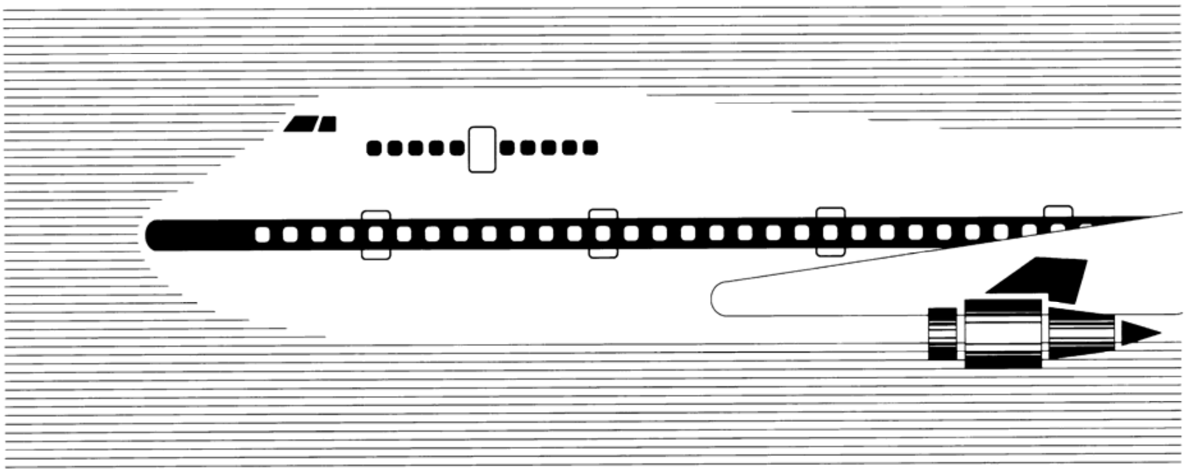
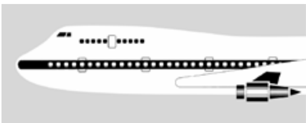
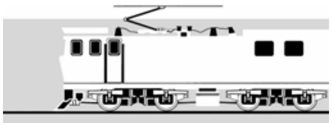


A V I A T I O N   O C C U R R E N C E   R E P O R T

05-006	**Fairchild-Swearingen SA227-AC Metro III ZK-POA, Loss of control and in-flight break-up, near Stratford, Taranaki province**	**3 May 2005**


TRANSPORT ACCIDENT INVESTIGATION COMMISSION
NEW ZEALAND

Report 05-006

Fairchild-Swearingen SA227-AC Metro III ZK-POA

loss of control and in-flight break-up

near Stratford, Taranaki province

3 May 2005

Abstract

On the night of Tuesday 3 May 2005, Fairchild-Swearingen SA227-AC Metro III aeroplane ZK-POA, operated by Airwork (NZ) Limited, was on a night air transport freight flight with 2 crew and 1790 kilograms of cargo when it suffered an in-flight upset which developed into a spiral dive. The crew did not recover control and the aircraft became overstressed and broke up, to fall in pieces about rural farmland near Stratford. Both crew were killed and the aircraft and cargo destroyed.

The crew was balancing fuel between tanks, flying the aircraft at an excessive sideslip angle with the rudder input trimmed, while on autopilot. The autopilot capability was exceeded and it disengaged, precipitating the upset.

Safety issues identified included:

- the need for a written standard operating procedure for in-flight fuel balancing for operators of this family of aircraft
- the need for the aircraft flight manual to include a limitation and warning that the autopilot be disengaged for in-flight fuel balancing, and to contain a procedure for in-flight fuel balancing.

A safety recommendation to address these issues was made to the Director of Civil Aviation.

Contents

Figures

Abbreviations

°	degree(s)
ACNZ	Airways Corporation of New Zealand
ADI	attitude director indicator
AFM	aircraft flight manual
ALT	altitude hold mode
ATC	Air Traffic Control
ATPL (A)	Airline Transport Pilot Licence (Aeroplane)
ATSB	Australian Transport Safety Bureau
°C	degrees Celsius
CAA	Civil Aviation Authority (New Zealand)
CAR	Civil Aviation Rule
cm	centimetre(s)
CPL (A)	Commercial Pilot Licence (Aeroplane)
CRM	crew resource management
CVR	cockpit voice recorder
FAA	Federal Aviation Administration (United States)
FDR	flight data recorder
FL	flight level
FO	first officer
ft	foot/feet
g	vertical acceleration due to gravity
GPWS	ground proximity warning system
hPa	hectopascals
HDG	heading mode
IAS	indicated airspeed
ICAO	International Civil Aviation Organisation
kg	kilogram(s)
km	kilometre(s)
kt	knot(s)
lb	pound(s)
MLG	main landing gear
NLG	nose landing gear
NTSB	National Transportation Safety Board (United States)
PF	pilot flying
SIGMET	significant weather information
s/n	serial number
SOP	standard operating procedure
UTC	co-ordinated universal time

