north-east of Taupo Aerodrome latitude: 38° 41.3´ south longitude: 176° 09.7´east
Type of flight:	air transport, charter
Persons on board:	crew: 1 passengers: 2
Injuries:	crew: 1 fatal passengers: 2 fatal
Nature of damage:	aircraft destroyed
Pilot's licence:	Commercial Pilot Licence (Aeroplane)
Pilot's age:	36
Pilot's total flying experience:	2950 hours (634 on type)
Investigator-in-charge:	I R McClelland

Acknowledgements

The Transport Accident Investigation Commission acknowledges the assistance of the Australian Transport Safety Bureau and the United States National Transportation Safety Board during the conduct of the investigation.

[1] Times in this report are in New Zealand Daylight Time (UTC + 13 hours) and are expressed in the 24-hour mode.

1 Factual Information

1.1 History of the flight

1.1.1 On Wednesday 2 February 2005, ZK-FMW, a Piper PA34-200T Seneca aeroplane, was chartered to fly a couple on a morning scenic flight from Ardmore to Kerikeri, and after lunch continue to Taupo. The flight was part of a package organised by a tour operator in conjunction with the operator of ZK-FMW.

1.1.2 At about 0715 on the morning of the flight, the pilot of ZK-FMW contacted the tour operator and advised that the weather between Auckland and Kerikeri was not good and would probably affect the scenic elements of the flight. There was also the possibility that they might be unable to land at Kerikeri during the morning, but the weather was forecast to improve in the afternoon. The use of alternative road transport to Kerikeri was discussed, with the pilot uplifting the couple after their lunch and continuing on to Taupo from there. The tour operator telephoned the couple and advised them of the weather conditions and the options available. The couple advised that they wished to continue with the flight as originally planned, but accepted that it might be disrupted by the weather.

1.1.3 In preparation for the flight, the pilot filed an instrument flight rules (IFR) flight plan using the callsign "Christian 2 Whisky", and inspected ZK-FMW. Records showed that 239 litres of fuel were loaded at this time. The passengers arrived at the operator's base at Ardmore Aerodrome shortly before 0900 and were briefed by the pilot before boarding. The flight departed at about 0915 and after being identified on radar by Air Traffic Services (ATS), flew northward to Kerikeri.

1.1.4 At Kerikeri the pilot flew 2 instrument approaches in an attempt to become visual and land. At about 1030, after the second unsuccessful attempt, the pilot contacted ATS and obtained a clearance to climb to 10 000 feet (ft) and continue to Taupo via overhead Auckland.

1.1.5 At 1133 the pilot requested descent for approach to Taupo. The ATS controller cleared Christian 2 Whisky to descend and vacate controlled airspace on track to Taupo. The controller also advised that there was no reported IFR traffic in the area. The pilot correctly read back the clearance after which the controller asked what type of instrument approach the pilot intended to fly. The pilot advised "probably an NDB DME[2] Bravo off the arc" (see Figure 1).[3] The controller requested that the pilot report when changing to the local Taupo Aerodrome frequency and advised that there had been parachuting activity but thought bad weather had prevented any flying for the last 30 minutes. The pilot replied that the AWIB (aerodrome and weather information broadcast)[4] for Taupo was still reporting no overheard rejoins due parachuting, and he was still "happy with the Bravo on the arc".

1.1.6 The AWIB weather information being broadcast at this time advised the surface wind was 230º magnetic (M) at 5 knots (kt), visibility 50 km, cloud broken at 4000 ft[5]. Temperature 22 º Celsius (C), dew point of 17º C, and QNH of 1014 hectopascals.

1.1.7 At 1143 the controller instructed the pilot to change to the Taupo frequency and to terminate the flight plan after landing at Taupo. The pilot acknowledged the instruction and changed to the local Taupo radio frequency.

[2] Non-directional beacon and distance measuring equipment. DME distances are measured in nautical miles.
[3] To join and fly around the 10 nautical mile arc from Taupo DME before flying the inbound leg of the approach.
[4] A radio broadcast for an aerodrome that may include information such as runway in use, wind direction and strength, visibility, cloud cover, temperature and local pressure.
[5] Cloud heights were reported as feet above aerodrome elevation.

1.1.8 At 1144 the pilot reported on the Taupo Aerodrome frequency “Taupo Traffic, Christian 2 Whisky, Piper Seneca, is currently 18 miles to the west-north-west, 5000 ft. To join the NDB DME Bravo approach off the arc.” On hearing the radio transmission, the duty person managing the universal communication service (UNICOM)[6] facility at Taupo (the duty operator) replied “Taupo Traffic this is UNICOM. Our surface wind is 020 [at] 12 kt. Preferred runway 35.” The pilot replied “Understood, and what’s the cloud base?” The duty operator replied, “It’s closing in a bit. Our visibility now to the north is about 7000 m. To the south 30 km. And the cloud is now about few at 1000 [ft] and broken at about 2000 [ft].” The pilot replied “Understood. I’ll continue on the NDB DME Bravo approach via the arc, circling for 35.” The duty operator replied, “as far as I’m aware all parachute aircraft are on the ground.”

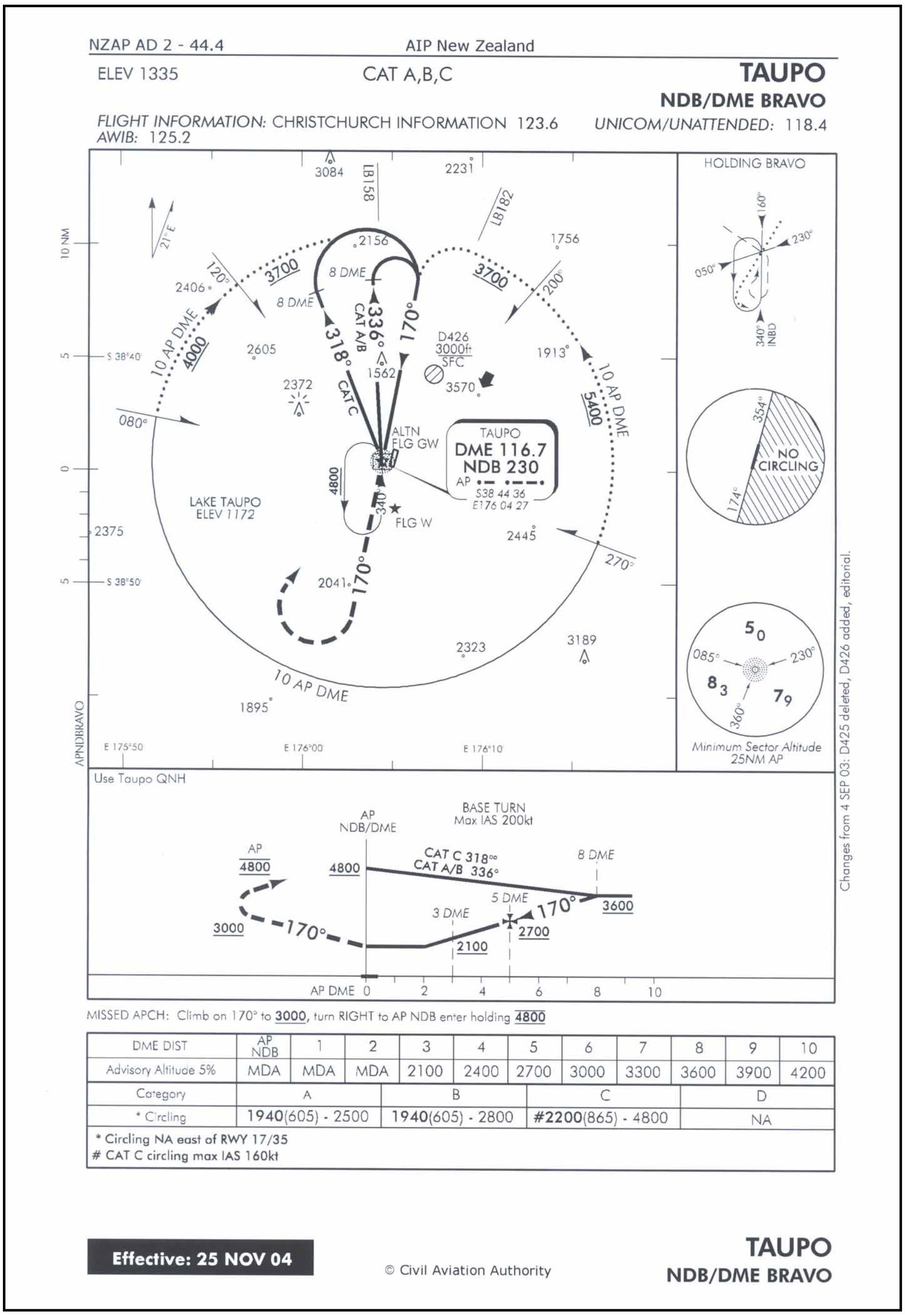

Figure 1
Taupo NDB DME Bravo approach chart
(applicable on day of accident)

[6] An aerodrome air-ground communications facility providing an information service where no ATS facilities are present.

1.1.9 At 1146 the pilot reported "Taupo Traffic, Christian 2 Whisky, established 10 mile arc, NDB DME Bravo." At this time a local floatplane operator reported airborne from the lakefront and vacating the area to the west.

1.1.10 At 1150 the pilot reported "Taupo Traffic, Christian 2 Whisky, established inbound NDB DME Bravo approach." And 3 minutes later, at about 1153, the pilot reported "Taupo Traffic, Christian 2 Whisky, final approach fix." This was the last transmission recorded from ZK-FMW.

1.1.11 At 1214 the Rescue Coordination Centre New Zealand (RCCNZ) received an initial alert of an emergency locator transmitter (ELT) signal. At about the same time, ATS became concerned that the pilot of ZK-FMW had not reported on the ground at Taupo to cancel his flight plan. The controller called Taupo UNICOM, who had also become concerned that the pilot had not reported downwind for the active runway or landing. At 1224 the ELT signal was identified as originating from the Taupo area and, after receiving information from ATS and Taupo UNICOM, a search for the overdue aircraft was initiated. At about 1316 the crew of a search aircraft located the wreckage of ZK-FMW on the northern side of Mount Tauhara, 8 km north-east of Taupo Aerodrome. Inspection of the site confirmed there were no survivors.

1.2 Injuries to persons

1.2.1 The 3 occupants sustained fatal injuries as a result of the impact.

1.3 Damage to aircraft

1.3.1 The aircraft was destroyed.

1.4 Other damage

1.4.1 Minor to bush and vegetation.

1.5 Personnel information

1.5.1

pilot:	male, aged 36	
licence and rating:	Commercial Pilot Licence (Aeroplane), instrument rating	
aircraft ratings:	Piper PA34, PA31, PA32, PA42 Cessna C172, C206	
medical certificate:	Class 1, issued 30 August 2004 and valid until 2 March 2005	
last biennial flight review:		19 August 2004
last instrument rating renewal:		19 August 2004
last competency assessment:		19 August 2004
flying experience:	total, aeroplane	2950 hours
	multi-engine	1930 hours
	PA34 type	634 hours
	total, last 90 days	85 hours
	last 7 days	11 hours
	total, instrument flight time	572 hours
	last 90 days	10.7 hours
duty time:		about 4 hours
rest before duty:		2 days

1.5.2 The pilot started flying in 1988 and obtained his Commercial Pilot Licence (Aeroplane) in March 1992. He joined the operator soon after. He started flying the operator's PA34 Seneca, ZK-FMW, in June 1993 and completed his type rating in September 1993.

