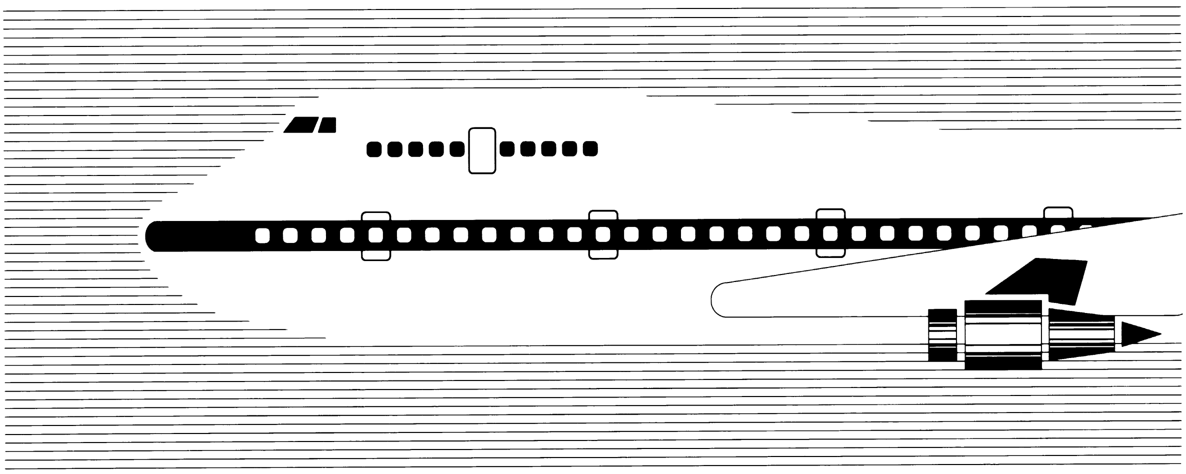

AVIATION OCCURRENCE REPORT

03-006 **Convair 580, ZK-KFU, loss of control and in-flight break-up, Kapiti Coast** **3 October 2003**

TRANSPORT ACCIDENT INVESTIGATION COMMISSION
NEW ZEALAND

TRANSPORT ACCIDENT INVESTIGATION COMMISSION
TE KOMIHANA TIROTIRO AITUA WAKA

Report 03-006

Convair 580

ZK-KFU

loss of control and in-flight break up

Kapiti Coast

3 October 2003

Abstract

On Friday 3 October 2003 at 2126, Convair 580 ZK-KFU was on a scheduled night freight flight from Christchurch to Palmerston North, when it was observed on radar to enter a tightening left turn and disappear. Attempts to contact the aircraft were unsuccessful and a search for the aircraft was started.

The aircraft had impacted the sea about 10 km north of Paraparaumu about vertically and at high speed. The crew of 2 was killed on impact.

After crossing Cook Strait the aircraft probably became heavily iced up while descending through an area of severe icing, and stalled after flying level for a short time. The crew was unable to recover from the ensuing spiral dive and the aircraft broke up as it descended.

Safety issues identified included:

- the need for all pilots and operators to have a better understanding of aircraft icing
- the use of air reports to alert pilots to hazardous meteorological conditions
- the adequacy of aircraft, operator and CAA documentation to assist pilots encountering adverse weather conditions, particularly for IFR and night freight operators in icing conditions
- the adequacy of the installation, performance and capabilities of cockpit voice and flight data recorders
- the requirement for a suitable tracking device to be readily available to find underwater location beacons.

Safety recommendations were made to the Director of Civil Aviation and the operator to address these issues.

Convair 580 ZK-KFU

Contents

Figures

Abbreviations

AC	alternating current
ADF	automatic direction finder
AF 642	Air Freight 642
AIP	Aeronautical Information Publication
AIREP	air report
AIRS	Alliance Icing Research Study
ATS	Air Traffic Services
ATSB	Australian Transport Safety Bureau
C	Celsius
CAA	Civil Aviation Authority of New Zealand
CDI	course deviation indicator
cm	centimetre(s)
COMM	VHF communications radio
CRM	crew resource management
CVR	cockpit voice recorder
DC	direct current
DME	distance measuring equipment
DFDR	digital flight data recorder
EGPWS	enhanced ground proximity warning system
FAA	United States Federal Aviation Authority
FDR	flight data recorder
FL	flight level
ft	feet
G	Acceleration due to gravity
GPS	global positioning system
hPa	hectopascals
HSI	horizontal situation indicator
IAS	indicated airspeed
kg	kilogram(s)
kHz	kilohertz
km	kilometre(s)
kt	knot(s)
m	metre(s)
MAC	mean aerodynamic chord
MATS	Manual of Air Traffic Services
MEL	minimum equipment list
METAR	aviation routine weather report
MetService	Meteorological Service of New Zealand
mm	millimetre(s)
MSC	Meteorological Service of Canada
NASA	National Aeronautics and Space Administration
NDB	non directional beacon
NRC	National Research Council of Canada
NTSB	National Transportation Safety Board of the United States

QNH	an altimeter subscale setting to obtain elevation above mean sea level
RMI	radio magnetic indicator
RNZN	Royal New Zealand Navy
rpm	revolutions per minute
SIGMET	significant meteorological report
TAWS	terrain awareness warning system
TC	Transport Canada
TSB	Transportation Safety Board of Canada
TSO	Technical Standing Order
ULB	underwater location beacon
UTC	Co-ordinated Universal Time
V_A	Design Manoeuvre Speed
V_{NE}	Never Exceed Speed
VHF	very high frequency
VOR/DME	very high frequency omni-directional radio range/distance measuring equipment
XPNDR	transponder

Data Summary

Aircraft registration:	ZK-KFU
Type and serial number:	Consolidated Vultee Corporation[1] Convair 580, 17
Number and type of engines:	2 Allison[2] 501-D13D turbo-prop
Year of manufacture:	1952
Operator:	Air Freight New Zealand Limited
Date and time:	3 October 2003, 2125[3]
Location:	Kapiti Coast, 10 km north Paraparaumu Aerodrome latitude: 40° 49.3´ S longitude: 175° 01.2´ E
Type of flight:	air transport scheduled night freight
Persons on board:	crew: 2 passengers: Nil
Injuries:	crew: 2 fatal
Nature of damage:	aircraft destroyed
Captain's age:	58
licence:	Airline Transport Pilot Licence (Aeroplane)
flying experience:	16 928 hours (3286 hours on type)
Co-pilot's age:	50
licence:	Commercial Pilot Licence (Aeroplane)
flying experience:	20 148 hours (194 hours on type)
Investigator-in-charge:	I R M[c]Clelland

[1] Later to become the Convair Division of General Dynamics.
[2] Later to become a division of Rolls Royce.
[3] All times in this report are in New Zealand Standard Time (UTC + 12) and are expressed in the 24-hour mode.

1 Factual Information

1.1 History of the flight

1.1.1 On Friday 3 October 2003, Convair 580 ZK-KFU was scheduled for 2 regular return night freight flights from Christchurch to Palmerston North. The 2-pilot crew arrived at the operator's base on Christchurch Aerodrome at about 1915 and together they checked load details, weather and notices for the flight. The flight, using the call sign Air Freight 642 (AF 642), was to follow a standard route from Christchurch to Palmerston North via Cape Campbell non-directional beacon (NDB), Titahi Bay NDB, Paraparaumu NDB and Foxton reporting point.

1.1.2 The pilots completed a pre-flight inspection of ZK-KFU and at 2017 the co-pilot (refer paragraph 1.10.4) called Christchurch Ground requesting a start clearance. The ground controller approved engine start and cleared AF 642 to Palmerston North at flight level 210 (FL 210[4]) and issued a transponder code of 5331[5]. The engines were started and the aircraft taxied for take-off on runway 20.

1.1.3 At 2032 AF 642 started its take-off on schedule and tracked initially south towards Burnham NDB before turning right for Cape Campbell NDB, climbing to FL210. The flight progressed normally until crossing Cook Strait.

1.1.4 After crossing Cape Campbell NDB, the crew changed to the Wellington Control frequency and at 2108 advised Wellington Control that AF 642 was at FL210, and requested to fly directly to Paraparaumu NDB. The change in routing was common industry practice and offered a shorter distance and flight time with no safety penalty. The Wellington controller approved the request and AF 642 tracked directly to Paraparaumu NDB. At 2113 the Wellington controller cleared AF 642 to descend initially to FL130 (13 000 feet (ft)). The co-pilot acknowledged the clearance.

1.1.5 At 2122 the Wellington controller cleared AF 642 for further descent to 11 000 ft, and at 2125 instructed the crew to change to the Ohakea Control frequency.

1.1.6 At 2125:14, after crossing Paraparaumu NDB, the co-pilot reported to Ohakea Control that AF 642 was in descent to 11 000 ft. The Ohakea controller responded "Air Freight 642 Ohakea good evening, descend to 7000 ft. Leave Foxton heading 010, vectors [to] final VOR/DME 07[6] circling for 25. Palmerston weather Alfa[7], [QNH[8]] 987."

1.1.7 At 2125:34 the co-pilot replied "Roger down to 7000 and leaving Foxton heading 010 for 07 approach circling 25 and listening for Alfa. Air Freight 642."

1.1.8 At 2125:44 the Ohakea controller replied "Affirm, the Ohakea QNH 987." The crew did not respond to this transmission.

1.1.9 A short time later the controller saw the radar signature for AF 642 turn left and disappear from the screen. At 2126:17 the Ohakea controller attempted to contact AF 642 but there was no response from the crew. The controller telephoned Police and a search for AF 642 was started.

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[4] Flight level refers to an altitude based on an altimeter setting of 1013 hectopascals. FL 210 = 21 000 feet.
[5] Aircraft are issued with a discrete code to assist in the identification of each flight. With the transponder turned on and the code selected, aircraft callsign and altitude could be displayed on a controller's radar screen.
[6] The VHF (very high frequency) omni-directional radio range/distance measuring equipment instrument approach for runway 07.
[7] Alfa was the designation for the current aerodrome conditions being broadcast on the automatic terminal information service (ATIS) frequency for Palmerston North.
[8] QNH, an altimeter subscale setting to obtain elevation when on the ground.

1.1.10 Within an hour of the aircraft disappearing from the radar, some debris, later identified as coming from AF 642, was found washed ashore along Paraparaumu Beach. Later in the evening an aerial search by a Royal New Zealand Air Force helicopter using night vision devices and a sea search by local Coastguard vessels located further debris offshore.

1.1.11 After an extensive underwater search lasting nearly a week, aircraft wreckage identified as being from ZK-KFU was located in an area about 4 km off-shore from Peka Peka Beach, or about 10 km north of Paraparaumu. Police divers recovered the bodies of the 2 pilots on 11 October and 15 October.

1.2 Injuries to persons

1.2.1 The 2 pilots were killed as a result of the accident.

1.3 Damage to aircraft

1.3.1 The aircraft was destroyed.

1.4 Other damage

1.4.1 About 15% of the freight was recovered, with the rest being either lost or destroyed.

1.5 Personnel information

1.5.1	*Captain*	male, aged 58
	licence:	Airline Transport Pilot Licence (Aeroplane)
	aircraft ratings:	numerous, including HS Argosy, DC3, DH 114 Heron, BN Trislander, Convair 580
	instructor ratings	"D" and "E" categories
	medical certificate:	Class 1, valid until 2 April 2004
	last instrument rating check:	7 August 2003
	last proficiency check:	7 August 2003
	flying experience:	16 928 hours, all types 3286 hours, on type 3477 hours, total at night 3200 hours about, on type at night 546 hours, actual instrument
	total flying, last 90 days:	106 hours, all on Convair 580
	total flying, last 30 days:	32 hours, all on Convair 580

1.5.2 The captain joined the operator in November 1995 and obtained his command in August 1998. At the time of the accident he held the position of Operations Manager and also performed the duties of line instructor. He was based in Christchurch and mainly flew the Christchurch – Palmerston North – Christchurch route twice nightly, 2 or 3 nights a week.

1.5.3 The captain's last routine medical examination was completed on 2 October 2003, the day before the accident, and he was issued a Class 1 medical certificate valid until 2 April 2004. His records contained no evidence of any medical problem and he was not known to be suffering from any unreported medical condition. He was observed by personnel at the operator's base to be in good spirits before departing on the accident flight.

1.5.4	*Co-pilot*	male, aged 50
	licences:	Commercial Pilot Licence (Aeroplane & Helicopter)
	aircraft ratings:	numerous, including SA227 Metro, F27 Friendship, Convair 580
	medical Certificate:	Class 1, valid until 8 March 2004
	last instrument rating check:	28 August 2003

last proficiency check:	28 August 2003
flying experience:	20 148 hours, all types
	10 798 hours, aeroplane
	194 hours, on type
	728 hours, total at night
	189 hours, on type at night
	118 hours, actual instrument
total flying, last 90 days:	153 hours, Convair 580
	17 hours, helicopter
total flying, last 30 days:	52 hours, Convair 580
	2.2 hours, helicopter

1.5.5 The co-pilot joined the operator in April 2003 and completed his type rating on the Convair 580 on 11 May 2003. He was approved for line operations on 28 August 2003 having completed his instrument rating renewal, 6-month competency check, route check and biennial flight review.

1.5.6 The co-pilot was normally based in Auckland but had moved to Christchurch for about 10 days to provide temporary cover for another pilot who had taken leave. He had flown the Christchurch – Palmerston North – Christchurch route on the previous Monday and Wednesday nights.

1.5.7 The co-pilot's last routine medical examination was completed on 9 September 2003 and he was issued a Class 1 medical certificate valid until 8 March 2004. There was no history or record of any medical problem that could have contributed to the accident. He was reported by personnel at the operator's base to be in good spirits on the night of the accident.

1.6 Aircraft information

1.6.1 ZK-KFU was a Convair 340, serial number 17, constructed in the United States in September 1952. In February 1966 the aircraft was re-designated as a model 580 when it was modified by the installation of Allison turbo-propeller engines. Another approved modification was the conversion of the aircraft to a freighter, with the fitting of a cargo door near the rear of the fuselage. The freighter conversion was completed by the previous owner of ZK-KFU, Kelowna Flightcraft Limited of Canada, who also held the Type Certificate[9] for the Convair 580 model of aircraft.

1.6.2 The aircraft was imported into New Zealand from Canada and registered as ZK-KFU on 5 May 1995. A Certificate of Airworthiness in the Standard Category was issued on 18 May 1995. The certificate was non-terminating provided the aircraft was maintained and operated in accordance with the approved manual.