V_A	the maximum speed at which individual application of full available flight control will not overstress the aircraft
V_{MO}	maximum operating speed
VHF	very high frequency
VOR	VHF omni-directional radio range
VOR/LOC	VOR or localiser tracking mode
VSI	vertical speed indicator

Data Summary

Aircraft registration:	ZK-POA
Type and serial number:	Fairchild-Swearingen SA227-AC Metro III**,** AC551B
Number and type of engines:	2 Garrett TPE 331-11U-611G turbine engines, driving Dowty Rotol R321/4-82-F/8 propellers
Year of manufacture:	1983
Operator:	Airwork (NZ) Limited
Date and time:	3 May 2005**,** 2214[1]
Location:	near Stratford, Taranaki province latitude: 39° 19.8′ south longitude: 174° 21.8´ east
Type of flight:	air transport - freight
Persons on board:	crew: 2 passengers: nil
Injuries:	crew: 2 fatal
Nature of damage:	aircraft destroyed
Pilot in command's licence:	airline transport pilot licence (aeroplane) (ATPL (A))
Pilot in command's age:	43 years
Pilot in command's total flying experience:	6500 hours (approximately 2750 hours on type)
Investigator-in-charge:	J J Goddard

Acknowledgements

The Commission acknowledges the assistance provided by:

Australian Transport Safety Bureau
M7 Aerospace Corporation

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

1 Factual Information

1.1 History of the flight

1.1.1 On 3 May 2005 Fairchild Metro III ZK-POA was scheduled to depart from Auckland at 2100 with a crew of 2 on a night freight service to Blenheim. The radio call sign was Post 23.

1.1.2 The payload comprised 1790 kilograms (kg) of courier packs and parcel mail that occupied all of the cabin volume and was constrained by five webbing "bulkheads". Loading of the freight was delayed, being completed at about 2115.

1.1.3 The crew ordered 570 litres (about 1000 pounds (lb) or 450 kg) of additional fuel and instructed the refueller to put it all into the left wing tank, rather than put half of the ordered amount into each tank, as was company practice. Refuelling was completed at 2130, with 2100 lb (950 kg) of fuel on board. The company Pre-Start checklist required that the fuel tanks be balanced within 200 lb (90 kg) before starting engines, and for take-off and landing.

1.1.4 The crew requested engine start at 2128 and Post 23 taxied for runway 23R at about 2132. The flight data recorder (FDR) showed that during the taxi a left turn through about 320° was made in 17 seconds. Post 23 departed at about 2136 with the first officer (FO) the pilot flying (PF).

1.1.5 The planned cruise level was flight level (FL) 180[2] but the cockpit voice recorder (CVR) showed that in order to get above turbulence encountered at that level the crew requested, and were cleared by air traffic control (ATC), to cruise at FL220. The autopilot was engaged for the climb and cruise. There were 2 CVR references to the crew's use of the de-icing system to remove trace or light icing from the wings. CVR comments also indicated that stars were visible, and that the aircraft's weather radar was serviceable.

1.1.6 At 2159 ATC cleared Post 23 to track from near New Plymouth very high frequency (VHF) omni-directional radio range (VOR)[3] direct to Tory VOR at the northeast end of the Marlborough Sounds, and at 2206 ATC transferred Post 23 to Christchurch Control. The CVR recorded normal crew interaction and aircraft operation, except that climb power remained set for about 15 minutes after reaching cruise level in order to make up some of the delay caused by the late departure.

1.1.7 At about 2212:28, after power was reduced to a cruise setting and the cruise checks had been completed, the captain said, "We'll just open the crossflow again…sit on left ball and trim it accordingly". The only aircraft component referred to as "crossflow", and operable by a flight deck switch or control, was the fuel crossflow valve between the left and right wing tanks.

1.1.8 The captain repeated the instruction 5 times in a period of 19 seconds, by telling the FO to, "Step on the left pedal, and just trim it to take the pressure off" and "Get the ball out to the right as far as you can …and just trim it". The FO sought confirmation of the procedure and said, "I was being a bit cautious" to which the captain replied, "Don't be cautious mate, it'll do it good".

1.1.9 Nine seconds later the FO asked, "How's that?". The Captain replied, "That's good – should come right – hopefully it's coming right." There was no other comment at any time from either pilot about the success or otherwise of the fuel transfer.

1.1.10 During this time, the repeated aural alert of automatic horizontal stabiliser movement sounded for a period of 27 seconds, as the stabiliser re-trimmed the aircraft as it slowed from the higher speed reached during cruise at climb power.