1.5.3 The pilot obtained a single-engine instrument rating in November 1993 and a multi-engine single-pilot instrument rating in December 1997. His last instrument rating renewal and 6-monthly competency check was on 19 August 2004 and was flown in the company's Piper PA31-350 Navajo Chieftain aircraft. The pilot's logbook recorded that during the check flight, which he passed, the pilot flew 3 instrument approaches for qualification, including an NDB DME approach using the Miranda NDB located about 20 nm south-east of Ardmore but flying the Invercargill NDB DME 22 chart profile. The pilot had not flown an NDB approach in this aircraft since 2 March 2003.

1.5.4 The pilot's last recorded flight to Taupo was on 17 December 2004, when he flew an NDB DME approach in a Piper PA42-1000 Cheyenne aircraft. The approach identification was not recorded in the logbook, nor was it required to be. The logbook also recorded the pilot having flown an NDB DME arc approach to Taupo on 23 November 2004 in a Piper PA31-310 Navajo. His last recorded instrument approach was on 11 January 2005, when he completed a very high frequency omni-directional radio range (VOR) DME approach to Hastings. The pilot was not trained or qualified to fly global positioning system (GPS) instrument approaches.

1.5.5 Because ZK-FMW was out of service from 13 November 2002 until December 2004, the pilot had not flown a PA34 Seneca type aircraft until 10 January 2005, when he completed a currency flight in ZK-FMW. The flight was recorded as 2.3 hours in duration with no instrument flight time or instrument approaches logged. Between 19 January and 28 January the pilot flew a tour party around New Zealand in ZK-FMW in conjunction with another company pilot in a second aeroplane. The pilot logged 15.15 hours over the 10 days but did not fly into Taupo or record any instrument time or approaches along the route. The tour party leader recalled the pilot as being "extremely professional and safe". The tour leader had flown with many different pilots and said she "couldn't fault the pilot". The pilot gave a safety briefing each morning as part of his normal daily routine.

1.5.6 The pilot did not work on Saturday 29 January and flew a different aircraft on a local visual flight rules (VFR) charter flight on Sunday 30 January. The operator reported that the pilot had Monday off work and performed only light duties but no flying on the Tuesday. He did not fly again until the accident flight on Wednesday 2 February.

1.5.7 The pilot held the position of Quality Assurance Manager for the operator. Passengers and fellow company pilots who knew or regularly flew with him expressed no concerns and generally regarded him as professional and thorough. On the morning of the flight, relatives and fellow employees who saw the pilot considered him to be well rested and his normal self.

1.6 Aircraft information

1.6.1 ZK-FMW was a Piper PA34-200T Seneca II aeroplane, serial number 34-8070181, manufactured in the United States (US) in 1980. The Seneca was a low-wing, twin-engine aeroplane fitted with 2 Teledyne Continental TSIO-360 engines. The aeroplane had retractable undercarriage and had seating for 6 people, including the pilot. The seating was arranged in 3 rows of 2 seats each row, with the centre row facing rearwards.

1.6.2 ZK-FMW was imported into New Zealand in 1986 and the operator purchased it in 1988. The aircraft was issued with a Non-terminating Certificate of Airworthiness in the standard category. Records showed that the aircraft was maintained in accordance with the operator's approved maintenance programme.

1.6.3 On 12 November 2002, ZK-FMW was involved in a landing accident at Ardmore Aerodrome. After touching down, the undercarriage partially collapsed and the aircraft slid off the side of the runway. There were no injuries but the aircraft sustained damage to the undercarriage, left wing, aerials, engines and propellers. Repairs took about 2 years to complete. During the repair, both engines were overhauled and new propellers installed.

1.6.4 On 24 December 2004, the aircraft was recorded as being ready for "return to service, dependent upon proving flight on all systems". The annual review of airworthiness and a 100-hour inspection were completed and on the same day a test flight was flown. The operator later reported that the aircraft was given a thorough test flight, including a check of the aircraft's instrument approach aids.

1.6.5 The operator's records showed that up to the day of the accident ZK-FMW had flown a total of 6130 hours, including 22.1 hours since returning to service. The operator reported the aircraft to be performing very well. There were no outstanding defects recorded, and the aircraft had 28 hours to run to the next scheduled servicing, a 50-hour inspection.

1.6.6 ZK-FMW was equipped with an autopilot and was capable of being flown single pilot under IFR. Navigation equipment included 2 VHF navigation receivers, one DME and one automatic direction-finder (ADF) receiver for NDB approaches. The aircraft was fitted with a GPS but was not certified for GPS instrument approaches. The GPS retained no recoverable information.

1.6.7 The ADF fitted to ZK-FMW was a Collins RCR 650A model. ADF tracking information for NDB approaches was presented on a relative bearing indicator (RBI) located on the lower left side of the pilot's instrument panel. The needle would point towards the beacon and the RBI compass card could be rotated manually to match the aircraft's magnetic heading to provide a magnetic bearing to the beacon. During an instrument approach this would require the pilot to continually turn the compass card to ensure the heading, and therefore NDB tracking information, remained correct.

1.6.8 An alternative method of using the RBI was to leave it set with 000º (360º) under the top reference marker. During an approach, a pilot would mentally transpose the relative bearing information for the NDB onto the magnetic directional or heading indicator for tracking guidance. This "fixed card" method avoided the requirement to turn the RBI compass card for each new aircraft heading. The operator advised that this was the standard procedure used by company pilots. The operator's PA31-350 Navajo Chieftain also had a fixed card RBI like ZK-FMW, but the PA42 Cheyenne and PA31-310 Navajo aircraft both had ADF indicator cards that were slaved to the aircraft's magnetic heading indicator and would rotate automatically as the aircraft turned.

1.6.9 Before departing from Ardmore the pilot completed a load sheet, which recorded the aircraft's take-off weight as 1974 kg and the centre of gravity (C of G) position to be at 94.7 inches aft of the datum. The load sheet included a take-off fuel weight of 234 kg, but contained no reference to the passengers' 2 suitcases, which had a total weight of 60 kg.

1.6.10 The maximum certified take-off weight for ZK-FMW was 2073 kg, at which the C of G was required to be between 90.6 inches and 94.6 inches aft of datum. The rear limit, 94.6 inches, remained constant as weight was reduced.

1.6.11 A reconstruction of the aircraft's take-off weight and balance was completed using the available information. The aircraft's basic weight and C of G position were recorded in the aircraft logbook, where a new data sheet had been completed on 22 December 2004 in conjunction with the aircraft's return to service. Pilot and passenger weights, and their positions in the aircraft, were obtained from accident site examination and later autopsies. From the aircraft load sheet, recorded flight plan endurance, known fuel uplift and operator's information, the aircraft was considered to have a full fuel load. The 2 suitcases were too large to fit in the forward locker and therefore they were assumed to have been located in the rear baggage area. This gave an estimated take-off weight of 2039 kg and a C of G position of 95.77 inches aft of datum, or 1.17 inches aft of the rear C of G limit.

1.7 Meteorological information

1.7.1 The Meteorological Service of New Zealand (MetService) provided an aftercast of the weather conditions on Wednesday 2 February 2005. Information is summarised as follows:

Synoptic situation over New Zealand

An anticyclone centred far to the east of New Zealand directed a moist east-north-east flow over the country. A shallow trough located over the Bay of Plenty coast at 0700 on 2 February moved slowly south and crossed the Taupo Aerodrome just after 1200. The flow behind this trough was north-easterly.

Low cloud and rain was associated with the trough. Generally, cloud bases were lower and visibility poorer after the trough had passed than before. This is probably due to the flow becoming north-easterly, more onshore, giving humid air originating over the sea better access to the central North Island.

Weather conditions in the vicinity of Taupo at 1200 on 2 February 2005

During the morning, ahead of the trough there was no significant weather, visibility [was] good and cloud broken at 4000 ft above Taupo airport. Conditions could be expected to worsen in the vicinity of Lake Taupo as the trough moved south across the area. At 1200, visibility at Taupo airport was reported as 7000 m in rainshowers. Cloud was broken at 2300 ft. The wind was from the northeast. Mount Tauhara may have provided the airport with some sheltering. Cloud bases may have been significantly lower on the north and northeast facing slopes of Mount Tauhara than indicated by observations at Taupo airport.

Judging from satellite imagery the trough crossed Rotorua airport [75 km north of Taupo] just after 0900. At 0945 Rotorua airport reported visibility of 6000 m with rainshowers in the vicinity. Clouds were few at 800 ft, scattered at 1500 ft and broken at 2000 ft above the airport.

In this case Rotorua airport provides the best information regarding what was going on upstream of Lake Taupo. At Rotorua, using a datum above [mean] sea level (amsl), cloud with the trough was reported at 0945 as few at 1700 ft, scattered at 2400 ft and broken at 2900 ft. Patches of cloud could of course have been expected to be lower in the precipitation associated with the trough. Conditions were very humid, 93% relative humidity at 0900.

The base of Mount Tauhara is 1600 ft and the top at 3600 ft amsl. The weather conditions at Mount Tauhara at 1200 were similar to the conditions reported at Rotorua at 0945. Therefore it is likely that significant portions of the mountain would have been obscured by rain and cloud around 1200, as the trough moved across it. Given the relatively light wind and high humidity, then cloud could have persisted about the mountain for some time after the trough had passed.

There was no lightning activity over the route during the morning or at the time of the crash.

Radar imagery during the morning covering the northern parts of the North Island indicated the presence of scattered rain or showers. An image at 1152 shows an area of precipitation to the northwest of Taupo. Earlier images indicated those echoes moving from the northeast in somewhat of a line – the orientation being similar. This information is further evidence of the existence of the trough, mentioned earlier.

1.7.2 The aerodrome forecast (TAF) for Taupo covering the time of the accident included the following:

> Surface wind 080º true (T) at 10 kt. Visibility 30 km, showers and rain. Cloud scattered 2000 ft, broken 3000 ft. Temporarily between 1200 and 2100, visibility 6000 m, showers and rain. Cloud broken 1200 ft, few cumulonimbus 2000 ft. The 2000 ft wind 060º T at 20 kt.

1.7.3 At 1150 the UNICOM duty operator issued a special aerodrome report (SPECI) for Taupo valid from 1200. The report was as follows:

> Surface wind 070º T at 15 kt, visibility 7000 m, showers and rain. Cloud broken 2300 ft.
> Temperature 23º C, dew point 18º C. QNH 1015. Remarks, visibility to the south 25 km.

1.7.4 Witnesses at Taupo Aerodrome reported that at the time of the accident the cloud base had lowered and Mount Tauhara had become obscured by rain. Local parachuting operators advised that there was no parachuting between about 1120 and 1400 due to the low cloud base.