1.6.3 ZK-KFU was fitted with 2 Allison 501-D13D turbo-propeller engines. The left engine, serial number CAE 501402, had operated for 48 966.8 hours and 5004.7 hours since its last overhaul. The right engine, serial number CAF 500631, had operated for 40 911.6 hours and 7519.6 hours since its last overhaul.

1.6.4 The 2 propellers were Aeroproducts A6441FN-606A type propellers, the left serial number WY12050, and the right serial number HC63. They had accrued 1091.2 hours and 1976.6 hours respectively since their last overhauls. The propeller units each contained 4 metal blades.

[9] The Type Certificate holder was responsible for the aircraft type's design, operating limitations, data sheet and flight manual.

1.6.5 The Convair 580's V_{NE} (Never Exceed Speed), or maximum permitted speed, at 10 000 ft was 313 knots (kts) indicated airspeed (IAS), reducing to 309 kts at sea level. The aircraft's V_A (Design Manoeuvring Speed), or the maximum speed at which the aircraft could be rolled and pitched using full control deflections, was about 165 kts. The maximum positive manoeuvring load limit was 2.94 G.[10]

1.6.6 Scheduled maintenance on ZK-KFU was based on a cycle of 6 inspections with an inspection or check every 125 hours. The last inspection completed on 1 September 2003 was a Check 4 inspection at 66 624.8 hours flight time. On 15 September 2003 ZK-KFU was returned to the operator's maintenance facility at Palmerston North for outstanding minor maintenance work, mainly corrosion inspection, including protection and repair. The aircraft returned to service on 2 October 2003 and flew 3.4 hours before the accident flight. The aircraft had flown 35.7 hours since the Check 4 inspection, for a total of 66 660.5 hours with 98 774 cycles[11]. The last annual maintenance review of the aircraft was completed 23 July 2003.

1.6.7 At 66 660.5 hours and 98 774 cycles, ZK-KFU was estimated by Kelowna Flightcraft to be about "the mean average of the CV580s." One of the highest time aircraft was C-GKFQ, Convair 580 serial number 34, at 81 409 hours and 143 445 cycles.

1.6.8 In January 1998 a repair to remove corrosion from the left wing upper spar cap wing attachment area was considered necessary by the operator. A repair was proposed to, and subsequently approved by the Civil Aviation Authority (CAA), who also directed that the area be inspected every 500 flying hours or every 12 months, whichever came first. The area was recorded as last inspected on 21 August 2003 at 66 608.3 aircraft hours. No problems or concerns were noted with the repair.

1.6.9 A review of aircraft maintenance documents identified no outstanding additional maintenance requirements on ZK-KFU. The right propeller revolutions per minute (rpm) was reported by company pilots and engineers to fluctuate slightly but still operated satisfactorily when the propeller synchronizer was selected off.[12]

1.6.10 On the morning of 3 October 2003 engineers completed the daily inspection on ZK-KFU and signed the daily inspection and replenishment records. Minor rectification work was completed, including such items as inflating the left main oleo to its correct height. According to the engineers and following a review of aircraft maintenance records, there were no defects that would have affected the conduct of the flight.

1.6.11 ZK-KFU was recorded as having a basic operating weight of 15 221 kg and a certified maximum take-off weight of 26 450 kg. On 3 October 2003, for the flight from Christchurch to Palmerston North, ZK-KFU was loaded with 3176 kg of fuel and had a gross payload of 6218 kg. The take-off weight was calculated to be 24 615 kg and the centre of gravity was confirmed as being within limits at 26.5% mean aerodynamic chord (MAC). The limits being 22% and 34% MAC. The fuel load was sufficient to give an endurance of over 3 hours flying, enabling the aircraft to fly from Christchurch to Palmerston North, complete an instrument approach and return safely to Christchurch if necessary.

1.6.12 The freight was contained in 11 "cargons", loaded according to the load plan prepared by the crew and signed by the captain. The cargons were of aluminium construction, fully enclosed except for a canvas access panel on one side. The cargons were located along rails on the floor of the aircraft and restrained by fittings pinned to the rails. The load occupied the total cargo floor space of the aircraft. A cargo net was fitted forward of the cargons to stop any freight entering the forward area of the aircraft. The aircraft was fitted with a fire detection system that included 3 smoke detectors located in the cargo area and a warning light in the cockpit.

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[10] Acceleration due to gravity, measured in the aircraft's vertical axis.
[11] A cycle is one take-off and landing.
[12] The rpm synchronizer was not listed as a critical item and operation of the aircraft was permitted without it.

1.6.13 The cargo manifest indicated that most of the cargo consisted of small parcels, including courier packs and the like. No dangerous or combustible cargo was recorded as being carried on the flight to Palmerston North.

Avionics

1.6.14 ZK-KFU was equipped with a range of radio and navigation equipment common to the operator's fleet of Convair aircraft. The equipment included 2 very high frequency (VHF) communications radios (COMM 1 and 2), 2 automatic direction finder (ADF) receivers, 2 VHF omni-directional range (VOR) navigation receivers, 1 distance measuring equipment (DME) system, 2 transponders (XPNDR 1 and 2), a weather radar and a global positioning system (GPS).

1.6.15 In July 2002 a terrain awareness warning system (TAWS) was fitted to ZK-KFU. Also known as enhanced ground proximity warning system (EGPWS), the TAWS used a terrain database and global positioning information to provide a range of warnings or alerts, including terrain, altitude and excessive bank angle callouts. For excessive bank angle the callout "*Bank angle Bank angle*" would be heard when the aircraft exceeded a specified combination of altitude and angle of bank. For example, above 5000 feet, the aircraft would need to exceed 50° angle of bank without the autopilot engaged and 33° angle of bank when engaged. A second alert would sound when the angle of bank increased by a further 20%, 60º and 39.6º respectively.

1.6.16 Power supply for aircraft avionics was sourced from a number of electrical buses on the aircraft, including both alternating current (AC) and direct current (DC) supplies of varying voltages. According to company pilots and engineers, it was routine for pilots to use COMM 1 and XPNDR 1 during a flight, especially for the first leg. COMM 2 was used for intra-company communications. Pilots were, however, encouraged to use XPNDR 2 on occasions, often for the second or last leg of the flight, to ensure it was serviceable as a back-up transponder. COMM 1 and XPNDR 1 were both powered from the Main DC bus through the #1 Radio DC bus. XPNDR 1 also required AC power from the Captain's AC bus through the #1 Radio AC bus. XPNDR 2 used Main DC power through the #2 DC Radio Bus. All aircraft radio and navigation equipment was reported as serviceable for the flight on 3 October.

1.6.17 The aerial for COMM 1 was located on the top of the aircraft fuselage, aft of the crew entry door, and for COMM 2 under the fuselage about in line with COMM 1. The aerials for the 2 transponders were located under the fuselage between the nose wheel and the leading edge of the main wing.

1.6.18 After the arrival of the aircraft in New Zealand, the operator added a "hot mike" intercom system to allow hands-free voice activation of the pilot intercom. The system was connected to the original intercom, which was retained as a back-up.

1.6.19 ZK-KFU was fitted with an autopilot that could be used during the climb, cruise and descent phases of flight. Company pilots reported that it was normal practice to re-trim the aircraft after a significant attitude change before engaging the autopilot, for example, changing from the climb to the cruise.

1.6.20 The pilot's handbook for the Convair 580 considered the use of the autopilot in turbulent conditions as "desired since its use will have several advantages". Some of the advantages of using the autopilot rather than hand flying included its ability to *read* instruments being unimpaired and less reaction time as it did not need to interpret the instruments. As a result the captain had more time to thoroughly monitor flight conditions. However, the handbook also recommended the altitude hold function not be used as a large out of trim situation could develop without warning and an inadvertent autopilot disconnect could occur. The recommended speed for flight through turbulence was about 165 kts depending on weight.

Ice prevention

1.6.21 The Convair 580 aircraft was fitted with a range of ice management equipment. Aircraft electrical power was used to provide anti-icing for the propellers, pitot tubes, windshields and sections of the inlet duct for the engines. Hot bleed air was taken from the engines to heat other sections of the inlets and the leading edges of the wings, horizontal stabiliser and the vertical fin.

1.6.22 The aircraft electrical anti-icing system was required to be checked before each take-off. However, the bleed air system could not be used on the ground or when the outside air temperature exceeded 5°C.

1.6.23 The Convair 580 flight manual and pilot's handbook both stated that "this airplane is limited to operation in light icing conditions when the anti-icing systems are functioning" and "the aircraft anti-icing system is not approved for use as a de-icing system. Turn the anti-icing system on when icing conditions are anticipated or first encountered."

1.6.24 The owner of Kelowna Flightcraft advised that "the operation in light icing conditions" restriction resulted from the original flight-testing done on the piston engine 340 series of aircraft in 1952 and when there were 2 categories of icing only – light and heavy.[13] Despite a significant improvement in the anti-icing performance with the installation of the turbo-propeller engines, the limitation remained because the Type Certificate holder did not consider it worthwhile to complete the full icing test certification process again.

1.6.25 The Convair 580 was not fitted with electronic ice detection equipment but according to the operator and other company pilots, the anti-icing systems were very effective in preventing and removing ice from the aircraft. Pilots were very aware of aircraft icing and used the aircraft's weather radar to give advance warning of severe weather ahead. Aircraft wing lighting and torches carried on board the aircraft assisted in confirming the presence of any ice. Anti-icing equipment was turned on at the slightest indication of ice being present and, as an added protection, flap settings were restricted for landing.

1.6.26 The leading edges and some of the upper surface of the wings were clearly visibly to the pilots, but they could not see the trailing edges of the wings or the tailplane. Pilots reported that with the hot engine bleed air having to travel further to heat the leading edges on the tailplane, the tailplane anti-icing temperature reading on the gauges took longer to rise than those for the main wings. Therefore, any ice formed on the tailplane took longer to dislodge compared to that on the main wings.

1.6.27 Pilots said they closely monitored the use of engine bleed air for anti-icing as it reduced engine power and if power was restored by the use of the power levers (throttles), engine temperatures and fuel consumption would increase.

1.7 Meteorological information

1.7.1 The Meteorological Service of New Zealand (MetService) provided an aftercast of the weather conditions on Friday 3 October 2003, with comment as appropriate. It also provided detailed colour weather radar images for the area and the period of the flight of AF642. Information included:

[13] According to Aviation Meteorological Services in the Unites States, in 1968 icing intensity levels were reclassified as trace, light, moderate and heavy or severe. The New Zealand Meteorological Service used 3 levels for reporting icing conditions - light, moderate and severe.

Weather Situation

During 3 October, an active trough of low pressure was crossing the country. In the evening, the trough extended from southeast of the South Island, across central New Zealand then to the area west of the North Island. (Refer Figure 1 for the Mean Sea Level Analysis Chart valid at the time of the accident.)
A frontal band orientated northnorthwest – southsoutheast, embedded in the trough, moved southeastward across the North Island between 1800 and midnight. This front was preceded by a very strong and moist north to northwesterly flow. It was followed by a moist but slightly weaker northwest flow. A small wave depression or low appeared to form on the back edge of the front as it crossed the southern North Island between 2100 and 2300.

Observations

Surface pressure recordings at Paraparaumu Meteorological Observatory (located near Paraparaumu Beach) during Friday evening showed a very marked fall and rise in surface pressure at approximately 2130. Also between 2125 and 2135 there was a distinct surface wind shift from northeast to north accompanied by a maximum gust of 32 kts or 60 kilometres per hour at about 2125. These observations are consistent with a small scale low associated with the main frontal band, moving southeastward across the Kapiti area at that time.

The very heavy rain in the area of the Kapiti Coast during the evening eased significantly after about 2130.

Radiosonde soundings taken at the Paraparaumu Observatory at 1100 Friday and again at 2300 Friday, indicated very moist or saturated conditions from the surface up to about 14 000 ft. These soundings were sampling both pre frontal and post frontal airmass.

The soundings also indicated a very strong northwesterly flow at all levels during the day, in the order of 70 kts easing to 50 to 60 kts by late evening. There appeared to be no significant wind shear below 18 000 ft.

Radar data

Metservice's Wellington Doppler weather radar data indicated the presence of very strong precipitation between 2100 and 2200 but with a distinct clearing western edge to the precipitation. This edge moved southeast across the Kapiti Coast during the period. (Refer Figure 2 for the 2130 radar weather picture).

Detailed analysis of the Doppler radar data indicated the presence of enhanced precipitation at a height of 14 750 ft to 18 000 ft in the area just to the north of Mana Island at 2117 to 2120. By 2132 to 2135 this area had moved to lie over the area between Porirua and Paraparaumu.

This enhanced precipitation may indicate a concentration of large supercooled water droplets at this height. The temperature at this height was of the order of -15° C to -18° C. The freezing level in the vicinity would have been close to 9500 ft. These conditions combined would be conducive to aircraft icing above the freezing level.

Doppler radar velocity data indicated the presence of a wind convergence line in the vicinity of Paraparaumu between 2115 and 2130 at an altitude of about 16 400 ft extending down to lower levels.

Radar data between 2100 and 2200 indicated that the rain over Wellington and Kapiti was primarily from stratiform cloud with no significant embedded convection (no thunderstorms). This is consistent with no lightning being detected by any of the detection equipment available.