[2] Flight levels are altitudes referenced to a standard altimeter pressure setting. FL180 is 18 000 feet on a "standard" day.
[3] A ground-based radio navigation aid used to define an air route and/or for instrument approaches to an airport.

1.1.11 Forty-seven seconds after opening the crossflow, the captain said, “Doesn’t like that one mate… you’d better grab it.” Within one second there was the aural alert “Bank angle”, followed by a chime tone, probably the selected altitude deviation warning. Both pilots exclaimed surprise.

1.1.12 After a further 23 seconds the captain asked the FO to confirm that the autopilot was off, but it was unclear from the CVR whether the captain had taken control of the aircraft at that point. The FO confirmed that the autopilot was off just before the recording ended at 2213:41. The bank angle alert was heard a total of 7 times on the CVR before the end of the recording.

1.1.13 During the last 25 seconds of radar data recorded by ATC, Post 23 lost 2000 ft altitude and the track turned left through more than 180^o. Radar data from Post 23 ceased at 2213:45 when the aircraft was descending through FL199 about 1700 metres (m) southeast of the accident area.

1.1.14 Commencing at 2213:58, the ATC controller called Post 23 three times, without response. He then initiated the uncertainty phase of search and rescue for the flight.

1.1.15 The operator had a flight-following system that displayed the same ATC radar data from Airways Corporation of New Zealand (ACNZ). The operator’s dispatcher noticed that the data for Post 23 had ceased and, after discussing this with ACNZ, he advised the operator’s management.

1.1.16 There were many witnesses to the accident who reported noticing a very loud and unusual noise. Some, familiar with the sound of aircraft cruising overhead on the New Plymouth – Wellington air route, thought the noise was an aircraft engine but described it as “high-revving” or “roaring”.

1.1.17 Witnesses A were located about 3 kilometres (km) south of the southernmost part of the track of Post 23 as recorded by ATC radar, and about 6 km south of the accident site. They described going outside to identify the cause of an intense noise. As they looked northeast and upwards about 45^o, they saw an orange-yellow light descending through broken cloud layers at high speed. A “big burst” and 3 or 4 separate fireballs were observed “just above the horizon” about 5 km away. No explosion was heard. The biggest fireball lasted the longest time and was above the others. The night was dark and it had been drizzling.

1.1.18 Witness B, almost 7 km to the northeast of the accident site, observed light and dark cloud patterns moving towards the northwest. She thought the moon caused the light variation; however moonrise was almost 3 hours later. This witness also first observed a fireball below the cloud at an elevation of about 6^o. She described it as “a big bright circle” followed by 2 smaller fireballs that fell slowly. No explosion was heard.

1.1.19 Witness C, who was less than 1000 m from the aircraft’s diving flight path, described seeing the nose section falling after an explosion “like a real big ball of fire”. The wings were then seen falling after a smaller fireball that was followed by a third small fireball. The witness said it was a still night, with no rain at that time, and the fireballs were observed below the lowest cloud. The fireballs illuminated falling wreckage and cargo.

1.1.20 Witness D, also less than 1000 m from the accident site, described parts of the aircraft falling, illuminated by the fireball.

1.1.21 Witnesses generally agreed that the first and biggest fireball was round and orange, and then shrank away. Descriptions of the smaller fireballs varied, but were usually of a more persistent, streaming flame that fell very steeply or straight down.

1.1.22 A large number of emergency service members and onlookers converged on the accident area. Those who got within about 1000 m of the scene reported a strong smell of fuel. The first item of wreckage was located at about 2315. The main wreckage field was on hilly farmland 7 km northeast of Stratford at an elevation of approximately 700 ft.

1.2 Injuries to persons

1.2.1 Both pilots received fatal injuries.

1.3 Damage to aircraft

1.3.1 The aircraft was destroyed.

1.4 Other damage

1.4.1 The payload, valued at NZ$98 000, was declared a total loss.

1.4.2 There was some ground disruption to farmland.

1.5 Personnel information

	Captain	**First Officer**
Age	43	41
Licence	ATPL (A)	commercial pilot licence (aeroplane) (CPL A))
SA227 type rating issued	22 February 2000	19 January 2005
Medical certificate	Class 1, valid to 30 Sep 2005	Class 1, valid to 7 Jul 2005
Last competency check	5 March 2005	20 March 2005
Last instrument rating check	5 March 2005	20 March 2005
Last biennial flight review	5 March 2005	20 March 2005
Flying experience	6500 hours total 2750 hours on type 3195 hours multi-engine	2345 hours total 70 hours on type 889 hours multi-engine
Duty time	2.3 hours	2.3 hours
Rest since end of last duty	80 hours	81.5 hours
Flying last 7 days	4.2 hours	9.8 hours
Flying last 90 days	129.7 hours	47.0 hours

Captain

1.5.1 The captain began flying training in 1989, and was issued with a CPL and his first multi-engine type rating in 1992. In 1993, he was issued with a category C flight instructor rating that was upgraded to B category in 1995. In 1997, he was issued with a D category instructor rating and an aerobatic rating.