1.8 Aids to navigation

1.8.1 Taupo Aerodrome was equipped with a co-located NDB and DME situated near the south-western corner of the aerodrome. The NDB transmitted a signal on 230 kilohertz (kHz) and the DME on 116.7 megahertz (MHz). Airways Corporation of New Zealand (ACNZ) was responsible for the maintenance of the navigation aids. ACNZ also designed and published the associated instrument approaches for Taupo. In addition to the 4 instrument approaches using the NDB and DME, there were 2 GPS approaches available for Taupo.

1.8.2 The NDB was equipped with an internal monitor that would switch off the NDB signal should there be a decrease in power of 50% or more, a failure of the identification signal, a failure of the monitoring system or a change in signal modulation of 5% or more. There was a 30-second delay before a shutdown was commanded to avoid unnecessary reaction to a transient fault. The Taupo NDB did not have an automatic restart capability in the event of a shutdown. Should a shutdown occur, staff at the ACNZ Centre in Christchurch would be alerted through a Remote Control Monitoring System.

1.8.3 A second independent monitor for the Taupo beacons was located in the Rotorua ACNZ facility and provided an audio-visual alarm that would also alert staff at Rotorua and Christchurch. The last routine flight inspection of the navigation aids was completed in September 2004 and ACNZ advised that no faults had been reported prior to the accident.

Radar information

1.8.4 ATS radar recorded most of the flight of ZK-FMW on the day of the accident. After departing from Ardmore, ZK-FMW was observed on the radar to intercept the Auckland to Kerikeri track at an altitude of 9100 ft.[7] The aircraft was labelled CHN2W on the radar presentation. Radar information for ZK-FMW was lost at 1002 as the aircraft passed about 20 nautical miles (nm) north of Whangarei descending through 3700 ft. At 1032 radar re-identified ZK-FMW as it was climbing to 10 000 ft and flying the Kerikeri to Auckland track. After overflying Auckland, ZK-FMW continued overhead Hamilton towards Taupo.

[7] The altitude was provided by the aircraft's transponder and may have varied slightly from the aircraft altimeter reading.

1.8.5 After passing Hamilton, ZK-FMW commenced descent and continued flying towards the Taupo NDB. The radar data for the flight recorded ZK-FMW manoeuvring onto about the 10 nm Taupo DME arc and flying around the arc, descending as it progressed (see Figure 2). Approaching the inbound track for the NDB DME Bravo approach, ZK-FMW turned right to fly diagonally across the inbound track. The aircraft levelled at about 2800 ft and after about 3 minutes it again turned right to nearly parallel the inbound NDB DME Bravo track. The last radar information was received at 1154:01. The aircraft accident site was calculated to be about 190 m southeast of the last radar recording.

Aircraft instrumentation requirements

1.8.6 Civil Aviation Rule 135.353[8] stated in part that operators were to ensure that an aircraft was equipped "with the number of instruments and equipment to ensure that the failure of any independent system required for either communication or navigation purposes, or both, will not result in the inability to communicate or navigate safely as required for the route being flown".

1.8.7 The Civil Aviation Authority (CAA) advised that for an IFR flight the Rule required aircraft to have a second independent navigation system available should the primary system fail. Therefore, for an NDB approach the aircraft should have 2 independent ADF installations. However, CAA conceded that there was still ongoing discussions with industry representatives and operators about the intention of the Rule, many of whom did not meet the requirements of the Rule.

1.8.8 Areas of discussion included alternative navigation equipment, for example GPS, to enable an aircraft to be climbed to a safe altitude should equipment fail during an instrument approach and either, conduct another approach using that equipment or being able to divert to an alternative destination. The ACNZ's planned phasing out of NDBs around New Zealand and the cost of installing new equipment that could soon become obsolete also needs to be considered.

[8] Civil Aviation Rule 135.353, effective 25 November 2004.

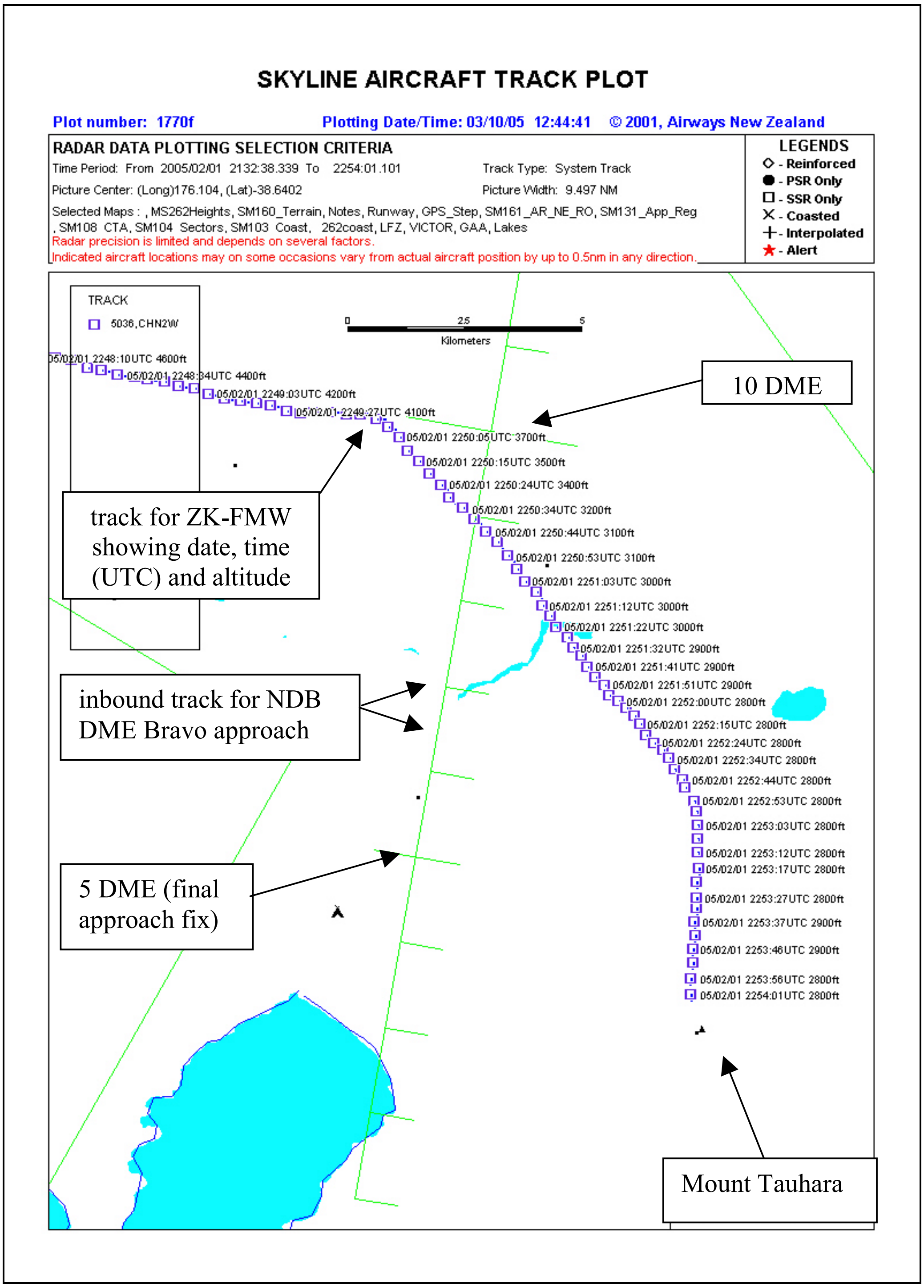

Figure 2
Radar track plot for ZK-FMW
(Courtesy of Airways Corporation of New Zealand)

1.9 Communication

1.9.1 All radiotelephone communications with ATS were made on very high frequency transceivers. A record of relevant transmissions is included in section 1.1 of the report.

1.10 Aerodrome information

1.10.1 Taupo Aerodrome was located 5 km south of Taupo township at an elevation of 1335 ft amsl. The aerodrome was uncontrolled, with uncontrolled airspace around the aerodrome extending from the ground to 6500 ft amsl. The main sealed runway was runway 35/17[9], with a grass cross vector 11/29.

1.10.2 A mandatory broadcast zone existed around the aerodrome. After landing, pilots would call ATS to advise they had landed and to cancel their IFR flight plan. Failure to do so would initiate search action once the flight planned search and rescue time (SAR time) had passed.

1.10.3 The ground around the aerodrome generally sloped upwards, with the exception of the land to the west where it sloped down towards Lake Taupo. The highest feature within 10 DME (19 km) of the aerodrome was Mount Tauhara to the north-north-east at 3569 ft (1088 m) amsl, the peak of which was 8 km from the aerodrome.

1.10.4 The Wairakei geothermal power station was located about 12 km north of Taupo Aerodrome, under the NDB DME Bravo approach track. Numerous 220 kilovolt (kV) high voltage (HV) transmission lines crossed the surrounding area, including 2 lines that ran to the east of the aerodrome. The Wairakei – Rangipo line was generally aligned with the NDB DME Bravo inbound track and passed about 1 nm east of the aerodrome. The second line, Wairakei – Whirinaki, ran around the lower northern and eastern slopes of Mount Tauhara before heading off towards Napier. Further information on transmission lines is contained in section 1.16.

1.11 Flight recorders

1.11.1 ZK-FMW was not equipped with any flight recorders, nor was it required to be.

1.12 Wreckage and impact information

1.12.1 The accident site was on the northern slopes of Mount Tauhara, 1 km north-west of the summit and 8.3 km (4.5 nm) from the Taupo NDB DME site on a bearing of 015º M. The accident site elevation was about 2600 ft (790 m).

1.12.2 ZK-FMW had struck the steep bush and tree-clad slope on a heading of between 160º M and 170º M, upright and in about a wings-level attitude. Damage to the vegetation indicated the aircraft was in about level flight when it struck the bush. As the aircraft progressed some 25 m through the bush and trees it was pulled slightly left and downwards before impacting the ground. The aircraft had struck several larger trees before coming to a sudden halt, causing the left wing to separate and the right wing to swing forward but remain attached to the fuselage. A smell of aviation fuel was noted around the accident site.

1.12.3 The 2 propellers had separated from their respective engines and were partially buried in the ground. The aircraft flaps were extended and the flap control lever corresponded with the flaps being in about the first notch or approach configuration position. The undercarriage position lever was in the down position and the 3 undercarriage legs were extended.

1.12.4 The occupants were found retained by their seat belts in their seats which had remained attached to the aircraft floor. The pilot was in the front left pilot's seat, while the passengers were in the centre right and rear left seats.[10]

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[9] 350º M and 170º M.

[10] Left and right correspond to facing forward in the aircraft.