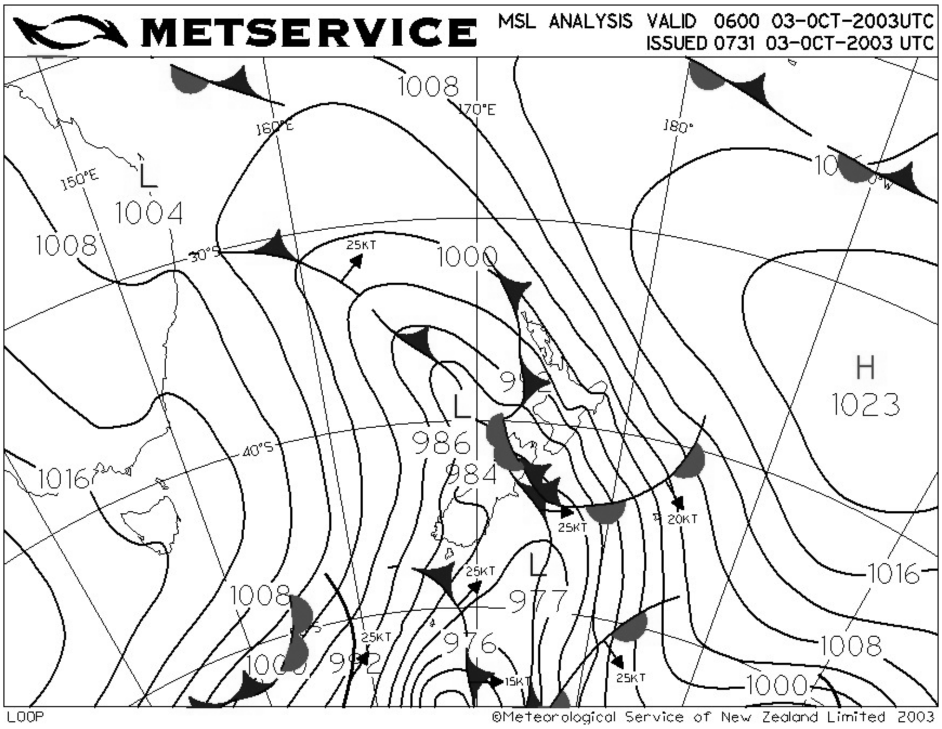

Figure 1
Mean sea level analysis chart issued at 1931 on 3 October 2004
(courtesy of MetService New Zealand)

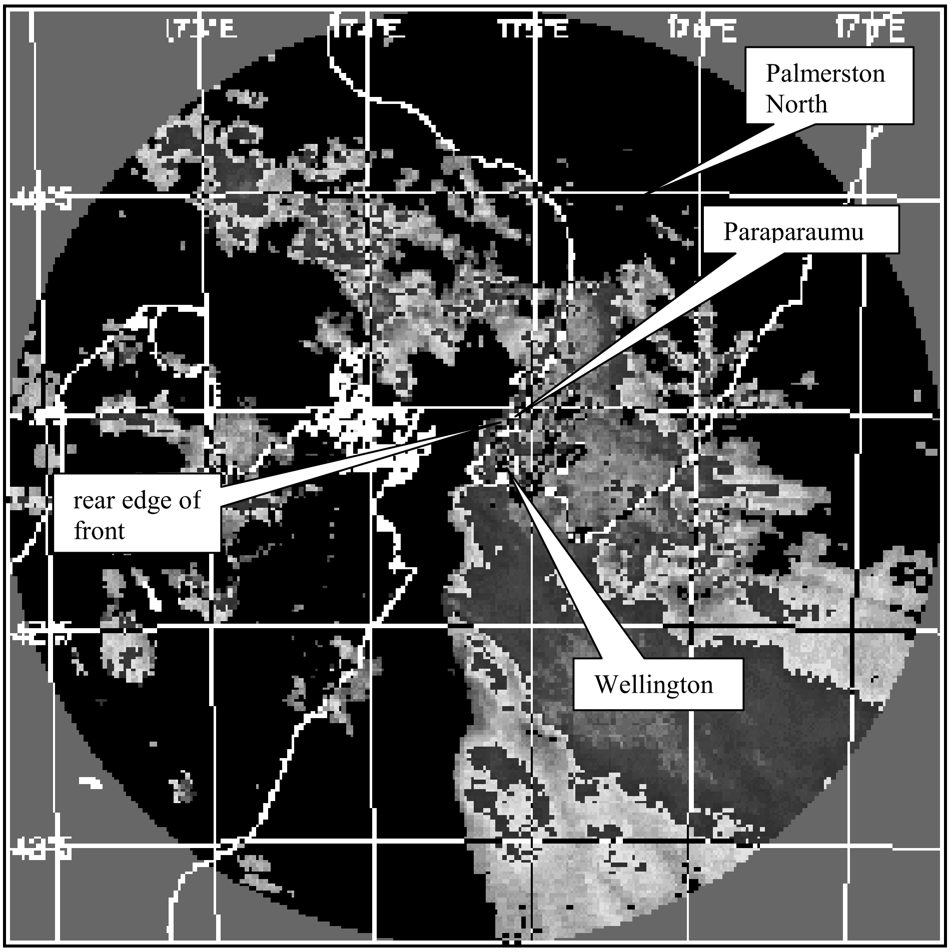

Figure 2
Radar weather map for 2130 on 3 October 2003)
(courtesy of MetService New Zealand)

Briefing information for AF 642

1.7.2 At 1805 on 3 October 2003 Air Traffic Services (ATS) forwarded a briefing package by facsimile to the operator in preparation for AF 642. The package included weather information MetService had provided for the route to be flown. The 1800 METAR (aviation routine weather report) for Palmerston North Aerodrome recorded the surface wind varying between 320° and 030° True at 6 kts, 15 km visibility, showers in the vicinity of the aerodrome, scattered cloud at 4000 ft and broken cloud at 9000 ft. The temperature was 15° C, dew point 13° C and local pressure 991 hectopascals (hPa).

1.7.3 A special weather report for Wellington Aerodrome was issued at 1800 and reported the surface wind as 350° True at 27 kts gusting to 41 kts, visibility reducing to 4000 m in rain, few cloud at 800 ft, scattered cloud at 1100 ft and broken cloud at 1500 ft. The temperature was 15° C, dew point 14° C and local pressure 987 hPa. A wind shear was reported for approach to runway 34.

1.7.4 The briefing information also contained 2 significant meteorological reports, SIGMETs 3 and 5. SIGMET 3, valid until 1903, forecast isolated severe icing between 9000 ft and FL210 north of a line from Westport to Kaikoura NDB and south of Hamilton. SIGMET 5, valid until 2147, advised of occasional severe turbulence forecast below FL180 over South Island north of a line from Haast to Timaru, and occasional severe turbulence forecast below FL330 over North Island.

1.7.5 At about 1945 an update of the main briefing package was automatically faxed to the operator's Christchurch office, where the crew of AF 642 were reportedly finishing their documentation before starting engines at 2017. The update contained SIGMETs 6 and 7. SIGMET 6 was essentially a repeat of SIGMET 3 concerning isolated severe icing and was issued at 1805 and valid until 2159. SIGMET 7 was issued at 1900 and concerned reports of isolated severe turbulence being observed over much of the country. The facsimile was not found in the Christchurch office after the accident.

1.7.6 At 1949 SIGMET 8 was issued. SIGMET 8 cancelled SIGMET 7 and was valid until 2347. It included reports of severe turbulence being encountered over parts of North Island and forecast north of a line from Christchurch to Hokitika. SIGMET 8 was not included in the updated package forwarded to the operator but would have been available to the ATS controllers at the time the crew of AF 642 started engines at Christchurch. There was no record of SIGMET 8 being passed to the crew of AF 642.

1.7.7 At 2112 SIGMET 9 was issued and was a continuance of SIGMET 6, containing the same text but extending the validity period until 0101 next morning. This later report was supplied to the ATS Wellington Control position at about 2113, as AF 642 was crossing Cook Strait. The crew of AF 642 was not alerted to the existence of this SIGMET.

1.7.8 ATS later confirmed that controllers were required to pass to pilots any relevant significant weather information for 90 minutes after time of issue.[14] ATS advised that SIGMET 8 should have been passed to the crew of AF 642 but there was probably an inadvertent oversight by one of the staff. For SIGMET 9, the Wellington controller possibly either considered the SIGMET not to be relevant as it was a repeat of SIGMET 6, which was valid until 2159, after AF 642 was due to land at Palmerston North, or the strip on which the SIGMET was printed was misplaced. The probability of the strip being misplaced was considered to be "extremely small."

1.7.9 The term "relevant" was included in wording contained in various documents describing the passing of information to pilots by ATS. These documents included Part 172 of Civil Aviation Rules, the CAA Aeronautical Information Publication (AIP) and the Manual of Air Traffic Services (MATS).

[14] Manual of Air Traffic Services, RAC 10-1, section 11, dated 21 March 2002.

Other reports

1.7.10 On the day of the accident, MetService received several pilot reports concerning weather conditions. One report, made at 1947, advised of moderate to severe turbulence in the vicinity of Wanganui below FL220. After the accident involving ZK-KFU a report was received of a severe ice encounter at about 1940 "just west of Otaki". The aircraft concerned was in descent and heading towards Wellington when, between 13 000 ft and 8000 ft, it encountered severe icing. One of the pilots on board the aircraft took photographs of the ice accruing on the window (see Figure 3).

1.7.11 Despite the reports that were received by MetService on 3 October, MetService expressed concern at a general lack of reports being made by pilots immediately after encounters with hazardous meteorological conditions. The CAA AIP[15] informed pilots that: "When hazardous conditions are encountered which, in the opinion of the pilot are, or may become severe enough to warrant a SIGMET, an AIREP (air report) SPECIAL should be made to the nearest ATS unit immediately." Examples of conditions included wind shear, turbulence and icing.

1.7.12 MetService advised that they would expect to receive an AIREP within 15 minutes of it being passed to ATS. MetService would then issue a new SIGMET stating that, for example, severe icing was forecast and observed.

Figure 3
Icing encountered by aircraft west of Otaki

1.8 Aids to navigation

1.8.1 All ground navigation aids relevant to the flight of AF 642 on 3 October 2003 were functioning normally. The flight from Cape Campbell NDB to Paraparaumu NDB required a left turn of about 5° to intercept the track from Paraparaumu NDB to Foxton reporting point. This latter track was 002° Magnetic.

1.8.2 As AF 642 crossed Cook Strait and flew overhead Paraparaumu NDB it was tracked by 3 radar sites, Mt Robertson, Balance and Hawkins Hill. The information from the 3 radars was correlated to give a consolidated picture to both the Wellington and Ohakea controllers. Information was updated every 5 seconds.

1.8.3 A review of the radar data confirmed that AF 642 passed overhead Paraparaumu NDB at 2125:14, descending through about 14 800 ft. The rate of descent was constant at about 1500 feet per minute and the groundspeed was steady at between 247 kts and 251 kts. The aircraft then made a slight left turn and diverged from the Kapiti Coast tracking generally towards Foxton reporting point.

[15] AIP GEN 3.5 – 21, paragraph 6, effective 4 September 2003.

1.8.4 Between 2125:19 and 2125:25 the transponder code and altitude readout for AF 642 stopped being transmitted. This coincided with the Ohakea controller passing on initial descent and approach instructions to AF 642. The aircraft had a steady groundspeed of about 252 kts and was at about 14 500 ft at this time. The controller wasn't initially concerned at the loss of transponder information as the co-pilot responded correctly to his instructions, the controller observed a good primary radar return with the aircraft's track continuing as expected and, although not common, a temporary loss of transponder signal did occur on occasions. Consequently, the controller did not inform the pilots of AF 642 of the loss of transponder signal.

1.8.5 The groundspeed and track remained steady until about 2125:48 when radar interpreted groundspeed started to reduce suddenly back towards about 75 kts. This corresponded to the radar track for AF 642 turning left through about 240°. The last radar return was recorded at about 2126:19 at position 40° 49.3158′ S, 175° 01.1655′ E – about 10 km north of Paraparaumu and about 4 km seaward of the coast.

1.8.6 The Ohakea controller on duty at the time of the accident later reported that there were no other aircraft in the area at around the time of the accident and that the last aircraft to pass through the general area was a flight from Wellington to Tauranga some 40 minutes earlier. The controller said that his radar display showed no indication of any severe weather activity during this time.[16]

1.9 Communication

1.9.1 Normal communications between AF 642 and air traffic control were maintained during the flight. The recording provided by ATS was used to provide the transcript of communications contained in section 1.1 of this report.

1.10 Flight recorders

1.10.1 ZK-KFU was fitted with a United Data Control cockpit voice recorder (CVR), model V-557, serial number 1182, and a Fairchild digital flight data recorder (DFDR), model F800, serial number 2106.

1.10.2 Police and Navy divers located the 2 recorders 7 days after the accident, still secure in their mountings on the rear bulkhead of the aircraft. After recovery the recorders were immersed in fresh water and taken to the Australian Transport Safety Bureau (ATSB) in Canberra for processing.

1.10.3 ATSB advised that the recorders were received in good condition and the underwater location beacons (ULBs) were both still transmitting. The ULBs transmitted a locating signal on 37.5 kilohertz (kHz) and had a nominal battery life of 30 days once activated by water.

CVR

1.10.4 The CVR was a "4-track" tape type recorder with a nominal 30-minute endless loop recording capability. The 4 tracks included the captain's audio selections, the co-pilot's audio selections, flight deck area microphone and a spare track. Examination of the recording tape identified that only VHF radio transmissions and some isolated background noises were recorded. The track for the area microphone contained no useful information and there was no recording of any intercom communication between the 2 pilots. While the radio transmissions were a duplication of communications recorded by ATS, the other noises did provide some useful information. A company pilot was able to identify the person making the radio transmissions from AF 642 as the co-pilot.

[16] The radar would occasionally display images that could indicate the presence of extreme weather. The images would, however, be sporadic and unreliable.

1.10.5 The CVR recorded that at about 2057 the ADFs for AF 642 were tuned to the Cape Campbell NDB. At about 2109, about one minute after AF 642 was cleared to fly direct to Paraparaumu NDB, the Paraparaumu NDB was selected on one of the aircraft ADFs. At about 2126:00, or 17 seconds after the end of the last transmission from AF 642, the CVR recorded the words "*Bank angle. Bank angle*". The words were in a synthesised voice of the type used in the TAWS alerts.

1.10.6 Analysis of background noises identified that the propeller speed varied between about 1016 rpm and 1032 rpm continuously over the 30-minute duration of the recording. This correlated with the normal governed propeller speed of 1020 rpm and was within the acceptable operating range of 1010 to 1032 rpm.

1.10.7 The maintenance schedule required the CVR to be checked every 125 flying hours as part of the normal cycle. The CVR was last recorded as being examined on 28 August 2003 as part of the Check 4 inspection, some 36 flying hours before the accident. The check called for a headset to be plugged into the CVR monitor in the cockpit overhead panel. A VHF radio transmission was then made on the captain's audio selector, which should be heard through the CVR monitor. The exercise was then to be repeated for the co-pilot's audio selector. To test the area microphone, a short phrase was to be spoken about one metre from the microphone, which should also be heard through the CVR monitor headset. The aircraft pre-start checklist also included a number of actions to check that the 3 channels were recording.

DFDR

1.10.8 In about 1996 the operator replaced old foil- type FDRs on the fleet of Convair aircraft with digital recorders, the Fairchild model F800. The new DFDR required 115 volts AC power for operation. According to the Pilot's Handbook and the operator, the required power was supplied from either the Captain's AC bus or from the Main DC distribution bus through an inverter. The power source on ZK-KFU could not be confirmed.[17]

1.10.9 The DFDR was capable of recording the following data:

- time (reference scale only)
- pressure altitude (from the co-pilot's static system)
- indicated airspeed (from the co-pilot's pitot and static systems)
- vertical acceleration (G)
- magnetic heading (from the aircraft's gyro-magnetic system)
- communication event (when a radio transmission was made from the aircraft).