1.5.2 In April 1998, the captain joined a small airline operating from Wellington, flying single-engine turbine and light twin-engine aircraft. In February 2000, he moved to the Gisborne base of another airline to train as a Fairchild-Swearingen SA227 Metro co-pilot, but he left that company in October 2000 to join a Wellington-based regional airline. In January 2001 he gained his ATPL and was appointed a captain on British Aerospace Jetstream 32 aircraft, but the airline ceased business 3 months later.

1.5.3 In April 2001 the operator employed him as a Metro co-pilot at its Wellington base, and promoted him to captain in June 2001.

1.5.4 In June 2003, the captain was appointed as a line training captain on the Metro. A line training captain had operator approval to give route and operational instruction to pilots already rated on the aircraft.

1.5.5 The operator's records showed that the captain's training prior to the appointment consisted of a competency check, which included unusual attitudes, flown from the right seat, 2 sectors observing another captain training, and 9 sectors and 7.85 hours of supervised flight instruction of a trainee captain. The captain flew 3 sectors of that training as PF.

1.5.6 On 5 March 2005, the captain passed recurrent instrument rating, aircraft competency and route competency flight checks. According to the operator's records all previous competency and rating checks performed by the captain had been satisfactory. He was generally well regarded as a pilot and instructor, and for his crew resource management (CRM) skills. Close associates considered him very happy in his work and life, and of stable disposition.

1.5.7 The operator had encouraged the captain to prepare himself for appointment to flight examiner. On 8 April 2005, the operator's Chief Pilot (Training) conducted a flight test of the captain, following which the captain was cleared for D category multi-engine day, night and instrument privileges. The Chief Pilot recommended that the Civil Aviation Authority (CAA) remove the multi-engine and night instruction restrictions from the captain's B category instructor ratings.

1.5.8 Prior to the day of the accident, the captain had accumulated about 2750 flight hours on the Metro. In the previous 7 days he had flown 4.2 hours and recorded 8.5 hours duty time. It was reported that he took part in normal domestic activities only during the 2 days free of duty prior to 3 May and was rested before the duty that night.

First Officer

1.5.9 The FO began flying in 1994, and was issued with a CPL and a category C instructor rating in 1995. A flight training organisation employed him as a flying instructor from December 1995 until he left in December 1998. During that time he gained a multi-engine instrument rating, and a category B instructor rating that was not valid for multi-engine instruction. The training organisation had considered the FO a reliable instructor.

1.5.10 In May 1999 the FO returned from a 5-month break overseas, and was employed by another flight training organisation until September 2001. The multi-engine restriction on his instructor rating was removed in June 2000.

1.5.11 In October 2001 the FO commenced employment with a third level airline as a Bandierante co-pilot, and converted to the Beech 1900D in April 2002, but left the airline the following month.

1.5.12 Over the next 15 months until August 2003, the FO flew intermittently with one of his previous flight training employers, but he was predominantly employed as a fixed-base simulator instructor.

1.5.13 The FO was not employed in aviation from August 2003 until January 2005. In that month, he paid for a Metro type rating conducted by the operator. The final check included his passing the operator's standard flight crew competency and instrument rating check flights.

1.5.14 The operator then invited the FO to continue with Metro route training. After that was completed on 20 March 2005, the FO became a part-time employee. According to the operator's records, the FO's training lacked continuity because of his part-time employment and being on a call roster, but his flying standard and CRM skills were considered satisfactory. The FO's partner said that once the FO was given the part-time flying position, that was the only job he held.

1.5.15 Until the day of the accident, the FO had accumulated 70 flight hours, or about 20 hours per month, on the Metro. During the previous 7 days he had flown 9.8 hours and recorded 22 hours duty time. It was reported that he took part in recreational and family activities only during the 2 days free of duty prior to 3 May, and had slept prior to reporting for duty that night.

1.5.16 The captain and FO had flown together once before, 5 days before the accident.

1.5.17 The operator's records showed that both pilots had been trained in autopilot use, and in fuel transfer procedures.

1.5.18 Three of the operator's 6 Metros were equipped with autopilots. During 2005 approximately one third of the captain's flight duties in Metro aircraft had been in autopilot-equipped aircraft, while two thirds of the FO's flight duties in Metro aircraft had been in autopilot-equipped aircraft.