1.12.5 The following trapped instrument readings or information were noted (see Figures 3 and 4):

Airspeed indicator	124 kt
Altimeter	QNH set to 1014, needle broken
Horizontal situation indicator (heading indicator)	
heading	155
heading selector[11] set to	158
course deviation bar set to	170
heading and navigation flags were displayed	
ADF(RBI) indicator	pointing 32º right of aircraft heading
Left engine cylinder temperature gauge	about 230º F
Right engine cylinder temperature gauge	about 250º F

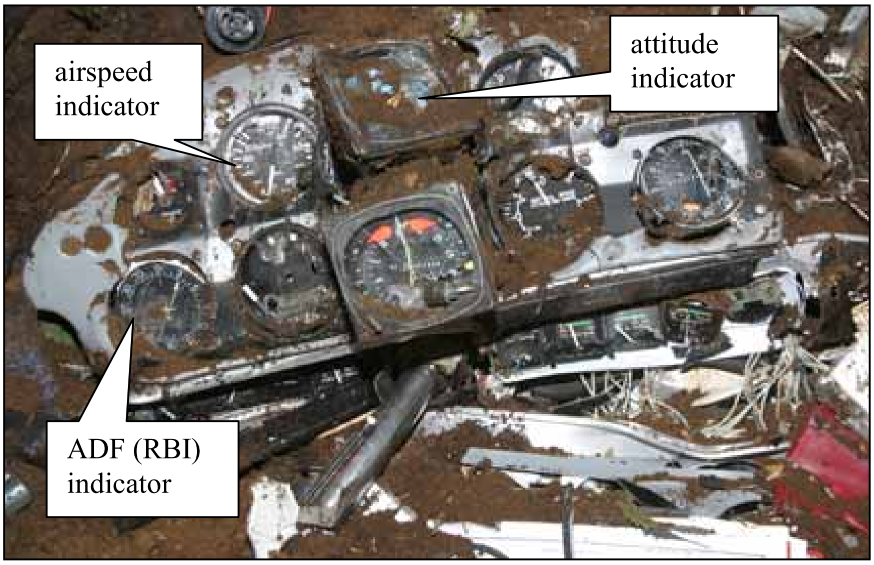

Figure 3
Pilot's instrument panel ZK-FMW

Figure 4
ADF (RBI) Indicator ZK-FMW

[11] A small pointer that can be set to a specified figure to remind the pilot of the required heading to fly or track to follow, or to be selected for autopilot heading.

1.12.6 Because of the distortion and damage to the forward section of the aircraft, positions of the aircraft flight controls, engine control levers and aircraft heater controls could not be reliably determined. On the audio control panel the rotary VHF radio transceiver knob was selected to COM 2 and the COM 1 toggle switch was towards the headphones position. All the remaining toggle type switches, including the ADF and DME selections, were in the off position.

1.12.7 Several aircraft components were removed for more detailed examination, including the ADF controller, ADF indicator, auto pilot annunciator panel, altimeter and a GPS receiver/indicator.

1.12.8 The operator's flight log form and instrument approach chart folder were found on the pilot's lap. The flight log contained navigation and weather information for the flight from Ardmore to Kerikeri and to Taupo. The folder was opened at the chart for the NDB DME Bravo instrument approach to Taupo. The chart was dated 25 November 2004 and was the current chart for the approach.

1.12.9 Two suitcases, belonging to the passengers, were found at the accident site. Both cases had been ejected from the fuselage and lay near the passenger entry door on the left side of the aircraft. The cases were later weighed and determined to have a combined weight of 60 kg.

1.12.10 On completion of the site examination, the wreckage was removed for further examination and the propellers and engines sent to recognised maintenance facilities for detailed analysis.

1.13 Medical and pathological information

1.13.1 The pilot's last medical examination was completed on 30 August 2004. A condition of the medical certificate required the pilot to wear correcting lenses for distance vision. Contact lenses were permitted provided spare spectacles were readily available.

1.13.2 In 1995 the pilot underwent cardiac surgery to insert a tissue (homograft) aortic valve graft following severe damage to the aortic valve by bacterial endocarditis. Thereafter, a condition of the pilot's medical certificate required him to complete 6-monthly cardiological assessments, which were to include echocardiography. These conditions were complied with.

1.13.3 Assessment reports recorded progressive increases in the values for the peak aortic velocity and mean pressure gradient across the aortic valve. The last recorded values, taken 20 July 2004, were 3.9-4 m/sec peak aortic velocity and 32-34 mm Hg mean aortic pressure gradient (MAPG). Mild left ventricular hypertrophy (enlargement) and mild aortic regurgitation (back flow) were also noted. By comparison an assessment completed 1 July 2003 recorded a velocity of 3.5 m/sec and a pressure gradient of 25 mm Hg. An earlier assessment completed 27 November 2001 recorded 3.3 m/sec and 24 mm Hg. Normal measurements were generally considered to be less than 2.0 m/sec and 20 mm Hg.

1.13.4 Post-mortem examination of the pilot identified obvious deterioration of the replacement aortic valve, in particular 2 of the cusps showed friable vegetations and one of the cusps had partly disintegrated and perforated. The valve showed evidence of calcification, degeneration and collections of fibrin. The heart was otherwise generally healthy.

1.13.5 Post-mortem examination of the 3 occupants confirmed they died on impact of extensive traumatic injuries. Toxicology tests identified saturated carbon monoxide levels of between 1 and 2%, well within the expected range of 0.4% to 3.7% for non-smoking urban dwellers. None of the occupants were known to smoke cigarettes.

1.13.6 Tests of the pilot's blood sample detected carboxy-tetrahydrocannabinol (THC-COOH) at a concentration of approximately 14 micrograms per litre. No tetrahydrocannabinol (THC) was detected. More detailed comment on THC-COOH and the effects of cannabis is contained in section 1.18 and the Appendices. There was no other finding of note.

1.14 Fire

1.14.1 There was no fire.

1.15 Survival aspects

1.15.1 The force of impact rendered the accident non-survivable.

1.16 Tests and research

1.16.1 The engines were removed from the wreckage and taken to an independent overhaul facility. The engines were stripped and examined under the supervision of the Commission. Both engines were found to be in good condition with no evidence of any pre-impact failure. They were considered to have been serviceable at the time of the accident. An assessment of the power being developed at the time of impact was not possible.

1.16.2 The propellers were stripped and examined at an approved propeller shop, again independent and under the supervision of the Commission. The propellers displayed evidence of being under power and in the operating range at the time of impact. No pre-accident anomalies were found.

1.16.3 Examination of the autopilot annunciator panel light bulbs revealed no evidence of filament hot stretch to indicate that the autopilot was engaged at the time of impact. However, the lack of hot stretch does not mean that the autopilot was not engaged.[12]

1.16.4 The model of GPS fitted to the aeroplane retained no useful information.

Aircraft ADF equipment

1.16.5 Examination of the wreckage of ZK-FMW by an avionics engineer determined that the aircraft ADF had been correctly installed and the cabling connecting the receiver to the antenna was intact. The terminations of the outer shields on all 3 tri-axial cables were bonded to the airframe at both ends for screening against interference. The receiver rack connectors were properly retained and in good order.

1.16.6 The ADF antenna was correctly bonded to the airframe and all 3 connectors were on and locked. However, on disconnecting the "Y" channel connector from the antenna, the cable pulled away from the crimped connector. Failure of the connection would result in the ADF indicator pointing directly forward or aft, depending whether the incoming signal was forward or aft of the aircraft.

1.16.7 The ADF receiver / controller was examined at an approved avionics overhaul facility. Although the controller faceplate and frequency selector knobs were damaged, the circuitry was found intact. Testing determined that the selected frequency was 230 kHz, the selected mode was "ADF", and the volume was set at about 67%. The identification function was enabled at the controller, but the pilot reception of the NDB's identification signal would also require selection of ADF on the audio control panel.

1.16.8 The damaged receiver and the undamaged antenna were bench tested as a pair and found to be operating correctly.

NDB testing

1.16.9 ACNZ technicians completed special ground inspections of the NDB and DME about 6 hours after the accident. The navigation aids were found to be satisfactory in all respects. Flight Inspection Services completed an airborne inspection of the navigation aids the next day, including all published NDB and NDB DME approaches to Taupo.

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[12] Hot stretch of the filament can be an indicator that a bulb was illuminated at the time of impact, therefore showing that the associated system was active.

1.16.10 During the airborne inspection the NDB DME Bravo approach was flown from a point on the 10 nm DME arc, through the turn to final track, to the missed approach point. The maximum needle swing detected during the approach, when compared to an equivalent GPS track, was ± 4º. An off-set visual approach was also flown, approximating the track of ZK-FMW after it commenced the turn towards final approach. A maximum needle swing of ±5º at 10 DME and 3700 ft was noted, reducing to zero error at 7 DME and 2700 ft. The maximum permitted ADF needle swing was ±5º for approach tracking. ACNZ considered the operation of the NDB and DME were satisfactory in all respects.

Possible interference sources

1.16.11 Two damaged cellphones were recovered from the accident site. One cellphone was identified as belonging to the pilot, while the second belonged to a passenger. Telephone company records were examined and it was confirmed that the passenger's cellphone had not been operated for the duration of the flight.

1.16.12 Records for the pilot's cellphone showed that between 1148 and 1213 the couple's tour agent had attempted to contact the pilot 6 times. At 1150:01 one of the calls was recorded as being completed and lasted 12 seconds. The tour agent was waiting at Taupo for the aeroplane to arrive and was adamant that he had not spoken to the pilot, but had probably been connected to the pilot's answering facility.

1.16.13 The ATS radar plot for ZK-FMW on 2 February showed the aircraft's track overlaid part of the Wairakei – Whirinaki 220 kV transmission line to the north of Mount Tauhara. Power line operators used narrow bandwidth power line carriers to send speech and control information along transmission lines, using frequencies in the range 40 – 464 kHz, but excluded the aeronautical frequency band (for NDBs) of 200 – 416 kHz. The Whirinaki and Rangipo transmission lines used 2 dedicated frequencies in the range 153 – 184 kHz.

1.16.14 In humid conditions, air is more conductive and so there is a greater power loss from HV lines. The power loss, termed coronal discharge, produces a broad-spectrum electromagnetic "noise" that attenuates quickly to low levels beyond 100 m from the line.[13]

1.16.15 Another source of NDB signal interference can be environmental electrical interference. This can be most noticeable during lightning discharge, where there is a short duration burst of static over a wide frequency range. A more continuous type of static interference can occur during flight through heavy moisture-laden cloud or precipitation. By listening to an ADF frequency being used, a pilot might detect the presence of intense static electricity.

1.16.16 The line operator considered that radio frequency interference would be insignificant and unlikely to affect NDB frequencies or ADF processing at typical aircraft overflight distances, 300 m (about 1000 ft) or higher above the lines. An independent avionics technician, familiar with ADF operating capabilities, agreed with the line operator's analysis.

1.16.17 In 2001, another operator reported several incidents of aircraft having tracking difficulty while conducting NDB approaches to Taupo, including the NDB DME Bravo approach. That operator believed the fault was with the aircraft's internal wiring as no cause could be identified and the incidents ceased when the aircraft type was replaced. The aircraft type was not of the same type as ZK-FMW and none of the deviations exceeded the designed containment area for the approach.

1.16.18 Several local operators expressed concern about the NDB DME Bravo approach and in one case directed its pilots not to fly this approach. Their concern was primarily to do with the proximity of high terrain, Mount Tauhara, to the final inbound track compared to other approaches, which offered potentially greater safety margins for any navigation error.

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[13] New Zealand Standard 6869:2004. Limits and measurement methods of electromagnetic noise from high voltage AC power systems, 0.15 – 1000 MHZ.