A fault indication discrete and a power supply discrete were also recorded. These latter 2 recordings confirmed that the data was valid with no fault or power supply interruption until the conclusion of the recording.

1.10.10 By cross referencing the DFDR's communication events and time reference with ATS recordings it was possible to plot an accurate time-line of events. A plot of DFDR data for the flight of AF 642 is at Figure 4, and a summarised plot of the last minute of recording is at Figure 5.

[17] Due to the age of the Convair 580 and the number of modifications made, power supply varied from aircraft to aircraft.

1.10.11 The DFDR data showed that at about the time the transponder stopped transmitting, the aircraft was being levelled at about 14 400 ft. The aircraft remained level for about 14 seconds with its IAS reducing by about 15 kts, to a minimum of 200 kts. During this time the co-pilot called Ohakea Control confirming the onward clearance for AF 642. This call started at 2125:34 and lasted between 7 and 8 seconds. Over the duration of the transmission a steady turn to the left was flown. At about 2125: 40, as the transmission was about to conclude, a descent was started. The rate of descent and IAS increased rapidly but the left turn remained steady for about another 9 seconds before heading information became erratic. The *Bank angle* alert occurred at 2126:00 as the aircraft descended through about 9000 ft at about 345 kts. The last recording was at about 2126:05 as the aircraft passed 6800 ft at an IAS of 392 kts.

1.10.12 The CVR and DFDR onboard ZK-KFU complied with CAA Rules[18]. However, the CAA requirements for CVRs referred to United States Technical Standing Orders (TSOs) that had either been replaced or upgraded. The TSO[19] current at the time of the accident contained new minimum performance standards, including enhanced fire test requirements. ATSB flight recorder specialists advised that the model V-557 fitted to ZK-KFU would be unlikely to meet the new standards for CVRs.

1.10.13 In reviewing FDR requirements internationally, the Transportation Safety Board (TSB) of Canada advised that the Convair 580 aircraft required to have fitted as a minimum an 11-parameter FDR. The additional parameters included pitch and roll attitudes, longitudinal acceleration, control column or pitch control surface position and thrust of each engine. The National Transportation Safety Board (NTSB) of the United States advised that the Convair 580 was one of the few models that were exempt from this requirement because the original type certificate was issued before 1969. The Convair 580 was therefore only required to have a 6-parameter FDR. The ATSB advised that aircraft certified with a maximum take-off weight of less than 29 000 kg, which included the Convair 580 at 26 450 kg, were only required to have a 6-parameter FDR fitted.

[18] Civil Aviation Rule Parts 121.89, 121.371, 121.373 and Appendix B, effective 1 August 2003.
[19] TSO-C123a, Cockpit Voice Recorder Systems, effective 2 August 1996.

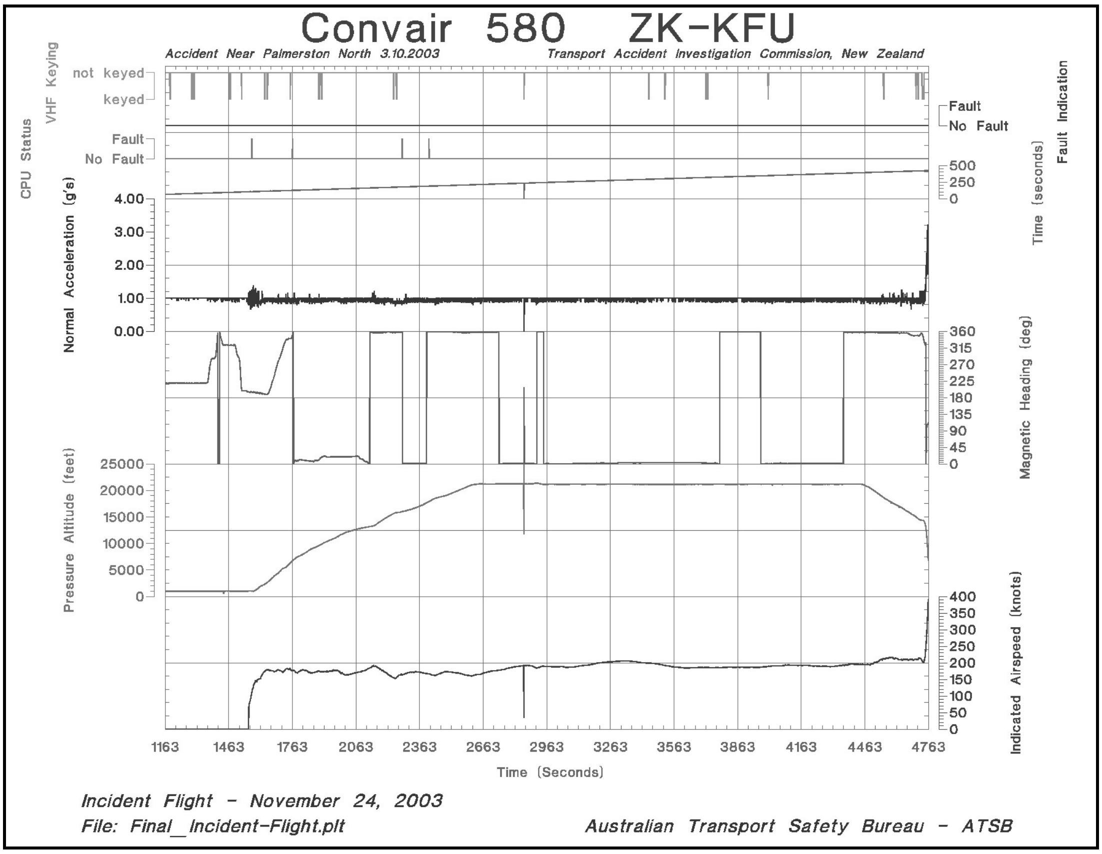

Figure 4
DFDR information for flight of ZK-KFU on 3 October 2003

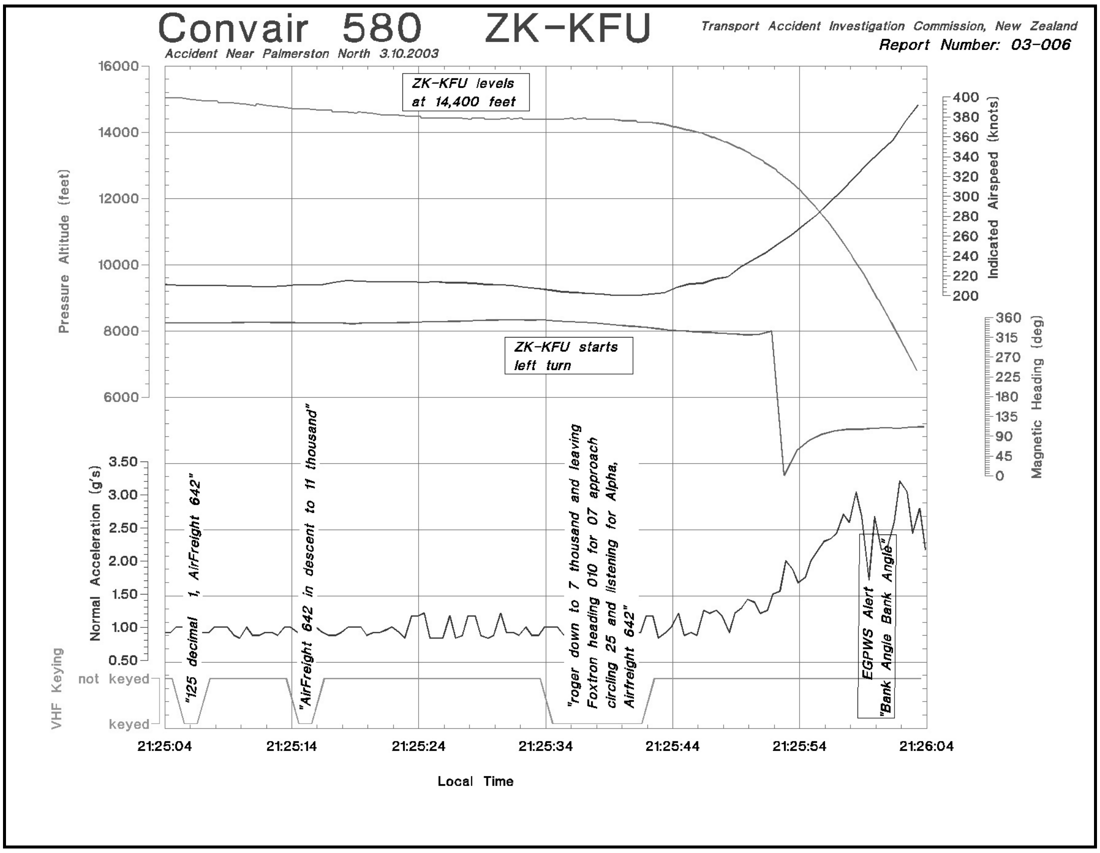

Figure 5
Combined DFDR and radar information for ZK-KFU after passing Paraparaumu

1.11 Wreckage and impact information

1.11.1 Within an hour of the search for ZK-KFU being started, items from the aircraft were being handed to Police. Some cargo, particularly paper tags and labels were found around Waikanae Beach and up to 0.5 km inland. Other items, including courier packs and light pieces of the aircraft were soon found washed up along the beach from Paraparaumu to Paekakariki, 10 km south. The aircraft pieces included the nose cone, the navigation aerial normally mounted on the aircraft roof, section of the rear cargo hold panel, the entry door to the flight deck, blanks for engine intakes and other sundry items. The nose cone displayed no compression marks directly on the tip of the nose, but rather the cone appeared to have been torn off at an angle. In the days and weeks that followed items continued to be washed ashore as far south as Ohau Point, 50 km south of Paraparaumu.

1.11.2 Four pieces of aircraft fuselage panelling were found inland, running about in line with Peka Peka Road in about a northwest to southeast direction. The first piece was found near the beach and was the heaviest and most distorted of the 4 pieces. A lighter but larger item, measuring about 1.35 m by 750 mm, was found about one km inland. The item found the furthest inland, at about 3 km, was the lightest and smallest, measuring about 200 mm by 200 mm. The pieces matched each other and were identified as wing to fuselage fairing from the right upper wing area.

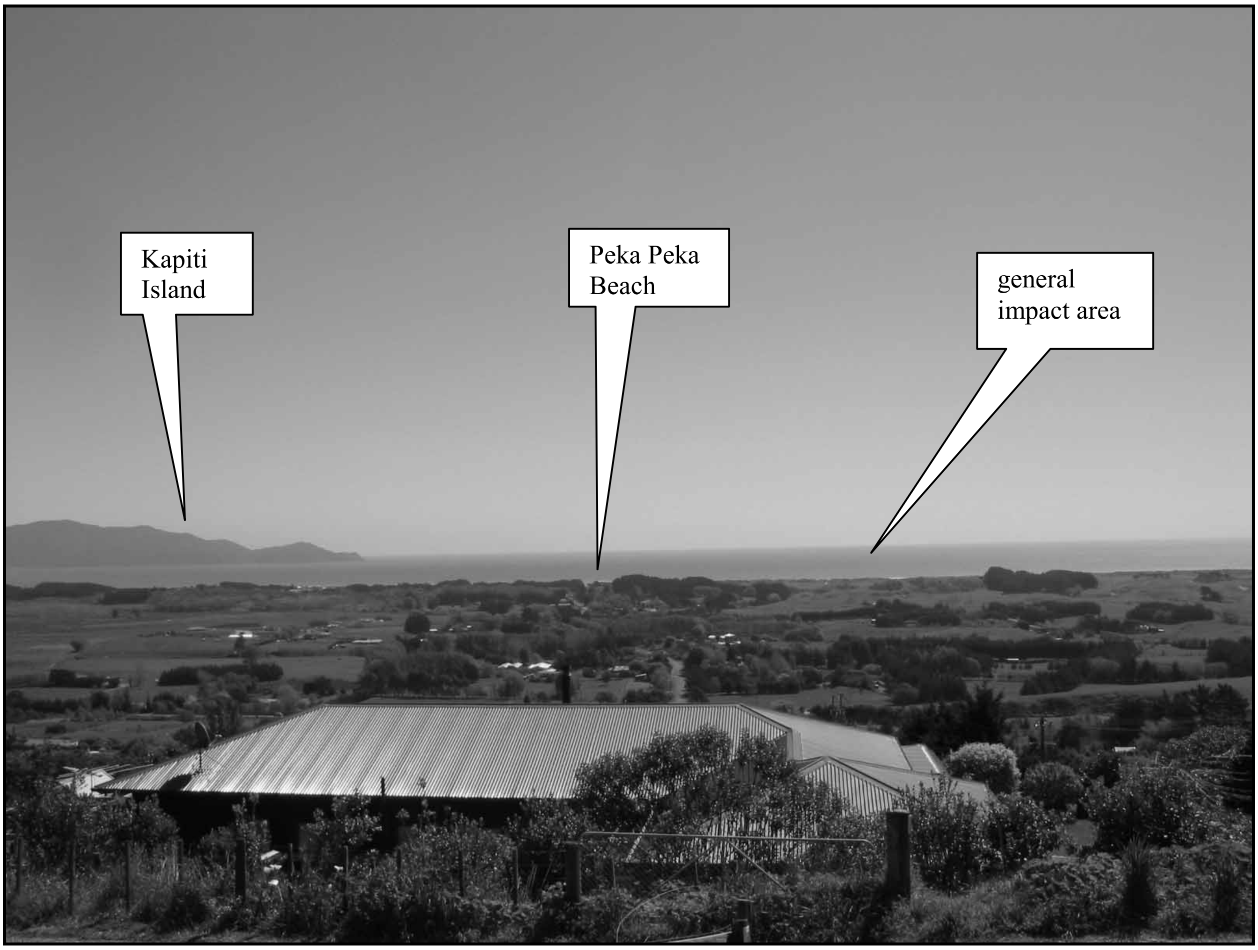

Figure 6
General view of accident site looking west

1.11.3 The initial sea search for ZK-KFU was hampered by poor weather and sea conditions and a lack of accurate data. There was no fuel or oil slick to help identify the impact area but some local residents did note a kerosene-type smell at about the time of the accident. To assist in the search Police, Royal New Zealand Navy (RNZN) and commercial dive teams were used, supported by Coastguard vessels, a Police launch, an RNZN patrol boat and a commercial dive boat - the latter 2 with side-scanning sonar capabilities. The identification of wreckage was further hampered by the large number of logs and other debris on the sea floor, deposited by the recent heavy rain and flooded rivers. None of the vessels were fitted with equipment capable of tracking the ULBs on the 2 aircraft recorders. Further, none of the organisations involved in the search for ZK-KFU possessed such a capability in New Zealand.