1.6 Aircraft information

1.6.1 ZK-POA was a Fairchild-Swearingen SA227-AC Metro III, manufactured in 1983 and imported into New Zealand in December 1990. It was operated by Airwork (NZ) Limited, primarily for contracted postal flights.

1.6.2 The calculated take-off weight on the night of 3 May 2005 was 15 821 lb (7175 kg), within the limit of 16 000 lb (7255 kg). Prior to despatch, ZK-POA had accumulated 29 010 flight hours and 29 443 cycles since new.

1.6.3 The left engine, serial number (s/n) P44108C, had accumulated 25 549.17 hours total time and 26 879 cycles since new, and 710.16 hours and 846 cycles since its last overhaul on 3 April 2003. The overhaul period was 7000 flight hours.

1.6.4 The left engine drove a Dowty-Rotol model R321/4-82-F/8 propeller, s/n DRI/DRG/559/82, that had accumulated 5885.21 hours total time since new and 889.21 hours since overhaul on 21 January 2003.

1.6.5 The right engine, s/n P44743C, was installed on 27 April 2005 to replace an engine with a reported gearbox defect. Engine s/n P44743C had accumulated 10 102.0 hours total time and 12 312 cycles since new, and 3491.2 hours and 4104 cycles since overhaul on 30 June 2000. The engineering work order for the engine replacement task was missing a duplicate inspection signature against the item "install truss upper aft mount", but the mount installation was confirmed after the accident.

1.6.6 The right engine drove a Dowty-Rotol model R321/4-82-F/8 propeller, s/n DRG/1776/80. It had been removed and re-installed during the engine change on 27 April 2005. The propeller had accumulated 23 704.62 hours total time since new and 2326.82 hours since last overhaul.

1.6.7 Records provided by the operator showed that ZK-POA had been maintained in accordance with the operator's approved maintenance programme, and all relevant airworthiness directives had been complied with. The last annual maintenance review was on 20 March 2005.

1.6.8 On 3 May 2005 the aircraft was dispatched with 4 deferred maintenance items. Rectification of one, related to a microswitch in the ground power electrical circuit, was deferred to 6 May for maintenance convenience.

1.6.9 The 3 other defects were:

- some sealant breaking around window retainers at positions 1C, 2C, 9C and 7A
- ailerons approaching free play limits, and
- right wing extension has small cracks in top skin around 2 fasteners.

1.6.10 Other recent maintenance carried out related to the autopilot flight guidance computer. This had been reported unserviceable on 18 April 2005, and was removed, along with the separate autopilot computer, the following day. The flight guidance computer from another aircraft and a repaired autopilot computer were re-fitted to ZK-POA on 3 May 2005, and after the prescribed ground checks the aircraft was released to service.

1.6.11 The aircraft was fitted with an Allied Signal MkVI ground proximity warning system (GPWS). In addition to the terrain warning modes, the system provided an aural advisory of "bank angle" if the bank angle exceeded 40°. The advisory callout was repeated every 3 seconds if the bank angle continued to exceed 40^{o}. The bank advisory mode re-set if the angle reduced below 40^{o}.

1.6.12 The maximum indicated airspeed (IAS), V_{MO}, was 246 knots (kt) from sea level to 17 800 ft altitude, decreasing to 227 kt at 22 000 ft. The maximum IAS at which individual full application of any flight control would not overstress the aircraft, V_A, at the estimated weight at the time of the accident, 15 400 lb, was 181 kt. The manoeuvring load factor limits with flaps up were +3.02 g to -1.21 g.

Fuel system

1.6.13 Left and right integral wing fuel tanks supplied only their respective engines, with no cross-feed system. A fuel imbalance between wing tanks could be corrected, or all of the usable fuel from both tanks made available during single engine operation, by opening a valve in a 2-inch (5 centimetre (cm)) diameter crossflow tube that connected the tanks. The operator considered that during a typical flight sector length, with normal engine operation and the crossflow valve closed, a fuel imbalance was unlikely to develop, so there was normally no need to open the crossflow valve in flight. Other operators reported that an imbalance of up to 120 lb/hour had been observed between engines that were at opposite ends of the overhaul period.

1.6.14 A switch on the lower centre instrument panel controlled the motor-operated crossflow valve. Selecting the switch to open illuminated an integral "OPEN" light. An additional, adjacent annunciator illuminated whenever the crossflow valve was not fully closed.

1.6.15 The operator's normal practice was to refuel both tanks through over-wing filler points to achieve a balanced fuel distribution. It was possible to refuel one tank only and allow gravity to balance the fuel through the open crossflow valve, but that was an informal practice only occasionally resorted to. Fuel transfer, in that case, could be expedited by performing additional turns while taxiing.