1.17 Organisational and management information

1.17.1 The operator was formed in 1984 and certified under Civil Aviation Rule Part 135 Air Transport Operations – Helicopters and Small Aeroplanes, and performed mainly IFR and VFR charter operations, including air ambulance flights. The operator flew and maintained a fleet of 6 aircraft, including ZK-FMW, which were capable of carrying between 3 and 9 passengers each.

1.17.2 The operator advised that in addition to using the fixed card method for flying NDB approaches on the RBI, it was also company policy to not engage the autopilot during an instrument approach but to manually fly the aircraft.

1.17.3 The CAA's last routine audit of the operator was on 27 October 2004 and recorded a satisfactory standard. Comments reflected previous audit inspection reports, including "aircraft maintained to a high standard and in excellent condition". At the time of the audit, the operator had 9 employees, consisting of 5 pilots and 4 maintenance staff. The chief executive, one of the 5 pilots, was a qualified instructor and flight examiner who conducted most of the pilot training and flight checks. In these roles he had been involved in much of the pilot's training and conducted his most recent competency checks. However, the pilot's early training, including his PA34 Seneca training, was done by other instructors. A flight examiner, external to the operator, conducted the check flights on the chief executive.

1.18 Additional information

NDB approaches Taupo

1.18.1 Pilots conducting the NDB DME Bravo approach were able to fly the full-published instrument approach procedure or join the inbound final approach track of 170º M from either straight-in or via the 10 nm DME arc. To complete the full approach, pilots would fly overhead the beacon and fly outbound on a track of either 318º M or 336º M, depending on aircraft approach category. At 8 nm they would turn right to fly the inbound approach track of 170º M track to the beacon. During the approach, minimum altitude requirements were established for particular segments of the approach.

1.18.2 For the full approach an aircraft was not permitted to descend below 4800 ft amsl until flying outbound from the beacon. The aircraft could then descend progressively but not below 3600 ft until within 8 nm on the inbound final approach track, and not below 2700 ft amsl until past the final approach fix at 5 nm and not below 2100 ft amsl until within 3 nm. The minimum descent altitude for the approach was 1940 ft amsl or 605 ft above the aerodrome elevation. On achieving visual reference with the aerodrome, a pilot was permitted to land on either of the runways but was required to remain west of runway 17/35 if manoeuvring the aircraft for runway 35.

Cannabis information

1.18.3 On 26 September 2002, a Piper PA32-300 (Cherokee Six) crashed shortly after take off from Hamilton Island, Queensland, Australia, killing all 6 occupants. The investigation by the Australian Transport Safety Bureau (ATSB) found that the pilot had evidence of alcohol, cannabis metabolites (THC-COOH), opiates and paracetamol in his blood.[14] The ATSB report stated the "evidence indicated that the pilot had used cannabis within the few weeks prior to the occurrence. That evidence did not necessarily indicate that the pilot was affected by cannabis at the time of the occurrence."

[14] ATSB Occurrence 200204328, Piper PA32-300, VH-MAR, Hamilton Island, Queensland, 26 September 2002.

1.18.4 As a part of that investigation the ATSB commissioned a research report on cannabis and its effects. The report, titled *Cannabis and its Effects on Pilot Performance and Flight Safety: A Review*, was released in March 2004.[15] Parts of the report are summarised and contained in Appendix A.

1.18.5 In addition to documenting the effects of cannabis on pilot performance, the ATSB report noted that "after alcohol and tobacco, and excluding caffeine, cannabis is the third most popular recreational drug". Further, "the use of marijuana in the young adult population has been increasing in recent years. It is logical to assume, therefore, that some pilots will be at least social users of cannabis."

Comments on the pilot's toxicology findings

1.18.6 After receipt of the initial toxicology results for the pilot, the Institute of Environmental Science and Research Limited (ESR) was asked a series of questions to clarify the information they had provided. The questions and full responses are contained in Appendix B.

Drug use legislation

1.18.7 Civil Aviation Rule 19.7 stated that:

> No crew member while acting in his or her official capacity shall be in a state of intoxication or in a state of health in which his or her capacity so to act would be impaired by reason of his or her having consumed or used any intoxicant, sedative, narcotic, or stimulant drug or preparation.[16]

1.18.8 The CAA advised that in 2002/2003 some initial work was done on drug testing in aviation; however, this was deferred as the Ministry of Transport (MoT) wished to look at the issue across all transport modes. At the time of writing this report the Australian Civil Aviation Safety Authority also had no legislation on drug and alcohol testing and the Australian Department of Transport and Regional Services was studying the implementation of a policy on testing.

1.18.9 In the US private pilots were not subject to a drug and alcohol testing programme, but commercial operators were required to have a drug testing regime in place.[17] This normally took the form of random testing and was to be applicable to all persons directly associated with the operation of aircraft, including all aircrew, maintenance personnel and air traffic controllers.

1.18.10 For the US specific limits were set for alcohol levels but there was zero tolerance for prohibited drugs:

> No certificate holder or operator may knowingly use any person to perform, nor may any person perform for a certificate holder or operator, either directly or by contract, any function listed in appendix I while that person has a prohibited drug in his or her system.[18]

Prohibited drugs included marijuana (cannabis), cocaine, opiates, phencyclidine (PCP), and amphetamines.

1.18.11 The United Kingdom permitted drug and alcohol testing of persons working in safety-sensitive areas within the aviation industry. The testing could be initiated at anytime when there was a suspicion of drug or alcohol abuse.[19] This could also apply pre or post-accident.

[15] For a full copy of the report see: www.atsb.gov.au/aviation/research/reports
[16] Civil Aviation Rule Part 19.7, Intoxicating liquor and drugs, dated 25 November 2004.
[17] United States Code of Federal Regulations Part 135.249 to 135.255, and Part 121.455 to 121.459.
[18] United States Code of Federal Regulations Part 135.249 (c) and Part 121.455 (c).
[19] United Kingdom Railways and Transport Safety Act 2003.

Terrain awareness and warning system (TAWS)

1.18.12 On 6 June 2003, a Piper PA31-350 Navajo Chieftain impacted terrain during an instrument approach to Christchurch.[20] The investigation identified the accident as a controlled flight into terrain (CFIT) event and the utility of TAWS was examined. An assessment of the aircraft's approach determined that had a TAWS been fitted a number of warnings would have been generated during the approach in time for the pilot to avert the collision with terrain.

1.18.13 On 30 November 2004, a Piper PA34-200T Seneca struck Mount Taranaki / Egmont, about 150 ft below the summit, while on a VFR flight from New Plymouth to Nelson.[21] The investigation determined that the pilot probably unknowingly lost visual reference with the snow-covered mountain peak. Later calculations determined that had a TAWS been fitted and operating, the pilot would have received 2 alert warnings, both in sufficient time to manoeuvre the aircraft away from the peak.

1.18.14 TAWS is the International Civil Aviation Organisation (ICAO) generic name for ground proximity warning systems (GPWS), including the Enhanced GPWS (EGPWS) that uses a terrain database and aircraft position information to provide "look ahead" warnings of terrain. Using the terrain database for the Taupo area and the ATS radar track and transponder altitude for ZK-FMW, a TAWS profile was calculated for the accident flight. Had a TAWS been fitted to ZK-FMW it was determined that an initial warning of "Caution Terrain" should have been generated between 60 seconds and 42 seconds before calculated impact. A second warning of "Terrain Terrain Pull Up" should have been generated about 33 seconds before calculated impact.

1.18.15 With some exceptions, aircraft operated under CAA Rules Part 121 Air Transport Operations – Large Aeroplanes and Part 125 Air Operations – Medium Aeroplanes, were required to have TAWS equipment fitted.[22] Aircraft having a passenger seating configuration of 9 seats or less and a maximum certified take-off weight of 5700 kg or less, such as ZK-FMW, which operated under Civil Aviation Rule Part 135: Air Operations – Helicopters and Small Aeroplanes, were not required to have TAWS fitted.

1.18.16 Safety Recommendation 063/03 issued as a result of the Chieftain accident near Christchurch, recommended that the Director of Civil Aviation:

> Monitor closely the future development of TAWS equipment with a view to amending Part 135 to require its installation in relevant aircraft.

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[20] Refer TAIC Aviation Occurrence Report 03-004, Piper PA31-350 Navajo Chieftain ZK-NCA, controlled flight into terrain, near Christchurch Aerodrome, 6 June 2003.
[21] Refer TAIC Aviation Occurrence Report 04-007, Piper PA34-200T Seneca II ZK-JAN, controlled flight into terrain, Mount Taranaki / Egmont, 30 November 2004.
[22] CAA Rules Part 121.381 and Part 125.379 dated 25 November 2004.

1.18.17 The Director accepted the recommendation. In June 2005 the CAA advised that "the extension of TAWS requirements to initially cover IFR air transport Part 135 aircraft had been included as a Rules Project in the 2005/2006 Rules Programme." The plan was to split the Notice of Proposed Rule Making (NPRM) implementation into 2 parts – TAWS required for aircraft new onto the New Zealand register and the retro-fitment of TAWS to existing Part 135 aircraft. The key milestones identified by CAA were:

Part 135 TAWS – New Aircraft	
Draft NPRM to MoT	March 2006
Draft Final Rule to MoT	September 2006
Rule Signed by Minister	February 2007
Part 135 TAWS – Retro-fit	
Draft NPRM to MoT	September 2006
Draft Final Rule to MoT	March 2007
Rule Signed by Minister	August 2007

1.18.18 The CAA considered the TAWS implementation "to be the highest priority new rules project in the programme".

1.18.19 US FAA Regulations required all turbine-powered aeroplanes operated under Part 135 with 6 or more passenger seats to be fitted with an approved terrain awareness and warning system.[23]

Medical standards

1.18.20 The New Zealand CAA Medical Manual, Section 2.3 Cardiology, did not provide any standards or policy on the assessment of valvular disease.[24] Other national and multinational aviation regulating and licensing authorities, for example the European Joint Aviation Authority (JAA), the United States Federal Aviation Administration and Transport Canada, specify limits for acceptance of pilots with aortic valve disease on the basis of criteria such as pressure gradient, peak aortic velocity or valve cross sectional area. The JAA Medical Advisory Panel reviewed the criteria for acceptable aortic valve disease as recently as 2005.

[23] FAA Code of Federal Regulations 135.154, 29 March 2000.
[24] New Zealand CAA Medical Manual, Volume 2, Chapter 3 Cardiology, recorded as last amended 31January 2002.

2 Analysis

2.1 The accident flight was a routine charter for the operator and the pilot was experienced in such operations. While initially planned as a scenic flight, all parties agreed that due to the prevailing weather conditions at Kerikeri the primary objective was to reach Taupo.

The flight

2.2 The aircraft departed from Ardmore as planned and progressed normally to Kerikeri. Radar information indicated that the aircraft was accurately navigated along the direct Auckland to Kerikeri track. The pilot's decision not to land at Kerikeri after 2 unsuccessful attempts showed that he was not under pressure to take unnecessary risks. However, this meant that the 3 occupants would spend nearly 3 hours in the aircraft before landing at Taupo.

2.3 The leg from Kerikeri to Taupo was also accurately flown, indicating that the pilot was receiving good information from the aircraft's navigation equipment. All radio calls were correct and gave no indication that the pilot was under stress or distracted from his primary task of flying the aircraft. The turn onto the 10 nm Taupo arc, the manoeuvring around the arc, and the start of the turn inbound on the NDB DME Bravo approach were all properly initiated and flown, and again showed that the pilot was receiving correct NDB information.