1.11.4 After about 4 days some wreckage was located but it was another 2 days before it could be identified as being from ZK-KFU. The wreckage was found centred about an area 4 km offshore from Peka Peka Beach and 10 km north of Paraparaumu Aerodrome and NDB. The wreckage lay in about 35 m of water and was subject to 2 strong currents. An inshore flow moved along the coastline to the south, while a tidal current further out moved back and forth parallel to the shore. Diving was, therefore, limited to a combination of good sea conditions and the slack of the tide, when visibility would improve from near zero to 1 or 2 m.

1.11.5 The larger, heavier pieces of the fragmented aircraft were found in an area measuring about 600 m by 200 m. Divers located the bodies of the 2 pilots caught in aircraft debris between 5 m and 10 m away from a forward section of the aircraft. The pilots' seats were nearby, with the captain's shoulder harness and lap belt still fastened and the co-pilot's lap belt only fastened.

1.11.6 The tail section of the aircraft, from the rear bulkhead rearwards, was found about 200 m north of the front section. Divers reported that some of the fuselage had been attached to the tail section but had separated during recovery. The divers believed that the section of fuselage extended forward to about the cargo door area. The separated part was not found again.

1.11.7 The left engine was found tangled with a main undercarriage leg and wheel between 500 m and 600 m north of the forward section, referred to in paragraph 1.11.5. The right engine was found about 30 m away, with a second undercarriage leg nearby. The propellers had separated from the engines and were also found in this general area. All the propeller blades were located, with one blade still attached to the hub of the left propeller and 2 blades attached to the hub of the right propeller.

1.11.8 Near the engines a piece of inner wing section and an engine nacelle were found. The wing section was identified as coming from the right side, while the engine nacelle was from the left side.

1.11.9 Between these larger concentrations of wreckage, other pieces were recovered, including the left wing outboard of the engine, flap sections, nose undercarriage, vertical fin and numerous other small items. In total about 70% of the aircraft by weight and about 15% of the cargo was recovered to a secure facility for further examination. No dangerous goods were found in the cargo recovered. The recovery operation took about 7 weeks to complete. The fuselage section from the wing attachment points and aft to the rear bulkhead was not recovered. This section included the upper spar cap wing assembly.

1.11.10 The forward section of the aircraft contained much of the aircraft cockpit and extended back to nearly the wing attachment area (see Figure 7). The section was severely deformed and cutters were used to gain access for examination. The crew access door, located on the left side of the aircraft just aft of the cockpit, the door opposite and the belly hold door were still attached. The crew door and frame displayed compression lines consistent with a large rearwards force being applied. The door opposite was not deformed to the same extent and the belly hold door was essentially undamaged.

Figure 7
Forward section of ZK-KFU

1.11.11 The left outer wing section displayed less impact damage than other pieces of the recovered aircraft.

1.11.12 The co-pilot's instrument panel, portions of the centre engine instrument panel, overhead panel and both side panels were not recovered. Instrument indications and settings found on the captains panel included:

- Main attitude indicator showed a left bank of about 85º angle of bank with a slight nose up attitude
- Standby attitude indicator also indicated a left bank with about 70º, and about 30º nose up
- Off flag extended
- Horizontal situation indicator (HSI) DME counter read 005,[20] [21] heading 086º and heading bug was set to 350º. The course deviation indicator (CDI) bar was bent and sitting on about one dot left of track
- Radio magnetic indicator (RMI) heading on 095º, ADF 1 needle on 138º and ADF 2 needle on 051º
- Radar altimeter needle indicated off scale
- Altimeter subscale set to 1013 hPa but the indicating needles were missing[22]
- Vertical speed indicator showed either a 2600 feet per minute rate of climb or off scale rate of descent.

[20] The accident site was 10 km, or about 5 nautical miles from Paraparaumu DME.
[21] The DME display was in nautical miles.
[22] At altitudes above 13 000 feet a standard 1013 hPa was set on the altimeter subscale.

1.11.13 Engine panel indications included:

- Turbine inlet temperature for the left engine – needle indicating at about 970º C and counter reading 848º C. For the right engine – needle indicating at about 730º C and counter reading 604º C[23] [24]
- The 2 engine rpm gauges had sustained heavy damage. The 2 needles for the left engine rpm gauge were present but no logical interpretation of their positions could be determined. The right engine gauge indicated about zero rpm[25] [26]
- Flap indicator showed off scale in direction of fully up.

1.11.14 Centre pedestal readings and settings included:

- COMM 1, box 1 was set to 125.(?). The last digit was missing.[27] Box 2 was set to 122.35[28]
- COMM 2, box 1 was set to 12(?).7. The third digit was missing. Box 2 was set to 130.7[29]
- Both VOR navigation receivers were set to 113.4.[30] The position of the DME hold selector could not be determined
- Propeller synchronizer selector was set to SYNCH
- The temperature trim and 2 temperature control switches were found in the NORM (normal) position.

1.11.15 Control settings from the overhead panel included:

- The gated[31] engine fuel ignition switches for both engines were in the 'ON' position
- Both engine feather buttons were depressed or in the 'FEATHER' position. However, the guards around the buttons had been broken and so their pre-impact positions could not be confirmed
- Both left and right propeller and engine inlet electrical icing control switches had been forced in an upwards direction, making it impossible to determine if the switches had been in the OFF or ON positions.
- The toggle type switch for the left engine hot air ice control was bent upwards and past the ON selection. The right engine toggle switch was broken but the base of the toggle was towards the ON position. The left pitot heater switch was missing while the switch for the right pitot was in a down or OFF position. The loadmeter for the pitot heaters was registering a load of 0.5
- The bleed air control button for leading edge anti-icing was extended by about 5 mm. This equated to the OFF position. The button was depressed to activate hot bleed air for anti-icing of the leading edges
- The windshield anti-ice selector was missing but the pole over which the selector would have fitted corresponded to the selector being in an OFF position. The cockpit heater selector was also missing, but the position of the pole indicated that it was between the OFF and LOW positions. The panel, however, was severely buckled.

[23] Maximum limit 971º C, with a cruise power setting of 845º C.
[24] When power is removed the indicators freeze and retain their last reading.
[25] Normal engine operating rpm was about 13 800, giving a propeller rpm of 1020.
[26] Engine driven tachometer generators provide a direct rpm reading. Any interruption and the gauges run back to zero.
[27] The Ohakea Control frequency was 125.1 megahertz (mHz).
[28] The Wellington Control frequency was 122.3 mHz.)
[29] The operator's VHF chatter frequency was 130.7 mHz.
[30] The Palmerston North VOR frequency was 113.4 mHz.
[31] Gated switches require a deliberate act to pull and lift the toggle type switch over a gate to change position.

1.11.16 Other settings found included:

- The 2 throttles were found in the nearly full forward or full power position. The elevator trim tab control displayed about 7 units nose-up trim, the aileron about 5 units left trim and the rudder trim control nearly full left trim. However, the positions of these levers and controls did not necessarily confirm their pre-impact positions due to their construction and the extensive disruption that had occurred during the accident sequence
- The master radio override switch was found in the 'NORMAL' position. The switch enabled COMM 2 radio to be used in case of an electrical generating failure.

1.11.17 Inspection of the aircraft's various electrical panels identified that about half of the electrical circuit breakers had tripped. There was no consistency or logic to explain the positions of the various breakers.

1.11.18 Examination of light bulbs from the cockpit, including the warning annunciator panel, was undertaken to determine if there was any evidence of hot stretch. Hot stretch can be an indicator that a bulb was illuminated at time of impact and, therefore, shows if it was switched on or activated. The absence of hot stretch does not, however, mean that the bulb was not illuminated.

1.11.19 There was no conclusive evidence of hot stretch found. The speed and impact forces appeared to have damaged all the bulbs found in the wreckage, with the 2 engine trim lights on the warning annunciator panel slightly elongated and many of the other bulb filaments shattered with small pieces of metal found embedded on the inside of the bulbs.

1.11.20 The undercarriage and flaps were determined to have been in the fully retracted position.

1.11.21 Examination of the recovered wreckage found no evidence of any metal failure or other initiating fracture that may have contributed to the aircraft departing from controlled flight.

1.12 Medical and pathological information

1.12.1 Post-mortem examination of both pilots revealed they sustained extreme trauma injuries. The examination also identified numerous fractures of the forearms and lower legs, suggesting the pilots were conscious and operating the controls of the aircraft at the time of impact. No toxicology tests were completed due to the nature of the injuries.

1.12.2 There was no evidence of pilot fatigue, or other medical or personal factors that might have contributed to the accident.

1.13 Fire

1.13.1 The aircraft wreckage recovered displayed no evidence of any fire or explosion. Several items found on the beach did display some fire damage but these were identified as not coming from ZK-KFU and were probably previously discarded motor vehicle or other parts.

1.13.2 Two or three of the paper items found near Waikanae Beach did show signs of unusual damage, including possible immersion in fuel, hydraulic oil or similar type liquid. However most paper tags and labels were not so damaged.

1.14 Survival aspects

1.14.1 The accident was not survivable. The evidence indicates that the 2 pilots were ejected from their seats during the impact sequence and the use of the shoulder harness by the co-pilot would not have changed the result. The release of the shoulder harness at altitude was common, with pilots refastening the harness during descent and before final approach.

1.15 Tests and research

Radar coverage

1.15.1 Several days after the accident a light aircraft was flown over the general area where the last radar returns were observed. Primary radar coverage was determined to be good down to an altitude of about 1100 ft.

Engines

1.15.2 The 2 engines were taken to an approved overhaul facility and examined with the assistance of the manufacturer under the supervision of the Commission.

1.15.3 All evidence on both engines indicated that they were operating during the impact sequence. There was cracking of the combustion chambers consistent with thermal shock or cold water quenching as the engines entered the water. All 14 stages of compressor blades displayed rotational damage and some aircraft debris, including pieces of wiring, painted fibreglass and aluminium, were found ingested well into the engines. No determination of power levels was possible.

Propellers

1.15.4 The propeller hubs were sent to the manufacturer in the United States, for disassembly and examination. To facilitate the transport of the hubs, those blades that remained attached were cut off outside the shank of the blade. The hubs were examined under the supervision of a representative for the NTSB on behalf of the Commission.

1.15.5 The examination determined that the blade fracture surfaces showed evidence of a single cycle overload, which resulted when the propellers impacted the water. There was no evidence of fatigue crack propagation and none of the blades appeared to have separated during flight.

1.15.6 Because of the large impact forces, the impact impressions on the fixed spline were fairly easy to identify and the blade impact angles were very close to the *"as found"* indicating little movement after the assemblies had impacted the water. The blade impact angles were found to be about 24.45º for the left propeller and about 31.3º for the right propeller. The manufacturer reported that the blade angles were lower than expected but were above the mechanical low pitch stop blade angle setting of 18.5º. Further, all evidence during the investigation "indicates that the propellers were operating normally during the flight and no evidence was found of a propeller malfunction which would have precipitated the subject accident."

Trajectory analysis

1.15.7 The NTSB completed trajectory analysis of the 4 pieces of wing fairing found inland from Peka Peka Beach. The aerodynamic characteristics and ballistic coefficients were calculated and it was determined that in the prevailing wind conditions the items would have separated from the fuselage as the aircraft descended between 7800 ft and 6800 ft.

Computer modelling

1.15.8 With the assistance of the ATSB and NTSB, computer modelling of the descent profile of ZK-KFU was completed. Using both ATS radar and DFDR information, the modelling indicated that the aircraft was in about a 60º to 70º nose down attitude shortly after the final descent commenced and the flight path or descent angle was about -70º. The descent angle increased to -86º as the aircraft approached 6800 ft.

1.16 Organisational and management information

1.16.1 The operator was established in 1989 to conduct airfreight operations using the Convair 580 aircraft. Certified under Civil Aviation Rule Part 121, *Air Operations – Large Aircraft*, the operator used 4 Convair 580 aircraft to provide regular night freight services between Auckland, Christchurch and Palmerston North. A fifth aircraft was added in mid 2003.

1.16.2 The aircraft were based at either Auckland or Christchurch, while major maintenance was performed in Palmerston North at a maintenance facility owned by the parent company. Crewing of the aircraft was done by contract with a pilots collective set up specifically for the Convair 580 operation. About 17 pilots flew the Convair 580 for the operator.

1.16.3 The operator and several of the operator's pilots advised that during conversion training on the Convair 580, emphasis was placed on the observance of company standard operating procedures as the best way of avoiding unnecessary emergency situations. As soon as practicable after conversion training, all pilots were required to attend an approved crew resource management (CRM) course. The course was designed to promote crew communication and co-ordination.

1.16.4 There was no formal follow-on CRM training but regular meetings were held where all pilots attended, and where videos and articles were presented and discussed. The topics included, among other things, the effect of ice on the Convair 580 aircraft. In November 2002 during a technical refresher course for pilots, several United States National Aeronautical and Space Administration (NASA) videos on turbo-propeller aircraft icing, including tailplane icing, were shown. A pilot representative and the operator advised that; "we are very aware of the risk of icing in New Zealand and engine/propeller and airframe de-icing is turned on at the slightest indication of icing conditions."

1.16.5 Information and guidance to pilots for operating in adverse weather conditions were contained in various documents and supported by the regular meetings and distribution of additional information when available. The pilots' handbook contained a section on "all-weather operations", which included information on tailplane icing and turbulent conditions. The operator advised that the aircraft's weather radar was used to provide information for best tracking and pilots would maintain an awareness of aircraft safe manoeuvring speeds for transiting areas of expected turbulence. There were, however, no written guidelines on the use of radar for this role.

1.16.6 The operator's minimum equipment list (MEL) for the Convair 580 stated that a flight may commence if the weather radar was inoperative provided the latest weather forecast, including pilot reports, indicated that thunderstorms or other hazardous weather conditions were unlikely to be encountered. A flight could also commence if the captain was satisfied that such weather conditions could be seen and avoided. The MEL also stated that if any anti or de-icing equipment was inoperative, flight into known or forecast icing was not permitted.

1.16.7 Instructors for the operator advised that, while there were no written instructions or guidelines, in the event of a weather radar failure, pilots were expected to obtain guidance from ATS and any other aircraft in the area to avoid or escape any hazardous condition. The weather radar had proved to be reliable and one of the instructors could not recall a radar failure for many years. The pilots' operating handbook recommended an immediate change in altitude should severe icing conditions be encountered.

1.17 Additional information

Witness information

1.17.1 Witnesses generally described the conditions at about the time of the accident as dark, with a heavy overcast and a strong wind from a north to north-westerly direction. The heavy rain was easing. Severe flooding was reported along the foothills to the east and south-east of Paraparumu.