1.6.16 The aircraft flight manual (AFM) required the crossflow valve to be in the closed position in the before-starting-engines-checks and the before-take-off checks, and in both the descent and before-landing checks.

1.6.17 The operator's standard operating procedures (SOP) permitted no more than a 200 lb (90 kg) fuel imbalance prior to engine start. The AFM allowed a maximum of 200 lb (90 kg) fuel imbalance for take-off and landing when total fuel was greater than 2000 lb (900 kg).

1.6.18 The operator's usual but unpublished technique to balance the fuel in flight, if necessary, was to open the crossflow valve and fly with the fuller wing held just higher than wings-level attitude. Slight opposite rudder, or "cross control", was necessary to maintain the desired heading. The operator considered that this method was adequate and balanced the fuel quickly. Information obtained from pilots with Metro experience with several operators confirmed that this method was used; it required minimal rudder control input, and was efficient. Some pilots reported that they would apply a small amount of rudder trim while the aircraft was flying on autopilot to achieve this.

Flight control system

1.6.19 The Metro III was fitted with manually operated and trimmable ailerons and rudder, and a manually operated elevator. An electrically operated horizontal stabiliser provided pitch trim. A trim-in-motion aural alert, or sonalert, was provided to indicate pitch trim actuation.

1.6.20 Each pilot's flight instrument panel included an attitude director indicator (ADI) that provided basic attitude information through 90^{o} in pitch up or down, and 360^{o} in roll, as well as computed steering information and other functions. The ADI incorporated an inclinometer, more commonly referred to as the slip indicator or simply the "ball". This was a liquid-filled, curved glass tube that contained a weighted ball. Aircraft slip or skid conditions were displayed by the direction of the displaced ball relative to the turn direction. A standby attitude indicator was mounted to the left of the centre instrument panel.

1.6.21 An autopilot was not standard equipment for the Metro series, nor was it required by Civil Aviation Rules (CAR) for the 2-pilot operation of the operator, but 3 of the operator's Metros were fitted with autopilots. ZK-POA had a Collins FCS-80 flight control system which integrated the flight instrument displays, a flight guidance system, an APS-80 autopilot system and a yaw damper.

1.6.22 The flight guidance computer took the mode selections made by the pilots and computed the guidance commands sent to the autopilot and the ADI command bars. The flight modes typically used during the cruise phase of a flight from Auckland to Blenheim would be heading (HDG) or VOR tracking (VOR/LOC), and altitude hold (ALT).

1.6.23 The autopilot control panel, mounted below the centre console, included provision for manual pitch and roll control. The autopilot manoeuvred the aircraft via servomotors that actuated the elevators and ailerons only. The autopilot could be manually disengaged at the control panel, or by pressing a switch on either pilot's control wheel or by operating the stabiliser trim control switch. The system would disconnect the elevator channel if the vertical acceleration exceeded 1.6 g, and the aileron channel if excessive roll angle or rate was detected. Protection was also provided to prevent unbalanced servo loads. The autopilot would not engage without a successful system self-test of all of the protective features.

1.6.24 Warning of autopilot disconnection was a single flashing red annunciator on the central instrument panel. The annunciator was extinguished by pressing the autopilot disconnect button on either control wheel. There was no aural warning of autopilot disconnection.

1.6.25 The yaw damper was a gyro system sensitive to changes in yaw, which fed a signal to a rudder servo to oppose the yaw. The system also assisted in keeping turns balanced. The yaw damper fitted to the Metro applied rudder through the same control circuit used by the pilots. Servo activity was reflected in rudder pedal movement, and also a pilot would feel some opposition to pedal movement because the servo would command rudder deflection to counter the pilot's input.

1.6.26 A switch on the Metro autopilot control panel controlled the yaw damper system. It could be engaged without the autopilot being engaged, but when the autopilot switch was engaged, interlocks also engaged the yaw damper. The AFM required the yaw damper to be off for take-off and landing. The yaw damper was usually engaged after take-off and remained on until shortly before landing. Disengagement of the autopilot did not disengage the yaw damper.

1.6.27 According to the AFM, the yaw damper was required to be off prior to engine start, and selected on and tested during the taxi checks. In the event of abnormal yaw damper operation, it could be overridden by the pilot and selected off without any adverse operational consequence. An operative yaw damper system was not required for dispatch.

1.6.28 The AFM Supplement for the Collins FCS-80 system, Section 1, Limitations, included:

A. All gross weights:

6. Do not engage autopilot if airplane is out of trim.

9. Fuel Balance must be maintained for autopilot operation.

B. Additional limitations:

2. For gross weight from 14 500 lb to 16 000 lb:

b. Maximum altitude for autopilot operation is 20 000 feet pressure altitude.