2.4 At 1149:51 the radar data recorded ZK-FMW approaching the inbound NDB approach track and turning right through about 45º, onto a track of about 120º M. With a forecast 2000 ft wind of 060º T at 20 kt, there would have been little or no crosswind component as the pilot flew around the arc, but up to about 20 kt crosswind as he flew inbound. This would have given about 10º of right drift, which the pilot would have needed to make allowance for. However, what is not known is why the pilot turned about 45º only and not the normal 90º, plus an allowance for any known crosswind, as would be expected for a turn inbound from the arc. Nevertheless, after completing the short turn the pilot made a routine radio call advising Taupo traffic that he had turned inbound on the approach.

2.5 The aircraft continued on the 120º M track for nearly 3 minutes, crossing the correct inbound track for the approach, to position about 3 nm left of the required approach track. During this time the aircraft was descended and levelled at about 2800 ft. The descent of the aircraft matched the height profile for the instrument approach, which prohibited descent below 2700 ft until past the final approach fix at 5 nm DME.

2.6 At about 1152:44, the aircraft turned right, again by about 45º, onto a track of about 165º M. This was close to the 158º set on the heading indicator, and suggested the pilot was possibly making an allowance for the crosswind effect from the left. The new heading took the aircraft onto a slightly diverging path from the inbound approach track and directly towards Mount Tauhara. The aircraft remained level on this track for a little over one minute until it impacted the mountainside.

Considerations

2.7 The flightpath flown during the early stages of the instrument approach was as would be expected for an aircraft approaching Taupo with the intention of conducting the NDB DME Bravo via the arc. It was not until the aircraft was turned right off the arc to fly the inbound track of 170º M that the flight deviated significantly from the required track. Possible reasons for this deviation were considered.

2.8 The weather, though inclement, was still suitable for the pilot to fly a successful instrument approach to Taupo and land. The wind was moderate but steady from the north-east. Any excessive or unexpected increases in wind velocity would have drifted the aircraft to the west and not east of the inbound track as flown by ZK-FMW. There was no evidence of lightning or other severe weather phenomena that could have dramatically affected the performance of the aircraft or ADF reception. Further discussion on ADF interference is contained in paragraph 2.19.

2.9 Post-mortem CO measurements were well within normal levels, discounting the possibility of incapacitation due to CO poisoning. The 2 radio calls made after turning inbound and reporting at the final approach fix, also discount the possibility of pilot incapacitation during the approach.

2.10 The pilot was unlikely to have been flying by primary reference to GPS information. The track flown by ZK-FMW did not match any of the GPS approaches to Taupo, the pilot was not qualified, nor the aircraft certified to fly GPS instrument approaches.. Further, the pilot advised ATS and UNICOM that he was conducting the NDB DME Bravo approach and had the appropriate chart open on his lap. Also, the course deviation bar was set to 170º, the inbound track for the approach. Nevertheless, the pilot may still have had the Taupo Aerodrome selected as a GPS reference point to provide additional orientation information for the NDB DME approach.

2.11 There was no evidence of any obvious mechanical fault with the aircraft. The engines were producing power and the radar data showed the aircraft was holding about level with no unusual loss of airspeed as it approached the mountainside. The configuration of the aircraft, undercarriage down and some flap selected, probably one notch, was consistent with normal actions for an instrument approach.

2.12 The aft C of G could have affected the handling qualities of the aircraft, but this was unlikely to result in the aircraft becoming unstable and causing the accident. The conduct of the flight and the fact that the aircraft impacted the mountainside in a straight and level controlled manner supports this view. That the pilot did not include the weight of the passengers' bags, and still incorrectly calculated a C of G aft of the maximum limit before take-off was puzzling.

2.13 The radio calls made during the flight were routine and in accordance with normal protocols. There was no indication that the pilot was under stress at any time during the flight. The last radio call was probably only a few seconds before impact and indicates the pilot was controlling the aircraft and aware of his distance from the aerodrome but was unaware of his lateral displacement from the published inbound track.

2.14 The pilot was probably manually flying the aircraft, in accordance with normal company procedures, as there was no evidence that the autopilot was engaged at the time of impact. While there may be some advantages in this, use of an autopilot during an approach can help ease a pilot's workload.

2.15 The pilot was familiar with ZK-FMW, having just flown it for 10 days around New Zealand. However, until the accident flight there was no record of him having flown any instrument approaches in the aircraft since November 2002. The pilot was also familiar with Taupo and its instrument approaches, having last flown there about 7 weeks previously, when he flew an NDB DME approach in the PA42 Cheyenne. However, the ADF presentation in the PA42 used a slaved or rotating compass card to show actual aircraft magnetic heading, and not a fixed RBI compass card as in ZK-FMW.

2.16 Before the accident flight the pilot last flew a fixed card NDB approach during his instrument check on the PA31-350 Navajo Chieftain on 19 August 2004. Although he had not flown an NDB approaches using a fixed card RBI for nearly 6 months, he had just completed 2 approaches to Kerikeri using this equipment.

2.17 After nearly 3 hours seated in a small aircraft, all the occupants would have been looking forward to landing at Taupo. However, the pilot was reported to be well rested before the flight and, although perhaps a little tired after 3 hours, should have easily been able to manage this period of time without his performance deteriorating to the point of becoming unsafe.

2.18 There was no evidence to suggest the pilot was distracted during the approach. Radio calls were correct and the deviation from the required approach track took place over several minutes.

NDB and ADF information

2.19 The possibility that the pilot received an incorrect ADF indication during the flight was considered. There was no evidence to suggest that the signal from the NDB transmitter was faulty at the time of the accident, and the ground and flight inspections found the beacon conformed to specifications.

2.20 However, the flight inspection was not undertaken in exactly the same weather conditions prevailing at the time of the accident. Therefore, while there was no electrical discharge in the form of lightning, there was the potential for static electricity to be present with the cumulonimbus activity. This could have interfered with the accuracy of the NDB signal, but was considered unlikely as it would need to be sustained and intense as ZK-FMW progressed closer to the beacon. Further, the radio transmission shortly before impact gave no indication of static interference being experience by the aircraft's electrical system.

2.21 Possible interference of the signal by either cellphone or the local HV power lines was also considered as unlikely. Both cellphones were probably switched off and the call to the pilot's phone was likely diverted to his automated answering facility. The aircraft was too high and far away from the electromagnetic discharge of the power lines to be affected by it.

2.22 The ADF installation in the aircraft was found to be satisfactory. The condition of the "Y" channel connector cable probably resulted from the sudden and very forceful impact. Had the circuitry been compromised before the impact the pilot should have seen the ADF pointer align itself with the fore and aft axis of the aircraft – in this case probably pointing directly forward as the beacon was to the front of the aircraft. However, the pilot was likely receiving correct ADF information as he was able to fly around the arc and start the turn inbound at about the right position. Also the ADF needle was pointing about 30º to the right of aircraft heading, towards the NDB, at the time of impact.

2.23 Nevertheless, it was possible, albeit unlikely, that as ZK-FMW turned inbound from the arc, the cable connection became momentarily loose and made contact again just before impact. This could be an explanation for the steady divergence away from the inbound track, because with such a connector fault the ADF needle would point directly ahead of the aircraft. After nearly 3 minutes on the steady but diverging heading the pilot may have become concerned and turned right to fly the inbound heading. However, if that had been the case and the pilot had become concerned about the ADF information being presented to him, he should have immediately initiated a climb to a safe altitude and advised UNICOM or ATS. The last radio transmission gave no indication that the pilot had any cause for concern.

2.24 The concept of duplicated and independent navigation systems is laudable and should be practised where possible and practicable. However, further discussion was required, and is being undertaken, to ensure that unnecessary additional costs are not incurred by Part 135 operators, especially where a withdrawal of an NDB is planned and practicable alternatives may be available. For ZK-FMW it is unlikely that a second ADF would have indicated anything different from what the pilot saw as he flew inbound on the approach.

Aortic valve replacement

2.25 A failure of the aortic valve graft would have resulted in the sudden death of the pilot. The progressive departure from the instrument approach track accompanied by the pilot's radio calls did not support sudden incapacitation. Rather, the pilot was apparently manoeuvring the aircraft right up to the moment of impact with the hillside, as indicated by his radio call at about this time.

2.26 A progressive deterioration in the valve graft was observed with both the pilot's mean aortic valve pressure gradient and the peak aortic velocity rising over recent years. Increases in resistance and high flow rates were likely to cause increasing turbulence in flow across the valve, with consequential risk of endocardial damage, clot formation and subacute bacterial endocarditis. Significant degeneration of the graft was noted at autopsy and while it was not thought to have caused medical incapacitation of the pilot, progressively deteriorating medical symptoms and impairment were likely.

THC-COOH

2.27 The finding of the THC-COOH during the pilot's autopsy was both a surprise and a serious concern. Relatives of the pilot and the operator were adamant that he was not a user of cannabis, but the level found most probably excluded the possibility that he had passively ingested the drug.

2.28 Specialist medical opinion suggests that the pilot ingested cannabis between 12 and 24 hours before the accident, or earlier if he was a regular user of the drug. However, the presence of THC-COOH cannot be conclusively identified as a cause of the accident. The effects of cannabis are too varied and the timeframe too wide for a direct link to be made with the circumstances surrounding this accident.

Cannabis use in the transport industry

2.29 Flying is a specialised complex task, requiring high cognitive function and psychomotor performance. This can be especially so for a pilot flying a multi-engine aircraft on single-pilot IFR instrument approach in adverse weather conditions – arguably one of the most demanding roles in aviation. Anything that interferes with a pilot's ability to manage the aircraft, for example medical or psychological impairment, fatigue or a distraction, has an effect upon the safety of the aircraft and its occupants. The illicit use of drugs and alcohol is therefore a hazard to flight safety. The same risk applies to all other transport modes, of which there are recent examples for both rail and marine.[25]

2.30 The use of drugs and alcohol have become increasingly common in society, and so their misuse by persons in safety-sensitive areas of the transport industry should be of heightened concern. The mind-altering effects that can occur with cannabis use, even small amounts, cannot be accurately measured and so it would be difficult, if not impossible, to specify a tolerance limit other than zero.

2.31 New Zealand legislation prohibits the use of illicit drugs and Civil Aviation Rules state that a person may not take substances that will impair their performance while acting as a crew member. But there is no active mechanism for the detection of these substances before an accident or incident. Indeed, only after a fatal accident can tests be undertaken to identify the presence of any illicit substance.

2.32 A test regime should be put in place to both dissuade people from misusing drugs and alcohol, especially when working directly with aircraft or other transport machinery, and also to assure the travelling public that the aircraft, ship, train, bus or other vehicle is being correctly maintained, operated and controlled. The test regime therefore needs to include all those personnel that are directly concerned with the safe operation of transport machinery, for example, engineers, controllers and all crew members. The test regime must be robust enough to ensure it provides both a deterrent and is capable of identifying and disqualifying those personnel who compromise safety by using these substances.