1.17.2 Witness accounts were almost totally restricted to aural reports due to the inclement weather and the time of the accident. One possible visual sighting of ZK-KFU was not supported by radar and FDR information. Several witnesses recalled hearing an aircraft flying low overhead in a northerly direction. Again this was not supported by radar data.

1.17.3 Most of the witnesses recalled hearing a combination of aircraft engine noise and a "bang" or "boom". The "bang" occurred either before or after the engine noise and was similar to but was not thunder. Some witnesses also heard 2 "bangs", spaced by a few seconds. Others heard a "whooshing" noise increasing in intensity or speed. Two witnesses reported seeing light being reflected off the low cloud out to sea.

Icing

1.17.4 Structural or airframe icing is the accretion of ice on any exposed surface of an aircraft due to the impingement of water droplets on that surface that freeze.[32] The 2 basic requirements for ice to form are visible moisture and subfreezing temperatures. Icing conditions are, therefore, generally found while flying in cloud in the temperature range of 0º C to -14º C[33], but will vary according to water content, water droplet size and exposure time.

1.17.5 The presence of icing on an aircraft can be hazardous in that it alters or destroys the smooth flow of air over wings and control surfaces thereby reducing lift and increasing drag. Ice also increases aircraft weight and can affect the stability or controllability of the aircraft while also increasing the aircraft's stall speed.[34] Additional power may be required to maintain aircraft performance, or the wing's angle of attack to the airflow may need to be increased to maintain level flight. The problem with these courses of action is that power may be limited and by raising the aircraft nose, ice forms on the exposed underside of the aircraft compounding the problem.

1.17.6 There are 4 categories of airframe icing:

- clear ice (also known as glaze ice)
- rime ice (also known as opaque ice)
- hoar frost
- freezing rain.

1.17.7 Clear ice occurs when large super-cooled water droplets spread out or flow back (often termed "runback") as they freeze, allowing trapped air to escape. The result is clear, high-density ice that is heavy and difficult to remove. The larger the water droplets or slower the freezing process, the more the ice will run back and form behind the leading edge – rearward of any anti or de-icing equipment. Clear ice is often associated with, but not restricted to, cumulus cloud within the first 6000 ft to 8000 ft above the freezing level.

1.17.8 Rime ice occurs when super-cooled water droplets freeze quickly, perhaps due to the smaller size of the droplet or if the droplet temperature is colder than some -15º C. The ice traps air and is lighter, rougher, brittle and milky in appearance. Building up on the leading edges of aircraft, it can dramatically affect performance but is easier to dislodge. Rime ice is usually associated with stratiform cloud where large water droplets are less common.

[32] On contacting the aircraft surface, latent heat of fusion is lost and the water droplet starts to freeze.
[33] Icing can occur at temperatures as low as -40º C, where water will freeze spontaneously.
[34] A stall occurs when the airflow reaches the critical angle of attack and lift decreases. If an aircraft stalls while flying in level flight it will be unable to remain level and will descend.

1.17.9 Hoar frost forms when an aircraft skin temperature is below 0º C and moist air freezes on contact without going through the liquid state. The potential effect of hoar frost can be underestimated as the layer of ice is generally thin and clear but, nevertheless, changes in weight and airflow over the wing will affect performance. Hoar frost can occur when an aircraft is very cold and moves rapidly into warmer moist air, for example during a rapid descent from above the freezing level.

1.17.10 Freezing rain occurs when rain falls from a warm cloud layer into a cold airmass with a temperature below 0º C. Freezing rain is normally associated with flight through a warm or cold front. An aircraft can be quickly enveloped in ice, usually clear, and performance may quickly degrade. There have been reports where aircraft have been unable to maintain level flight after less than a minute or so of exposure to freezing rain.[35]

1.17.11 While ice can form on any exposed surface, the leading edge of a larger radius object will have a lower collection efficiency than a smaller radius object. The larger the radius the greater the pressure wave in front of the surface, which deflects the air, and moisture, around it. According to the NASA Lewis Research Center, tail surfaces have higher collection efficiencies than wings because of their smaller leading edge radius and chord length[36] and can collect 2 to 3 times greater ice thickness.[37] Aircraft aerials will also act in a similar manner and will often "ice up" before any ice can be seen on the leading edges of the wings.

1.17.12 NASA data indicated that in 80% of cases, an altitude change of 2000 ft should be sufficient to get clear of icing conditions.

1.17.13 Between November 1999 and February 2000 a North American joint field project on aircraft icing was undertaken. Titled the Alliance Icing Research Study (AIRS), the project involved organisations such as NASA, Meteorological Service of Canada (MSC), National Research Council of Canada (NRC), Federal Aviation Administration of the United States (FAA) and Transport Canada (TC). Several specially equipped aircraft were used for the research flights, including a Convair 580 from NRC.[38]

1.17.14 On 25 January 2000, the test Convair 580 flew through a patch of freezing drizzle and the icing on the aircraft was categorised by the crew as moderate to severe. The crew observed an "ice build up immediately aft of the heated leading edge. The estimated thickness of the ice was 1 – 3 cm." Aircraft speed reduced by about 20 kts to 30 kts during this time.

1.17.15 On 16 February 2000, the test Convair 580 encountered severe icing conditions. "Runback icing was observed near the leading edge of the wing. Ice appeared on the leading edge of the horizontal stabiliser completely covering over the heated surface. On descent to warmer temperatures, one could actually see water running underneath this ice surface, which tenaciously remained attached. This encounter was severe enough that after 5 minutes of operating in these conditions the pilots first increased power by 20 – 30% to maintain the flight conditions and shortly after this decided to ascend above cloud to de-ice."

1.17.16 Several other incidents involving Convair 580 aircraft, including 2 in New Zealand have occurred, where the aircraft encountered severe icing and were unable to maintain level flight. Pilots reported significant decreases in airspeed, over 30 kts, and in some cases encountered pre-stall buffet. In all cases the aircraft were recovered to safe flight by the application of power or use of the standard stall recovery technique, or part thereof.

[35] On 21 December 2002 the pilot of an ATR-72 twin turboprop aircraft in Taiwan reported being in severe icing for 73 seconds before the CVR abruptly ended. The cargo plane crashed with the loss of the 2 pilots.
[36] The chord line is a straight line joining the centres of curvature of the leading and trailing edges.
[37] Some organisations believe that tailplane ice can be as much as 3 to 6 times thicker than ice on the wings.
[38] AIRS preliminary results, published by the American Institute of Aeronautics and Astronautics Incorporated, 2001.

1.17.17 Following 2 weather related accidents in 1987[39] and 1997[40], and a Ministerial Inquiry in 1998, the CAA commissioned an independent report into icing hazards in New Zealand. Titled *New Zealand Aircraft Icing Hazards*, the report recommended, among other things, the following:

- an icing education programme for pilots be developed
- pilot licensing syllabi be amended to include greater reference to icing
- all company Operations Manuals be reviewed with regard to their icing content
- improvements to icing forecasting be investigated
- certification requirements for IFR[41] and night freight operations be reviewed.

1.17.18 The CAA adopted the recommendations and in 2000 the *Aircraft Icing Handbook* was made available on the Authority's web site. Articles on icing were also printed in the CAA's bi-monthly safety magazine Vector and a video on airframe icing was released in March 2003.

1.17.19 Licensing syllabi for private, commercial and air transport licences were amended to include greater emphasis on icing. Company Operations Manuals for Civil Aviation Rule Part 135, *Air Operations – Helicopters and Small Aircraft*, were reviewed as part of the re-entry certification of all operators to the new Rules. In the case of Part 121 and Part 125 operators of large and medium aeroplanes, a specific review was not seen as necessary as this was already routinely dealt with as a key certification requirement and was well entrenched in the airline environment.

1.17.20 The CAA held initial discussions with MetService on improvements in icing forecasts. The CAA subsequently determined that MetService was continually striving to improve forecasting via technological advancements and no further prompting was required.

1.17.21 The CAA advised that the recommendation to review certification requirements for IFR and night freight operations focused on aircraft ice protection equipment requirements. In accepting this recommendation, CAA considered the requirements to be adequate but that Flight Manual and company manuals may be misleading to pilots in terms of aircraft icing capabilities. Therefore, action was intended to focus on pilot training as covered in the training sections of Civil Aviation Rules Parts 121, 125 and 135. This action had not been completed at the time of this accident.

Tailplane stalling

1.17.22 The horizontal stabiliser on a tailplane provides longitudinal stability by creating a downward force (or negative lift) to compensate for the nose-down pitching moments of the wings and fuselage. Should the tailplane stall the aircraft nose would suddenly pitch down and the control yoke may be abruptly snatched forward. Factors that affect a tailplane stall include:

- shape, texture and location of any ice
- increase in aircraft speed or power
- degree of gustiness or turbulence
- increase in flap setting
- pilot's pitch control input.[42]

[39] Refer Court of Inquiry for the Office of Air accidents Investigation file 87-120, Cessna 208 Caravan ZK-SFB, off the Kaikoura Coast, 27 November 1987.
[40] Refer TAIC Report 97-012, Beechcraft BE58 Baron ZK-KVL, Tararua Ranges, 11 June 1997.
[41] Instrument Flight Rules.
[42] Refer Federal Aviation Authority (FAA) Advisory Circular 23.143-1, dated 20 December 2001.

1.17.23 Because the tailplane works in the opposite sense to the wings, recovery from a tail stall is opposite to the traditionally taught wing stall recovery. For a wing stall recovery airflow must be restored to the wings upper airfoil surface while for a tail stall airflow must be restored to the lower airfoil surface. The recovery actions for a tailplane stall are:

- immediately raise flaps to the previous setting
- pull aft on the yoke (assistance may be required)
- reduce power if altitude permits
- do not increase airspeed unless it is necessary to avoid a wing stall.[43]

2 Analysis

2.1 The lack of any pilot intercom or cockpit recordings on the CVR limited the investigation and may have prevented an early and exact determination of the causes of the accident. Fortunately, the DFDR and ATS recordings and the captured CVR radio transmissions did provide valuable factual data to direct the investigation.

The flight

2.2 The accident flight was the first of 4 sectors planned for the night, as part of a routine scheduled trip between Christchurch and Palmerston North. The crew was well rested and the weather forecast was suitable for the flight to proceed. ZK-KFU was recorded as serviceable and there was no evidence of any limitation that may have affected the conduct of the flight. The cargo consisted mainly of courier packs. No dangerous goods were reported as being aboard the aircraft and none were found in the cargo recovered.

2.3 The flight progressed normally until after passing Paraparaumu in descent, when the aircraft initially levelled, turned and descended, rapidly entering a spiral dive. Control of the aircraft was not recovered and it impacted the sea about vertically and at high speed, probably around 400 kts.

2.4 Reports by some witnesses of an aircraft flying very low over the land were probably the result of aircraft noise being distorted by the heavy cloud and a range of hills to the east. ATS radar and the DFDR clearly record ZK-KFU not descending below 14 400 ft while over land.

2.5 The aircraft was levelled at about 14 400 ft possibly because the crew was concerned about adverse weather ahead. The DFDR confirms that light to moderate turbulence was being encountered as the aircraft descended, particularly after passing Paraparaumu. The captain may have wished to slow the aircraft to reduce the effects of that turbulence.

2.6 The left turn after the aircraft was levelled, was preceded by a short turn to the right of about 9º over 13 seconds. The right turn may have been unintentional or to counter the effects of the changing winds along the route, as there was no obvious change in the radar track during this time. However, the turn to the left, a turn of about 35º over 16 seconds, was made at a constant rate of turn that equated to an angle of bank of about 30º being held during this time. This was consistent with positive controlled manoeuvring of the aircraft, possibly to avoid bad weather ahead.

[43] Refer NASA / FAA Tailplane Icing Program Overview, report E-11502, dated January 1999, and the United States Aircraft Owners and Pilots Association newsletter Safety Advisor, dated November 2002.

2.7 Nevertheless, the content and demeanour of the co-pilot's transmission to Ohakea Control indicated nothing untoward with either the aircraft or the conditions being encountered as the aircraft levelled and turned left. Had the captain wished to remain level for a significant period of time, say a minute or thereabouts, it would have been expected that ATS would have been informed in accordance with procedures described in the AIP, to coordinate with any traffic.[44] Similarly, if the intention of the left turn was to deviate significantly left of track, a radio call to Ohakea Control should also have been made. That a call wasn't made indicates that either the deviation was going to be minor or the pilots were unable to make a call before the aircraft started to descend rapidly.

2.8 The levelling of the aircraft followed by the left turn indicates that the aircraft's weather radar was probably working normally, providing the crew with information of adverse conditions ahead requiring the aircraft to be manoeuvred. Had the radar not been working the crew would likely have advised ATS and requested assistance to avoid any significant weather.

2.9 Aviation communication protocols required the crew of AF 642 to read back the repeated transmissions from Ohakea Control informing them of the Ohakea altimeter setting. All previous transmissions were correctly made and, therefore, the lack of a response to this call was unusual. That neither the co-pilot nor the captain responded probably indicated that there was an electrical malfunction, that the pilots were incapacitated or they were busy trying to control the aircraft.

2.10 There was no evidence to indicate an electrical malfunction of the radio at this stage of the flight. COMM 1 had operated normally and a back-up radio was available. The DFDR and CVR continued to record confirming an essentially normal power supply. (The loss of transponder information is discussed later.)

2.11 Crew incapacitation was also improbable. Both pilots would need to be affected and the injuries sustained indicated that they were conscious and at the controls at the time of impact.

2.12 No thunder or lightning was recorded and there was no evidence of a lightning strike on the aircraft. Witness accounts were of a "bang" that was not like a thunderclap. There was probably insufficient time for a fire to develop, in the cargo or elsewhere, between when the co-pilot read back the ATS clearance and the aircraft started to descend rapidly. Had there been a fire, the aircraft's warning systems should have alerted the crew to allow them time to make a distress call and start a controlled descent. (The damaged paper tags and labels are discussed later.)

2.13 With the aircraft starting to descend steeply shortly after the co-pilot read back the onwards clearance, the pilots' priority would have been to fly the aircraft and a radio call would have been of secondary importance. The absence of any visual references because of the darkness and cloud would also have compounded the situation with probable pilot disorientation.

2.14 The speed at which the aircraft started to descend indicated that there was a rapid and large nose down pitch of the aircraft. Analysis of the DFDR and radar data, indicate that the aircraft may have been in a nose down attitude of over 70º. This large pitch attitude change would not have been intentional, as it did not fit with a pilot controlled situation. Possible causes include:

- a loss of propeller pitch control causing the aircraft to yaw rapidly and roll to a steep nose down attitude
- a break-up of the aircraft due to either structural failure, explosion or turbulence
- an instrument system failure causing erroneous indications and pilot disorientation
- the aircraft stalled, due to either turbulence or icing.