1.6.29 Rockwell Collins, the autopilot manufacturer, advised that the 20 000-ft limitation was made because, during the certification flight testing at the increased gross weight above that altitude, the aircraft exhibited decreased stall margin handling performance. The test pilot had reported pre-stall buffet at 25 000 ft when the test aircraft was turned using the autopilot, and that the IAS at 25 000 ft, at full power, was 120 kt.

Landing gear

1.6.30 The Metro landing gear comprised one main landing gear (MLG) strut on each wing, which retracted forward into the engine nacelle extension, and a nose landing gear (NLG) strut, which retracted forward into the nose. Each strut carried 2 wheels. Landing gear extension and retraction was electrically controlled and hydraulically operated. When fully retracted, each landing gear engaged a mechanical uplock hook.

1.6.31 According to the AFM, a landing gear warning sonalert would sound if:

any landing gear down-and-locked switch is not made

and either power lever is at the flight idle gate

or if the flaps are more than half way down, regardless of power lever position.

1.6.32 The maximum IAS for extending the landing gear was 175 kt.

1.6.33 A hydraulically powered, electrically controlled actuator was used for nose wheel steering. Controls for the system included a test switch, an arm switch and a park button. A nose wheel steering button was installed on the left power lever. With the system armed and the power lever button depressed, the rudder pedals were moved to steer the aircraft. Depressing the park button increased the maximum nose wheel deflection from 10^{o} to 63^{o}, permitting tight turns.

Other equipment

1.6.34 The aircraft ATC transponder provided mode C altitude data in increments of 100 ft, referenced to standard pressure. These data were recorded by the ACNZ radar system at approximately 5-second intervals. The mode C data accuracy was determined by the aircraft’s encoding altimeter accuracy.

1.7 Meteorological information

1.7.1 MetService provided an analysis of the weather situation around the time of the flight. It said in part:

Synoptic situation
A large high straddled the South Island with centres over the central Tasman Sea and to the southeast of South Island. A complex surface low covered North Island. Strong low-level southeasterlies covered central New Zealand between the low and the high. At 2100, the main surface low was centred just north of Bay of Plenty while an upper low was centred about 60 miles to the west of the Raglan area and

moving northeast. Bands of convective cloud covered much of the central and northern North Island. These bands moved across northern New Zealand from west to east. The cloud across the central North Island was rather slow moving.

Weather in the vicinity of Stratford area around 2215
Extensive cloud affected the Waikato to Taranaki areas at this time. The cloud in this area was organised in a band orientated eastnortheast to westsouthwest. Within this cloud area it was likely there were embedded cumulonimbus clouds. Cloud tops were likely to have been of the order of 25 000 – 28 000 ft. This cloud band intersected the Auckland – Woodbourne (Blenheim) track. Immediately to the south of the main cloud band was a distinct change in the character of the cloud with significantly lower tops and less continuous coverage. This cloud was likely to have been well below cruise level of 22 000 ft, and with gaps. Winds at 22 000 ft were blowing clockwise around the upper low which was centred just to the west of Raglan. Near Stratford, the winds at this level were eastnortheast at around 20 kt.

Icing
The outside air temperature at 22 000 ft in the area of Stratford at the time was about -25°Celsius (°C). It would be unusual for airframe icing to occur at such a low temperature however it is not impossible. The fact that embedded cumulonimbus clouds were likely present in the vicinity with strong upward motion could have made icing in this area more likely than otherwise might have been the case,. A SIGMET for isolated severe icing was valid at the time of the accident for the area east of a line from Woodbourne to New Plymouth to Tauranga, between 8000 ft and 20 000 ft.

Turbulence
Given the likely cloud conditions between Auckland and the accident site, it is likely there was moderate turbulence, especially in cloud and especially near any cumulonimbus clouds. It is possible in the vicinity of such clouds there may have been isolated severe turbulence.

Thunderstorms and lightning
Although there is evidence that cumulonimbus clouds were present in the area between Auckland and the accident site, no lightning was detected by the lightning detection network, either at the time of the accident or in the 15 minutes before 2215.

Surface observations
New Plymouth automatic weather station recorded some rainfall up to 2200.

Summary
Based on the above, it was likely that the aircraft was flying in cloud over the area to the north of the accident site, and emerged from cloud at 22 000 ft just prior to the accident. It was likely that there were convective cloud cells embedded within the cloud with cloud tops to about 25 000 to 28 000 ft. It was possible there was moderate, possibly severe, icing and/or moderate or briefly severe turbulence in the cloud band mentioned above. A SIGMET for icing was valid at the time of the accident and covered the area of the accident. There were no lightning strikes detected in the vicinity of the accident or anywhere over the North Island in the hour beforehand.