Terrain awareness warning

2.33 The characteristics of the accident - a serviceable and controlled aircraft in almost level flight on a steady heading, inclement weather and approaching the conclusion of an instrument approach are typical of a CFIT type accident. There was substantial evidence indicating that the pilot was

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[25] Refer TAIC Marine Occurrence Report 04-21, Fishing vessel Iron Maiden, foundering off Pandora Bank, Northland, 16 August 2004, and TAIC Rail Occurrence Report 02-116, Express freight Train 533, derailment, near Te Wera, 26 July 2002.

controlling and manoeuvring the aircraft during the approach but was not aware of his exact geographical position. A TAWS alert of the rising terrain ahead of ZK-FMW should have given sufficient warning to have allowed the pilot to manoeuvre the aircraft away from the mountain.

2.34 The effectiveness of TAWS is indisputable, especially for single pilot IFR operations, and the Commission strongly supports the requirement to have this equipment fitted to Part 135 aircraft which operate single pilot IFR, as soon as practicable. Equipment is currently available and recent accidents indicate the proposed NPRM should not differentiate between aircraft new onto the register and the retro-fitting of currently registered Part 135 single pilot IFR aircraft.

Controller warning

2.35 Although ZK-FMW was recorded on radar as it approached Taupo, it would have been unreasonable to expect the ATS controller to have notified the pilot in time to avoid the accident. The pilot had vacated controlled airspace on descent to Taupo and therefore he was solely responsible for the safe conduct of the flight by adherence to established procedures and maintaining adequate terrain separation.

2.36 The deviation left of the approach track would have appeared minor on the controller's radar screen at the ACNZ Centre in Christchurch as he continued to manage the safe orderly flow of other aircraft in controlled airspace above. Further, any deviation from the inbound approach track could be explained by the pilot becoming visual early and manoeuvring the aircraft to position for landing.

2.37 Had a controller observed ZK-FMW deviating significantly from the required approach track and wanted to check with the pilot, they would have needed to first call the Taupo UNICOM duty operator, who would then relay any information to the pilot. For ZK-FMW there was probably insufficient time for this to take place, and the controller had no responsibility to do so.

Search action

2.38 The ELT functioned as designed and the activated signal provided a good reference point for the search. Once initiated, the search action was effectively controlled and the wreckage was found promptly.

2.39 The actions of the ATS controller and the Taupo UNICOM duty operator were appropriate considering the location and timing of the accident. The controller was waiting for the pilot to report safely on the ground at Taupo. Knowing the type of approach and the route the pilot intended taking, the controller would not have expected to be called for at least 20 minutes after the pilot reported changing to the UNICOM frequency.

2.40 UNICOM was established to provide an aerodrome information service and not for active flight following – it was not an aerodrome control tower. Unbeknown to the UNICOM duty operator, the pilot of ZK-FMW may have initiated a missed approach and changed to ATS to obtain another clearance without advising Taupo traffic. Alternatively the pilot may have been manoeuvring downwind to land on runway 35 and had yet to call, or the duty operator may have missed the call.

3 Findings

Findings 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 held a current medical certificate but unbeknown to him, his heart condition had deteriorated to the extent that he should have been medically disqualified from flying duties.

3.3 Current medical standards and monitoring may not be adequate to intervene and prevent a pilot operating with an imminent disqualifying medical condition.

3.4 The pilot's ability to fly ZK-FMW on the day of the accident was probably not affected by his heart condition.

3.5 The pilot was experienced in charter operations and current in instrument flying.

3.6 In the 2 years before the accident the pilot had probably flown only one NDB instrument approach using a fixed card RBI.

3.7 The aircraft had a valid Certificate of Airworthiness and was recorded as being serviceable for the flight.

3.8 Although the aircraft centre of gravity was outside limits, this probably did not contribute to the accident.

3.9 Why the pilot calculated a centre of gravity outside of limits, and did not include any baggage in the calculations, could not be determined.

3.10 The flight progressed normally until the aircraft turned inbound on the instrument approach to Taupo.

3.11 Why the pilot deviated from the final approach track could not be determined.

3.12 The aircraft would have been in instrument meteorological conditions as it was flown towards Mount Tauhara, but the weather conditions were not extreme at the time of the accident.

3.13 Aircraft navigation equipment was probably operating correctly in the time leading up to the accident, but this could not be proved.

3.14 There was no evidence of any aircraft mechanical fault causing the accident.

3.15 An intermittent fault in the wiring for the ADF receiver might explain the deviation from track, but this scenario was not supported by the pilot's actions, including the last radio transmission at the correct distance out for the final approach fix, nor by the captured indication on the RBI, and is considered unlikely.

3.16 There was no evidence of NDB signal interference or transmitter malfunction, but the possibility of electrical interference cannot be fully ruled out.

3.17 There was no evidence of any pilot incapacitation or distraction that would cause the aircraft to deviate from course.

3.18 The deviation from the required track occurred during a period of moderately high workload.

3.19 Despite the flight taking nearly 3 hours, there was no evidence of pilot fatigue or stress.

3.20 The pilot's mental function and flying performance may have been impaired as a result of prior cannabis use, but this could not be proved.

3.21 No conclusive cause for the accident was determined.

3.22 This accident was probably preventable had TAWS equipment been fitted to ZK-FMW to give the pilot a warning of terrain ahead in sufficient time to take avoiding action.

3.23 The search for the missing aircraft was correctly initiated and appropriately handled.

4 Safety Actions

4.1 The MoT formed a group to investigate the misuse of drugs and alcohol in the transport industries. The group, titled the Substance Impairment Group (SIG), was made up of representatives from the various transport modes and was charged with scoping the problem and making recommendations to the Minister of Transport to initiate any required changes in legislation to the Civil Aviation Act, Maritime Safety Act and Railways Act.

4.2 On Monday 19 September 2005, the inaugural meeting of the SIG took place. The Commission was part of the group and presented to the group its experience in investigation where drugs or alcohol had been involved or suspected, and any recommendations that had been made as a result.

4.3 The Commission will continue to be part of the SIG and provide input where required. The group is to make initial recommendations to the various transport managers and the Minister of Transport by May 2006, followed by consultation with the transport industries.

5 Safety Recommendations

Safety recommendations are listed in order of development and not in order of priority.

5.1 On 4 January 2006 it was recommended to the Director of Civil Aviation that he:

5.1.1 define criteria for clinical parameters, such as peak aortic velocity, that would limit the risk of sudden incapacitation in pilots with mild heart valve disease to within acceptable limits, and establish appropriate medical surveillance criteria. (095/05)

5.1.2 promote the early introduction of terrain awareness and warning systems for Part 135 aircraft, current and new, flown under single-pilot IFR in accordance with the criteria to be prescribed by the proposed new Rules. (096/05)

5.2 On 5 January 2006 the Director of Civil Aviation replied:

5.2.1 I will not accept this recommendation as worded; however I will review CAA handling of pilots with valvular heart disease at a joint clinical workshop that will take place in June 2006.

I have come to this decision because; there is no evidence, provided by TAIC or obtained from other sources, to suggest that the pilot had a risk of sudden incapacitation that was outside of the acceptable limits. Certainly the pilot failed to meet our medical standards but he was subsequently assessed under the flexibility provisions of the legislation. This case-by-case assessment considered the medical information available, including the aortic flow characteristics, and determined that the incapacitation risk was within acceptable limits. In issuing that medical certificate stringent medical surveillance requirements were also imposed. (095/05)

5.2.2 I will accept this recommendation and will continue to promote the early introduction of terrain awareness and warning systems for Part135 aircraft consistent with the time frame established with the Ministry of Transport. It is anticipated that the Draft NPRM will be completed by September 2006. No precise time frame for final implementation can be stated as the date is dependant on the consultation process being completed. (096/05)

Approved on 16 December 2005 for publication

Hon W P Jeffries
Chief Commissioner

Appendix A

Australian Transport Safety Bureau Research Report: Cannabis and its Effects on Pilot Performance and Flight Safety: A Review. Released March 2004.

Introduction

Cannabis, or marijuana, is a commonly used recreational drug, which has widespread effects within the body. Smoking is the most common form of administration. The adverse effects of cannabis on behaviour, cognitive function and psychomotor performance are dose-dependent and related to task difficulty. Complex tasks such as driving or flying are particularly sensitive to the performance impairing effects of cannabis. Chronic cannabis use is associated with a number of adverse health effects, and there is evidence suggesting the development of tolerance to chronic use as well as a well-defined withdrawal syndrome. There is also evidence that the residual effects of cannabis can last up to 24 hours.

Significantly, the modern dose of cannabis is much more potent than in the past, when the majority of research was conducted. As such, the reported adverse health effects may be conservative. Although only a limited number of studies have examined the effects of cannabis on pilot performance, the results overall have been consistent. Flying skills deteriorate, and the number of minor and major errors committed by the pilot increase, while at the same time the pilot is often unaware of any performance problems. Cannabis use in a pilot is therefore a significant flight safety hazard.

The pharmacology of cannabis

Cannabis contains over 400 chemical compounds, including over 60 pharmacologically active constituents known as cannabinoids. The most potent and psychoactive of these is Δ^9-tetrahydrocannabinol (THC). Cannabinoids accumulate in fatty tissues, reaching peak concentration within 4 to 5 days. After that, the THC is gradually released back into other body areas, including the brain. For this reason, blood THC levels do not correlate well with intoxication.

Cannabinoids are metabolised in the liver over 1 to 2 days, this process resulting in the formation of over 20 different metabolites. Some of these are psychoactive, and all have long half-lives. The metabolites are excreted in urine (25%) and from the gut (65%). Metabolites in the gut are reabsorbed, which prolongs their actions in the body.

Eventually THC is broken down into an inactive metabolite, THC-COOH. This substance is then excreted from the body over a period of days to weeks. Detection of THC-COOH in the blood only indicates prior use of marijuana, within the previous few weeks.

Effects of cannabis

Cannabis produces a wide variety of effects in all parts of the body and most body systems. It thus shares some properties of alcohol and other drug classes such as tranquillisers and opiates.

Marijuana produces a sense of relaxation and euphoria, the so-called “high”, and gives a feeling of intoxication with decreased anxiety and increased sociability (if the drug is taken in friendly surroundings). Some adverse behavioural and mood effects have been noted in some users. These include severe anxiety reactions and panic attacks, as well as paranoia and psychosis.

The effects of cannabis on cognitive function and psychomotor performance are dose related. Acute exposure to marijuana impairs attention and learning, increases reaction time and causes difficulty in concentration. Reduction in motor skills has also been described. Acutely, marijuana impairs the ability to perform complex tasks requiring attention and mental coordination. The more difficult the task, the greater the degree of impairment.

A consistent finding with marijuana use is that it significantly affects memory, especially short-term or working memory. Working memory is extremely important and involves the temporary storage of information derived from sensory systems, long-term memory stores, and motor programmes to enable the completion of cognitive tasks that require conscious thought, reasoning, and divided or focused attention.

Chronic cannabis use is associated with a number of adverse health effects, including bronchitis and emphysema. It has been shown to interfere with the normal function of the immune system and has a number of reproductive risks. It has also been associated with increased apathy, loss of energy and lack of drive or motivation to work.