[44] AIP ENR 1.1 - 24, paragraph 9.4.3, effective 4 September 2003

Propeller malfunction

2.15 The loss of propeller control could cause a large asymmetric or yaw movement with the aircraft rolling excessively and descending. In March 1967 in Ohio, United States, a Convair 580 was in descent when a propeller torque cylinder failed and the blades moved to low pitch at a rate too rapid for the propeller pitch lock to operate effectively. The resulting propeller overspeed caused the blades to separate and yaw the aircraft excessively. One of the blades penetrated the fuselage, which then failed along the line of penetration.

2.16 For ZK-KFU there was no evidence of a propeller torque cylinder failure or operation of the mechanical low pitch stop, but rather that the propellers were operating normally during the flight. All the blades were found close to the engines and displayed evidence of being attached and rotating when striking the water. Finding the propeller synchronizer in the normal SYNCH position would also confirm that the pilots probably had no prior concerns about the operation of the propellers – the reported fluctuations in propeller rpm continuing to remain within limits as indicated by the CVR.

2.17 Further, there was no evidence of any large or sudden heading change that would be associated with a propeller malfunction. The DFDR recorded the steady left turn being maintained as the aircraft started to descend steeply. The lower than expected blade angles found during examination may have been a function of the power levers (throttles) being closed as the aircraft descended.

In-flight break-up

2.18 The possibility of an in-flight break-up starting at 14 400 ft was not supported by DFDR and CVR information or the distribution of the wreckage found. There was no evidence of any metal failure and the turbulence being encountered was generally light, varying between 0.83 G and 1.21 G. At 66 660 flying hours and 98 774 cycles, ZK-KFU was at about 82% and 69% respectively of the highest time Convair 580 aircraft still operating in Canada.

2.19 There was no evidence of the cargo door or any other door opening in flight. The 3 forward doors were found still attached to their hinges and were clearly closed when the aircraft impacted the water. While the cargo door was not located there was no evidence of it departing from the aircraft and striking the tail area. The difference between cabin pressure and outside pressure would have reduced as the aircraft descended making the possibility of an explosive decompression less likely.

2.20 The repair to the left wing upper spar cap wing attachment was last checked as part of the routine maintenance on the aircraft one month prior to the accident and no concerns were raised. Unfortunately, this section of the wing was not recovered. However, a failure in this location was not consistent with the flight path of the aircraft as it descended or the finding of the 2 engines in close proximity. The maintaining of the steady left turn, for about 10 seconds, as the aircraft started to descend steeply indicates that there was no wing drop, but rather a possible loss of elevator pitch control. The ailerons were possibly still effective and the elevator must still have been operable to some extent to initially hold the aircraft level at 14 400 ft and also give variations and an overall increase in G as the aircraft descended.[45] However, a loss of full elevator pitch control cannot be totally eliminated.

[45] Rearwards elevator control input pitches the nose of the aircraft up, thereby increasing the loading or G on the aircraft.

2.21 The autopilot probably would not have been engaged as the aircraft descended below 14 000 ft, as it can be assumed that the pilots would have been operating the flying controls in an attempt to arrest the descent. The TAWS *Bank angle* alert would, therefore, have sounded when the aircraft reached 50º in bank attitude – which was some 18 to 20 seconds after the descent commenced. There was no second *Bank angle* alert before the recording stopped and so aircraft bank attitude probably did not increase past 60º during this time. Had a break-up of some sort occurred at the start of the rapid descent, larger and more dramatic pitch and bank angle changes would have been expected and indicated on the DFDR recording and reported on the TAWS.

2.22 The rapid changes in direction that were recorded as the aircraft descended were probably a reflection of the limitation of the compass system. The compass readings were reliable only when the pitch attitude of the aircraft was within normal operating parameters. If the aircraft pitch angle became excessive, generally about 60º nose up or down, the gimbals of the gyros would have locked, and other components would possibly have malfunctioned. Heading information would then have been erratic and unreliable. Further, the radar data indicated only a left descending spiral path.

2.23 The location of the wreckage area, about one km south-west of where ZK-KFU started to descend, and the general distribution of wreckage found, suggested that an in-flight break-up did occur, but only after the aircraft had entered the spiral dive.

2.24 As ZK-KFU descended towards the final recorded altitude of 6800 ft, airspeed had increased to 392 kts and the G loading was peaking at 3.21 G. The angle of bank was probably between 50º and 60º. With a V_{NE} of 313 kts IAS at 10 000 ft and reducing as the aircraft descended, a V_A of about 165 kts and maximum load limit of 2.94 G, all the limits for ZK-KFU were exceeded by a significant margin.

2.25 Rolling G can cause large torsional loads at the wing roots. Therefore, it would not be surprising that as ZK-KFU descended the wing roots would be subjected to increasing torsional stress and panels would start to buckle and separate. Once the first section lifted, the tearing effect would quickly pull other sections off and the aircraft would start to disintegrate soon after.

2.26 The 4 pieces of right upper wing fairing found inland were probably torn from the aircraft as it descended at high speed and pulling high G. They were then carried by the 50 kt plus north-westerly winds to be deposited over the land. The trajectory analysis confirmed that the 4 pieces would have separated from the fuselage after the aircraft had descended below about 7800 ft.

2.27 While the forward section of the aircraft, the propeller blades and other items were severely damaged, the left wing and flap sections recovered were not damaged to the same extent. This would support the probability that sections of the wings broke off prior to impact with the sea and then fell more slowly. The tailplane would have been partially protected by the forward section of the aircraft taking the brunt of the impact.

2.28 That the DFDR stopped recording at 6800 ft suggests that this was about the time where wings, and possibly the engines also, started to separate and electrical power was affected. As the aircraft battery was located in the left wing just outboard of the attachment area, a total electrical power loss would have resulted from the wings separating. The uncontrolled loss of the engines with their electrical generators and final impact with the sea could account for the random tripping of the circuit breakers.

2.29 With a total electrical power loss, the engine temperature gauges retain their last reading while the rpm gauges return to zero. The 2 attitude indicators both showed a large left bank and nose high attitude. This, combined with evidence of the nose cone being torn off at an angle, may indicate that the forward section of the aircraft had separated and was oscillating slightly as it fell vertically.

2.30 The speed, impact forces and the direction of the forces would have strongly influenced the type of damage sustained by the bulbs from the instrument panel. That none of the bulbs displayed conclusive indications of hot stretch was not surprising considering that the aircraft would have taken about 9 seconds to fall from 6800 ft before impacting the water. This was more than sufficient time for any hot filaments to cool.

2.31 An aircraft break-up at about 6800 ft could account for the 2 "bangs" reported by some witnesses. The first bang being associated with the aircraft breaking up and possible ignition of some of the fuel, and the second bang as it struck the sea shortly after. This could also explain the distribution of the tags and other paper items in a general semi-circle around Waikanae Beach, the kerosene smell and the damage sustained by a small number of the tags. With the strong north-westerly winds, the light paper items could easily have drifted the 4 km to shore from a low altitude.

Instrument failure

2.32 The possibility of an instrument system failure causing pilot disorientation was considered remote. The 2 pilots, particularly the captain, had significant instrument flying experience and should have been able to identify and handle an instrument malfunction. The aircraft was fitted with multiple instrument display systems able to be powered from several sources. Had a fault developed with the aircraft's pitot-static systems, thereby affecting the altimeter, airspeed or vertical speed indicators, the pilots should still have been able to control the aircraft by reference to the various attitude indicators. The 2 independent attitude indicators on the captain's panel displayed similar trapped information confirming they were probably operating normally before the aircraft broke-up and power was lost. Further, the DFDR indicated reliable altitude, airspeed and heading information being generated and presented for the pilots to use.

Aircraft stall

2.33 ZK-KFU started to descend as the co-pilot was concluding his transmission to Ohakea Control. The radio call gave no indication of anything untoward and therefore it is likely that the pilot was recommencing the descent in preparation for landing at Palmerston North. However, within 1 or 2 seconds the rate of descent began to increase dramatically indicating a further large and sudden pitch down of the aircraft.

2.34 The decrease in groundspeed back to about 75 kts, as interpreted by ATS radar, coincided with the aircraft's indicated airspeed starting to increase dramatically. This also supports the probability that the aircraft was in a steep nose down attitude at this time.

2.35 The loss of pitch control and sudden descent was symptomatic of a stall. A stall could have resulted from the aircraft getting too slow, turbulence or increased loading, icing or a combination of these. At 200 kts the aircraft was well above the normal clean stall speed of about 105 kts with no flap extended. The DFDR confirms that the turbulence factor or loading on the aircraft as it approached the point at where it started to suddenly descend, never exceeded 1.21 G. This would not have been sufficient by itself to cause a stall. The most probable cause of a stall would have been a disruption of the laminar airflow over the wings and a significant increase in weight, or both, due to ice build-up. Similarly, the tailplane may have stalled at this time for the same reasons.

2.36 A loss of control due to icing over of the flight control surfaces was also a possibility. However, to level at 14 400 ft and remain steady at this altitude while airspeed decreased, required controlled elevator movements. Similarly deliberate aileron movement was required to roll the aircraft into the steady left turn and then hold the same angle of bank. Further, the initially steady turn after the aircraft started to descend and the generally increasing G loading during the descent would indicate that the flight controls were still probably effective at this time.

Icing

2.37 As ZK-KFU crossed Cook Strait the aircraft weather radar should have indicated to the crew an area of significant weather ahead, identifying the passage of the trough with its associated frontal band. This information would have been presented in a format similar to the weather radar picture provided by MetService, but probably not to the same standard or quality.

2.38 On the MetService radar picture, the frontal band had a clearly defined trailing edge, which was near the Kapiti Coast at the time ZK-KFU flew past Paraparaumu. ZK-KFU would have flown along the trailing edge of the frontal band and descended through the area of enhanced precipitation that extended from 14 750 ft to 18 000 ft. With the freezing level at about 9500 ft the temperature as the aircraft descended below 18 000 ft would have been between -6º C and -15º C. With super-cooled water droplets present, conditions were conducive to severe icing.

2.39 The crew should have been aware of the presence of icing, considering the SIGMETs issued, the local weather conditions and aircraft weather radar information available. The cockpit anti-icing switches were probably selected ON, and there was no evidence that they were not. The bleed air control button was probably ON as the aircraft descended, but when aircraft electrical power was lost the solenoid would have allowed the button to move to the safe or OFF position.

2.40 The temperatures being encountered during this time meant that clear or glaze ice was a probability. With the aircraft having descended from cooler altitudes through the area of the frontal band, freezing rain was also likely to be present. This ice most probably would have consolidated very quickly behind the heated leading edges of the main wings and tailplane. The crew members had sufficient experience that they should have been able to identify a developing dangerous situation and recover from it. But in the dark conditions and restricted visibility they were probably not aware of the seriousness of the icing or the speed at which it was building up. The initial descent and levelling at 14 400 ft was probably also completed using the autopilot, masking any effect the ice may have had on the flight controls.

2.41 As the aircraft was levelled and slowed at 14 400 ft, ice accretion could have increased rapidly including, probably, the underside of the aircraft as it become more exposed to the airflow. At about this time the transponder stopped transmitting. The isolated failure of the transponder signal, followed by a normal radio call, was possibly due to the transponder aerial underneath the aircraft becoming covered in ice and blocking the signal. No other cause for the signal failure could be identified, especially considering the timing of the failure and the power supply to the transponder being shared with COMM 1 and probably the DFDR, with both continuing to operate normally. The NRC advised that icing-over of aerials on their test aircraft was suspected "on occasions but without proof" as any ice had melted by the time the aircraft landed.

2.42 After remaining level for about 15 seconds and slowing, the build-up of ice probably became critical, to the point that the aircraft stalled and entered a spiral dive. The steady left turn being maintained for about 10 seconds after the descent was started, with no evidence of a wing drop, indicated that either the inner sections of the wings had stalled, the tailplane had stalled or a combination of both.

2.43 A stall would have caught the crew unawares, taking the pilots a few seconds to recognise what had happened and to start recovering from the now very steep nose down attitude. With no outside visual references the crew could also have become disorientated to some degree.

2.44 Had the tailplane stalled, which was possible considering the speed at which the rapid descent commenced, then unless the correct actions were immediately applied the stall would have become increasingly difficult if not impossible to recover from.

2.45 The 2 pilots were undoubtedly trying to recover the aircraft from the spiral dive, as indicated by the changes in aircraft loading and by their injuries showing they were using the controls. The aircraft started to break-up as it approached about 7000 ft.

2.46 Should an aircraft encounter significant icing, the most prudent action would be to immediately climb or descend until clear of the freezing band. If already in descent, the descent should be continued minimising any power, configuration and attitude changes. The aircraft should be manually flown to assist in identifying the severity of the icing. Experienced Convair pilots reported that the Convair 580 gave ample warning when approaching a normal stall condition. However, the same indications might not be present in a stalled tailplane situation, especially if the autopilot was engaged.

2.47 If a tailplane stall occured, probably identified by a lack of any normal pre-stall warning buffet and a sudden stall at high speed, flap should be raised to the last setting, immediate aft elevator applied and, if possible, power reduced. Airspeed should not be allowed to increase significantly.

Weather information

2.48 Why SIGMETs 8 and 9 were not notified to the crew of AF 642 was not fully determined. Normal practice was for controllers to alert pilots of a new SIGMET immediately on receiving it, or as soon as practicable afterwards. SIGMET 8 was issued 28 minutes before AF 642 first contacted Christchurch Ground and the crew should have been alerted to its existence.

2.49 For SIGMET 9 the Wellington controller could have believed that the report was not "relevant", in accordance with applicable rules and procedures, as SIGMET 6 was still valid until after AF 642 was due to land at Palmerston North. However, had SIGMET 9 been passed to the crew of AF 642 as it crossed Cook Strait, it could have given the pilots a timely reminder of the probability of encountering severe icing as they descended through the icing layer. Nevertheless, the pilots should have already been alert to severe icing as they were in receipt of SIGMET 3, and probably also SIGMET 6 as no copy of this report was found in the operator's Christchurch office, to where it had been faxed and where the pilots were completing their documentation.

2.50 The presence of severe icing, while forecastable with some accuracy, can only be confirmed when actually encountered. The crew of AF 642 was, therefore, in the best position to determine the severity of the icing they were flying through. Reports of actual icing encounters, as well as other weather phenomena, can therefore also play a significant role in helping to alert pilots to potentially hazardous conditions and thus allow them to take appropriate avoiding action.

2.51 The lack of AIREPs as reported by MetService may have been due to a general reluctance among pilots or it may have reflected an unintended interpretation of the wording in the AIP. (Refer paragraph 1.7.11) Pilots may have believed that if severe weather conditions were encountered, an AIREP was required to be made only if a SIGMET had not already been issued. This was clearly not the intention. Rather pilots should make an AIREP regardless of the SIGMET status to help reinforce everyone's general appreciation of the current weather conditions.

2.52 The operator and company pilots were acutely aware of the dangers of icing and the crew of AF 642 had undoubtedly encountered icing at some time during their extensive aviation careers. However, as AF 642 descended through the freezing conditions, the pilots were probably not aware of the speed at which ice may have been accreting on the rear of the wings and tailplane. By levelling for some 15 seconds a build up of ice probably reached a point where continued controlled flight was not possible.

2.53 With about 17 pilots flying the Convair 580, the pilots' collective was in a good position to help ensure a high level of standardisation was maintained among pilots and they were kept well informed on relevant topics. Formalised written procedures or guidelines assist in the maintenance of these standards, and with pilots based in 2 or more locations, their importance is increased. Therefore, benefit could be gained by expanding the pilots' handbook section on all-weather operations for the Convair 580, or generating another document to include information such as pre-flight planning considerations, use of the aircraft radar, actions in event of radar failure, descent profiles and configurations, and weather avoidance.

2.54 Although the conditions encountered on the night of 3 October 2003 were extreme they can occur on isolated occasions. The CAA has regularly produced training and educational material for pilots about icing, and in adopting the recommendations of the *New Zealand Aircraft Icing Hazards* report, CAA has also addressed a number of additional concerns. However, CAA had yet to complete the review of certification requirements for IFR and night freight operations, in particular pilot training for Part 121, 125 and 135 operations and the review of flight and company manuals to remove any misleading information.

Aircraft recorders

2.55 The failure of the CVR to capture any intercom or general cockpit information was unacceptable. Had this information been available to the investigation it may have disclosed why ZK-KFU was levelled at 14 400 ft, then turned left and ultimately why it entered the spiral dive. However, the performance of the CVR did not affect the safe operation of the aircraft.

2.56 The recorder was reportedly installed according to specifications and was tested every 125 hours of flying. Further, the pre-flight checklist included a test of the CVR that supposedly ensured the 3 channels were recording. No faults were reported for any of the other aircraft in the operator's fleet of Convair 580 aircraft following subsequent inspections.

2.57 That only some of the communications were recorded may have been due to the initial installation of the recorder, the audio pick-ups or the later modification of the intercom system. There was no fault found with the CVR itself. That the standard testing regime did not detect the recording fault(s) confirms that the installation of the CVR on other Convair aircraft and normal maintenance checks may be inadequate and need to be reviewed.

2.58 The new TSO standards for CVRs have resulted in the removal of some tape-operated recorders, and digital CVRs have now become the industry norm worldwide. The digital CVR is potentially more reliable both in general operation and in accident survivability.

2.59 While the DFDR onboard ZK-KFU did perform as required and provided valuable information, had the next level of FDR been installed, a more efficient and effective investigation would have possibly been achieved. The availability of aircraft attitude, longitudinal and control column information could have greatly assisted the analysis of the aircraft's flightpath as it approached and entered the spiral dive. The availability of engine thrust information could have also have enhanced the contribution of the FDR to the determination of the cause of the accident.

2.60 In New Zealand, the Convair 580 is used for both passenger and freight operations. Consideration, therefore, needs to be given to what type of DFDR should be fitted to an aircraft type that can carry up to 48 persons. For Canada the minimum standard was considered to be an 11-parameter digital recorder.

2.61 None of the vessels or aircraft searching for ZK-KFU was fitted with equipment capable of tracking the ULBs on the aircraft recorders. No search organisation, including the Police and the New Zealand Defence Force, had the capability to mount an immediate search specifically for aircraft recorders. Had such a capability been available, the recorders, and therefore the aircraft, probably would have been located and recovered earlier. The reliance on side-scan sonar and divers increased the chances of the recorders not being found at all.

2.62 Considering New Zealand's maritime environment, it is essential that large aircraft are fitted with suitable flight recorders and that there is the capability to quickly locate them underwater and recover them.

3 Findings

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

3.1 The crew was appropriately licensed and fit to conduct the flight.

3.2 The captain was an experienced company line-training captain, familiar with the aircraft and route.

3.3 The co-pilot while new to the Convair 580 was, nevertheless, an experienced pilot and had flown the route earlier in the week.

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

3.5 The estimated aircraft weight and balance were within limits at the time of the accident.

3.6 With a serviceable weather radar the weather was suitable for the flight to proceed.

3.7 The captain was the flying pilot for the flight from Christchurch to Palmerston North.

3.8 The flight proceeded normally until the aircraft levelled after passing Paraparaumu NDB.

3.9 Why the aircraft was levelled at about 14 400 ft was not determined, but could have been because of increasing or expected turbulence.

3.10 The weather conditions at around the time of the accident were extreme.

3.11 The aircraft descended through an area of forecast severe icing, which was probably beyond the capabilities of the aircraft anti-icing system to prevent ice build-up on the wings and tailplane.

3.12 The crew was probably aware of the presence of icing but might not have been aware of the likely speed and the extent of ice accretion.

3.13 The rate of ice accretion might have left insufficient time for the crew to react and prevent the aircraft stalling.

3.14 The transponder transmissions were impaired probably due to ice build-up on the aerials.

3.15 The aircraft probably stalled because of a rapid build-up of ice, pitching the aircraft nose down and probably disorientating the crew. This could have resulted from a tailplane stall.

3.16 Although the aircraft controls were probably still functional in the descent, a very steep nose-down attitude, high speed and a potentially stalled tailplane, made recovery very unlikely.

3.17 Under a combination of high airspeed and G loading, the aircraft started to break-up in midair, probably at about 7000 ft.

3.18 Although there was no evidence to support the possibility of a mechanical failure or other catastrophic event contributing to the accident, given the level of destruction to ZK-KFU and that some sections of the aircraft were not recovered, these possibilities cannot be fully ruled out.

3.19 The crew of AF 642 not being advised of the presence of a new SIGMET concerning severe icing should not have affected the pilots' general awareness of the conditions being encountered.

3.20 Had the crew been aware of the new SIGMET it might have caused them to be more alert to icing.

3.21 Pilots awareness of the presence of potentially hazardous conditions would be increased if other pilots commonly sent AIREPs when such conditions were encountered.

3.22 Operators' manuals, especially for IFR operators, might contain inadequate and misleading information for flight in adverse weather conditions.

3.23 The search for the aircraft and pilots was competently handled in adverse conditions.

3.24 The regular mandatory checks of the CVR failed to show that it was not recording on all channels.

3.25 The lack of any intra cockpit voice recordings hampered and prolonged the investigation.

3.26 The DFDR data and available CVR recordings provided limited but valuable information for the investigation.

3.27 Had more modern and capable recorders been installed on ZK-KFU, significantly more factual information would have be available for the investigation, thus enhancing the investigation and increasing the likelihood of finding a confirmed accident cause, rather than a probable one.

3.28 Had suitable ULB tracking equipment been available, the finding of the wreckage and recovery of the recorders would have been completed more promptly.

3.29 The lack of tracking equipment could have resulted in the recorders not being found, and possibly even the wreckage not being found had it been in deeper water.

4 Safety Actions

4.1 Airways Corporation advised that a review of the Manual of Air Traffic Services was to be undertaken. The review to include "an examination of the processes with which SIGMET and other similar flight information was handled, specifically on the scope and appropriateness of staff assessment of relevancy of such information."

4.2 The Transport Accident Investigation Commission commenced a study into the purchase of suitable underwater location beacon tracking equipment for use by New Zealand search organisations. This will be done in consultation with the CAA and the New Zealand Defence Force, to ensure that any equipment obtained is suitable for use by those vessels that may be tasked with any underwater searches.

5 Safety Recommendations

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

5.1 On 11 August 2004 the Commission recommended to the Director of Civil Aviation that he:

5.1.1 use this report to re-emphasise to pilots and operators the hazards of icing, in particular tailplane icing and freezing rain. (047/04)

5.1.2 educate pilots on the benefits of transmitting AIREPs, and amend the AIP to better reflect the objectives of the AIREP. (049/04)

5.1.3 ensure that, in addition to the current installation and operating requirements, all CVRs and FDRs are periodically interrogated to ratify the content and quality of the information recorded. (050/04)

5.1.4 complete the recommendations of the independent report, New Zealand Aircraft Icing Hazards, in particular:

a. ensure all IFR operators provide adequate written guidance for operations in adverse or hazardous weather conditions,

b. audit air operators to ensure they have clear and unambiguous procedures for avoiding not only turbulence and thunderstorms, but also severe icing conditions, and

c. ensure pilot training requirements for inadvertent flight into hazardous meteorological conditions are adequately defined for commercial operations under Civil Aviation Rules, Parts 121, 125 and 135. (051/04)

5.2 On 17 August 2004 the Director of Civil Aviation replied in part:

Recommendation 047/04
I will accept this recommendation and ensure that an article will be published in our December 2004 Vector magazine. This will emphasise to pilots and operators the hazards of airframe icing and will have specific reference to the TAIC report, Airframe Icing Video (2003) and the Aircraft Icing Handbook (GAP).

Recommendation 049/04
I will accept this recommendation and ensure that the AIP is amended to advise pilots to make Air Reports on weather that they encounter which is severe enough to warrant a SIGMET regardless of whether a SIGMET has been previously issued. An article will also be published in our February 2005 Vector magazine to inform pilots of these procedures.

Recommendation 050/04
I will not accept this recommendation as the current rule is adequate, in particular Rule Part 21 sets out the requirements. I will however review Convair CVR and FDR modification, installation and maintenance instructions in conjunction with the design data holder to ensure that instructions for continued airworthiness meet rule requirements.

Recommendation 051/04
I will accept this recommendation, and will amend the Airline audit procedures check list to ensure that operator's manuals provide adequate written guidance for operations in adverse or hazardous weather conditions. This will be completed by September 2004 and all operators will be audited against the new check list.
I will also ensure that an Advisory Circular is written for all IFR and night freight operators that will specify what the training specifications are for hazardous meteorological conditions. This will be completed by December 2006.

5.3 On 17 August 2004 the Commission recommended to the Managing Director of Air Freight New Zealand Limited that he:

5.3.1 as a matter of urgency inspect his fleet of Convair 580 aircraft to ensure the cockpit voice recorders are correctly installed and are functioning as required. (045/04)

5.3.2 review and update company manuals and procedures to ensure they are correct and provide the best available guidance for pilots to detect, avoid and escape from adverse or hazardous conditions. (046/04)

5.4 On 25 August 2004 the Managing Director of Air Freight New Zealand Limited replied, in part:

Cockpit Voice Recorders (CVRs) [Recommendation 045/04]
Air Freight's existing CVRs comply with New Zealand Civil Aviation Authority requirements.

Air Freight has, however, determined that the more modern solid state CVRs are deemed superior in operation to the existing metallic tape type CVRs. As a result Air Freight has scheduled the replacement of all CVRs in its Convair fleet with the upgraded CVRs.

The programme is expected to be completed by 31 October 2004.

Company Manuals [Recommendation 046/04]
Air Freight's policy and procedures manuals comply with New Zealand Civil Aviation Authority requirements. They are approved and regularly audited by the New Zealand Civil Aviation Authority. They reflect standard industry practice and are considered to provide adequate information in all respects including in relation to the detection, avoidance and escape from adverse or hazardous conditions.

Air Freight has conducted an internal review of its policies and procedures and will liaise with the New Zealand Civil Aviation Authority, to ensure 'best practice' principles are applied and/or developed.

The review is expected to be completed by 23 December 2004.

5.5 On 23 August 2004 the Commission recommended to the Director of Civil Aviation that he:

5.5.1 draft an amendment to Civil Aviation Rules for the Minister's approval, upgrading the standard of recorders carried on board New Zealand registered aircraft to a minimum of an 11-parameter capable FDR and a TSO-C123a compliant CVR, without reducing any higher standard already contained in Civil Aviation Rules. (048/04)

5.6 On 26 August 2004 the Director of Civil Aviation replied in part:

Recommendation 048/04
I will not accept this recommendation as an analysis (NPRM 97-1) was carried out in 1997-1998 and this is still valid. The CAA will continue to follow the FAA standards of FDR's and CVR's carried on board aircraft in New Zealand. Ref. Part 121.353 (2).

Approved on 19 August 2004 for publication

Hon W P Jeffries
Chief Commissioner

Recent Aviation Occurrence Reports published by the Transport Accident Investigation Commission (most recent occurrence at top of list)

04-001	Piper PA23-250E Aztec, ZK-DGS, landing gear collapse during taxi, Paraparaumu Aerodrome, 9 January 2004
03-007	Hughes 369HS, ZK-HCC, in-flight power loss and emergency landing, Fox Glacier, 30 November 2003
03-006	Convair 580, ZK-KFU, loss of control and in-flight break-up, Kapiti Coast, 3 October 2003
03-004	Piper PA 31-350 Navajo Chieftain ZK-NCA, controlled flight into terrain, near Christchurch Aerodrome, 6 June 2003
03-003	Boeing 747-412 9V-SMT, flight SQ286, tail strike during take-off, Auckland International Airport, , 12 March 2003
03-002	Cessna U206G ZK-EJG, engine failure after take-off, Ardmore Aerodrome, 2 February 2003
03-001	Kawasaki BK-117 helicopter ZK-III, collision with tree tops at night, Tararua Range, 14 January 2003
02-015	Piper PA31-325 Navajo ZK-TZC, loss of control and collision with the ground during a one-engine-inoperative landing approach by Feilding Aerodrome, 17 December 2002
02-013	Piper PA 34-200T ZK-FMW, undercarriage collapsed after landing, Ardmore Aerodrome, 12 November 2002
02-011	Bell 206B JetRanger III ZK-HRC, forced landing following reported power loss on approach Huka Falls, 3 km north of Taupo, 2 October 2002
02-010	Boeing 747-419 ZK-NBS flight NZ 2, in-flight flap separation over Manukau Harbour by Auckland International Airport, 30 August 2002
02-006	Partenavia P68B ZK-ZSP, engine power loss and off-field landing, 5 km southwest of Wairoa, 15 May 2002
02-005	Hughes 369D helicopter ZK-HRV, engine failure and forced landing, near Tarawera, 30 April 2002

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