Residual effects of cannabis

Some research found evidence of a residual drug effect on attention, psychomotor tasks and short-term memory during the 12 to 24 hour period following cannabis use. This effect may occur after just a single dose of cannabis. The residual drug effects of cannabis appear to consistently involve impairment of performance on tests of focused attention, visual and verbal memory, and visuomotor functions. It has also been demonstrated that marijuana can adversely affect human performance of complex cognitive tasks for up to 24 hours after smoking marijuana. It has been further suggested that the extent of cannabis effects post-exposure may well depend on the complexity of the task being performed.

The problem of marijuana in aviation

Flying an aircraft is a complex task requiring a high level of cognitive function and psychomotor performance. Marijuana has been shown in many studies to impair the performance of complex tasks. The marijuana-associated decrease in flight performance involved an increase in errors such as navigation errors, altitude deviations, heading errors, stalling and loss of control events.

In one study involving pilots who were experienced social marijuana smokers, the acute effects of marijuana were seen to persist for 2 to 6 hours after administration. Marijuana caused alterations in concentration, and in some cases complete loss of orientation. Attending behaviour also changed in some pilots, with them paying attention to only one variable to the absolute exclusion of all others. Temporal distortion, a known consequence of acute marijuana exposure, was also noted, with some pilots no longer being able to tell how long they had been flying.

Another study examined the difference between acute effects of marijuana on pilot performance and flight safety, and the carry-over or hang-over effects following cannabis use in pilots. This indicated that there were significant effects on pilot performance 24 hours after smoking a single marijuana cigarette. Pilots demonstrated much more difficulty in aligning with and landing on the runway. Control movements increased in number and magnitude during the approach. At 24 hours post-marijuana, the lateral deviation on approach to land was almost twice that of the pre-marijuana test. More worrying, perhaps, was their finding that the pilots were not aware of any impairment of their flying performance at 24 hours post-exposure. On the basis of their research findings, they concluded that recreational marijuana users may not necessarily have any performance difficulties with complex human-machine interactions such as flying. However, if other performance-reducing factors are added (such as bad weather or other flying related difficulties) then they may find that their performance becomes significantly impaired, due to the cumulative effects of these factors overloading cognitive function and working memory.

On the basis of the available evidence, it would appear that impairment of performance and skills is at a maximum during the first 4 hours after taking marijuana, although performance improves after this period there is still some residual impairment over subsequent 24 hours. The combination of this impaired performance at 24 hours and some other performance-reducing factors such as increased task difficulty can result in significant impairment of performance in pilots.

Appendix B

New Zealand Institute of Environmental Science and Research Limited: Comments on the Pilot's Toxicology Results

Question 1: Is there any chance of misidentification of samples during analysis?

Response: On arrival at ESR, all samples are assigned a unique identifier. Samples associated with this case were assigned TOX05962. With each analytical procedure carried out the analyst notes both the name on the bottle and the reference number. This has happened, in this case, for each analytical technique used. Furthermore, for the procedure that identified the presence of THC-COOH, I handed the blood bottle to the person who extracted the sample. It was the only blood sample in a batch of urine samples. The analytical techniques are designed to prevent cross-contamination or carry-over from one sample to another.

Question 2: Tests used to examine the samples for carbon monoxide (CO), THC and THC-COOH?

Response: Carbon monoxide. The test used is a standard documented method, used to determine CO saturation, usually in coronial cases where death is assumed to be due to car exhaust inhalation. It is also regularly carried out on fatally injured pilots to ensure engine exhaust did not impair the pilot. The method takes 2 samples of the blood provided, saturates one of the samples with CO, and compares the saturated and unsaturated samples. This comparison is made using an ultraviolet detector.

THC. The test used to determine the presence of THC is a standard validated method specific for THC. It involves manual extraction of samples of the blood, spiked with an internal standard. These samples are processed on a liquid chromatograph with tandem mass spectrometric detectors (LCMSMS) and are compared with standards of known concentration.

THC-COOH. The test used to determine the presence of THC-COOH is a standard validated method specific for the THC-COOH. This method has been validated for urine rather than blood. The blood sample is diluted with water and does not undergo the digestion that urine samples are subjected to. Urine samples undergo digestion to split the THC-COOH from a glucuronide group, a combination that is formed during metabolism. The urine analysis therefore tests for both free THC-COOH and the THC-COOH-glucuronide. The blood sample was tested only for the presence of free THC-COOH. I do not know how much THC-COOH-glucuronide would be present in the blood. An internal standard is added to all samples which are extracted using an automated extraction technique. The extract is derivatised and injected on a gas chromatograph with mass spectrometric detection (GCMS) along with standards of known concentration.

Question 3: Accuracy and precision of methods used?

Response: THC. Limit of detection (LOD) 0.1 nanogram per millilitre (ng/mL)
Accuracy and precision 5%
THC-COOH. LOD 1ng/mL
Accuracy within 10%
Not validated for blood and therefore may be less accurate than for urine.
Note. Nanograms per millilitre are equivalent to micrograms per litre.

Question 4: Low levels of THC-COOH are reported as negative and chances of false positive reporting?

Response: When analysis of THC-COOH in urine is carried out, the results indicate only if cannabis has been used. Standards have been set within Australia and New Zealand whereby there is a level below which the THC-COOH levels are considered negative. This is to exclude any possibility of a person exposed to second-hand cannabis smoke returning a positive result. Low levels of THC-COOH may be detected in urine, but not blood, following passive smoking. In our laboratory urine levels below 15 ng/mL are reported as negative. Blood THC-COOH levels cannot be related to urine levels. Urine is a waste product of the body. Levels of drugs can be concentrated or diluted in urine depending on how much liquid is ingested.

Using the tests described above the chance of a false positive result is infinitesimally small. One of the initial tests carried out on the blood sample was an immunoassay test specific for cannabis. This test indicated possible cannabis use. This test can give a small number of false positive results as it reacts to a range of cannabis metabolites as well as THC. Therefore the blood was analysed for the presence of THC.

No THC was detected in the blood. I would expect to see THC levels at or above 0.1 ng/mL. Because no THC was detected in the blood, and I could not leave the result as possible cannabis use based on the immunoassay test, I had the blood analysed for the presence of THC-COOH. This test exclusively identified the presence of THC-COOH as well as determining its level. Because the method is not validated for blood, I reported the level as approximate.

Question 5: Could the THC-COOH be present as a result of passive smoking?

Response: In a study reported in the scientific literature, levels of THC and THC-COOH in the blood or plasma resulting from passive smoking were reported. The circumstances of the exposure to the passive smoke would be considered extreme, sharing a small room with several smokers.[26] THC-COOH levels were not detected above 2.1 ng/mL during and immediately after exposure. Therefore the level of THC-COOH in the pilot's blood is unlikely to have resulted from passive exposure to cannabis smoke.

Question 6: The meaning of a negative THC result but positive THC-COOH result?

Response: In the studies reported in the literature, volunteers smoked standard sized cannabis cigarettes and their blood was taken at set times after the cigarette was finished. THC and THC-COOH levels were measured. The times at which THC was no longer detected and the THC-COOH levels were in the range of that detected in this case, ranged from between 12 and 24 hours. These results relate only to the use of a single cannabis cigarette. If cannabis is used regularly THC-COOH is likely to be detected in the blood, in the absence of THC, for longer than 24 hours.

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[26] Mason AP, Perez-Reyes M and McBay AJ "Cannabinoid Concentrations in Plasma After Passive Inhalation of Marijuana Smoke", Journal of Analytical Toxicology 7 (1983) 172 – 174.

Question 7: In the case of one-off consumption of cannabis?

Response: The time range in the above paragraph would be expected for one-off consumption. It is not possible with cannabis to determine how much has been used. The study results I have reported above are based on use of a single standard cigarette, not part of cigarette or several cigarettes. The potency of the cannabis in these studies is about 3% THC in the dry plant. When a study was carried out in New Zealand, about 10 years ago, the average potency of cannabis was about 3% but ranged from less than 1% to 10%. More recently with hydroponic growing methods, higher potency cannabis can be expected. In the few samples that have been analysed THC levels in New Zealand plants have been measured up to 20%, while overseas higher levels have been reported.

If a single cigarette of average potency was used I would expect the level of THC-COOH determined in this case, between 12 and 24 hours after use. If a higher potency cannabis was used such a level may be seen for a longer period.

Question 8: What is THC-COOH?

Response: THC-COOH is the main metabolite of THC. It is not psychologically active. A metabolite is a compound that the body produces when a drug is introduced into the blood stream. THC-COOH is produced very quickly. THC-COOH levels in blood exceed THC levels in blood within about 40 minutes of smoking.

Question 9: What are other sources of THC-COOH?

Response: THC-COOH must be produced from THC. It is only formed in the body by metabolism of THC. It is not found in nature, that is, on cannabis plants. Food products derived from hemp (low potency cannabis plant) are not legal in New Zealand. The only form available is hemp seed oil, formed by crushing hemp seeds. It is possible to find very low levels of THC in hemp seed oil. There are reports of THC-COOH being detected in urine following ingestion of hemp seed oil. However, unless the use of the product is excessive, urine THC-COOH levels remain below the cut-off. I can find no study where levels of THC or THC-COOH in blood has been measured following ingestion of these types of products. Based on the low levels detected in urine I would not expect a detectable amount of either THC or THC-COOH to be found in the blood. THC-COOH will not be produced by decomposition processes.

Question 10: Soil contamination?

Response: Even if soil has been used to grow cannabis, any possible contamination would be by THC not THC-COOH. THC will not be metabolised to THC-COOH after death.

Question 11: The relevance of the THC-COOH level?

Response: THC-COOH levels are never high in blood. They never reach the peak levels attained by THC itself. THC levels can get up to 100 ng/mL or more while a cigarette is being smoked but drop rapidly. In the studies mentioned above THC-COOH levels peak at 20 to 60 ng/mL, anywhere from 1 to 4 hours after smoking. THC levels drop to or below detection limit anywhere from 4 to 24 hours after smoking.

THC-COOH levels in blood do not drop as quickly as the THC levels because THC-COOH is more soluble in water, and therefore blood, than THC itself. The level of THC-COOH in the pilot's blood is such that unless he was a regular user of the drug, it may have resulted from cannabis use within the previous 24 hours. With regular use of cannabis, levels of THC-COOH build up and therefore take longer to clear from the body. Also, use of more than a single cigarette or use of particularly potent plant, will likely result in THC-COOH being detected for longer than 24 hours.

Question 12: THC-COOH is an inactive metabolite?

Response: It is not possible to determine if a person is affected by cannabis based only on either THC or THC-COOH levels. The drug works on sites in the brain. Levels of THC or THC-COOH in the blood do not relate to brain levels.

Question 13: Carbon monoxide (CO) levels?

Response: The level of carbon monoxide in the pilot's blood is consistent for a non-smoker or someone not exposed to CO fumes. A smoker of tobacco may have a CO level of up to 6%. Levels of CO will drop when no longer exposed to CO and for a person who does not smoke regularly I would expect CO levels to drop to that of a non-smoker within 12 hours.

Question 14: Could THC-COOH come from fat distributed in the blood due to trauma?

Response: THC is fat soluble. THC-COOH is water soluble. If fat were distributed into the blood as a result of the accident I would expect to detect THC rather than THC-COOH.

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