1.7.2 From the upper winds diagram provided by MetService, winds over New Plymouth at midnight were easterly at 15-20 kt, and southeasterly 20-40 kt at lower level.

1.7.3 The route forecast issued to Airwork, valid from 1425 to 0600 included:

Winds/Temperatures

	NZ1	NZ2
FL240	31033 M32	03031 M32
FL210	32030 M25	04023 M25
FL180	32028 M18	05019 M18
FL140	32029 M09	07019 M10
FL100	32021 M03	08017 M03
FL080	31016 P00	09017 P01

TURB: OCNL MOD BTN FL200-FL400 N OF NZTU-NZHK AND S OF NZAA-NZNR EASING.
OCNL MOD BLW FL120 N OF NZCH-NZHL AND S OF NZNP-NZGS.
CB: ISOL EMBD BASE 2000FT TOPS FL240 N OF NZPM AND S OF NZAA.

ICE: OCNL MOD BTN 6000 FT-FL200 N OF NZTU-MOUNT MARY VOR, SEVERE AS PER SIGMET.

1.7.4 SIGMET reports for the period were:

SIGMET 03 VALID 1803/2203 NZST.
NZFIR ISOL SEV ICING FCST BTN 8000FT-FL200 E OF A LINE NZWB-NZNP-NZTG. INTST NC.

SIGMET 04 VALID 2112/0112 NZST.
[repeated SIGMET 03]

1.7.5 The captain of an Air Post F27 aircraft that flew the same route as Post 23 about 30 minutes earlier, but at FL160, stated that no significant icing was encountered.

1.8 Aids to navigation

1.8.1 The flight had been planned to route via VORs at New Plymouth, Tory and Blenheim. Prior to crossing New Plymouth VOR, ATC had cleared Post 23 to fly directly to the Tory VOR.

1.9 Communication

1.9.1 Communications with ATC were on standard en-route VHF frequencies. No distress call was received from Post 23.

1.9.2 There were no radio communications between Post 23 and the operator’s base or other aircraft.

1.10 Aerodrome information

1.10.1 Not applicable.

1.11 Flight recorders

1.11.1 ZK-POA was equipped with a Fairchild model F1000 solid-state FDR and a Fairchild model A100 CVR. They were located on avionics racks aft of the rear cargo bulkhead. Each met the requirements of CAR Part 125 *Air Operations – Medium Aircraft*, except that the CVR was not fitted with an underwater locating device as required by CAR 125.353 and CAR Part 125 Appendix B3.

1.11.2 The Australian Transport Safety Bureau (ATSB) in Canberra assisted the Commission with the replay and analysis of the FDR and CVR.

1.11.3 The F1000 model FDR compressed the flight data before it was recorded, therefore the recording duration exceeded the minimum requirement of the most recent 25 hours. A total of 121 hours, 23 minutes and 21 seconds of data was recorded covering the accident flight and 63 previous flights.

1.11.4 The FDR recorded pressure altitude[4], IAS, magnetic heading and vertical acceleration, as well as elapsed time. Altitude and IAS were sensed from a transducer attached to the FDR, so the recorded values could differ slightly from those observed by the crew. The parameters were sampled once every second, except for the vertical acceleration which was sampled 8 times per second. In addition, the FDR could record discretes for VHF microphone keying and FDR status.

1.11.5 The FDR case was damaged but the memory module was undamaged. A successful download was obtained, apart from VHF keying data, which was not recorded. It was subsequently determined that the VHF keying circuit for the FDR was not connected, and had possibly been

[4] Altitude referenced to the standard altimeter setting of 1013.2 hectopascals (hPa), the same reference used by the crew at the time of the accident.

like that since the aircraft was manufactured. However, the applicable New Zealand Civil Airworthiness Requirements, Section C4, did not require this parameter. The FDR altitude data correlated well with the mode C values from the radar data, so correction was considered unnecessary. Accuracy of the altitude values was ± 100 ft. The FDR IAS data was considered reasonable and accurate, above 150 kt, to within 15 kt. The FDR magnetic heading recorded during the take-off from Auckland Aerodrome was checked against the runway heading. FDR heading data was uncorrected, and had an accuracy of ± 2^{o}. Vertical acceleration data came from an accelerometer mounted on the aircraft belly near the approximate centre of the aircraft. The FDR acceleration data did not need correction.

1.11.6 The FDR altitude data was compared with ACNZ radar mode C data to correlate the FDR elapsed time with UTC. The correlation was accurate to ± 2 seconds. The last 3 mode C values did not match the FDR altitude trace, and were radar system "coasted"[5] returns rather than actual returns.

1.11.7 The data listing covered the entire accident flight. The final data recorded was consistent with power being removed from the FDR once only. The accident flight was examined in detail and plots (refer to Figures 1 and 2) and a data listing were produced.

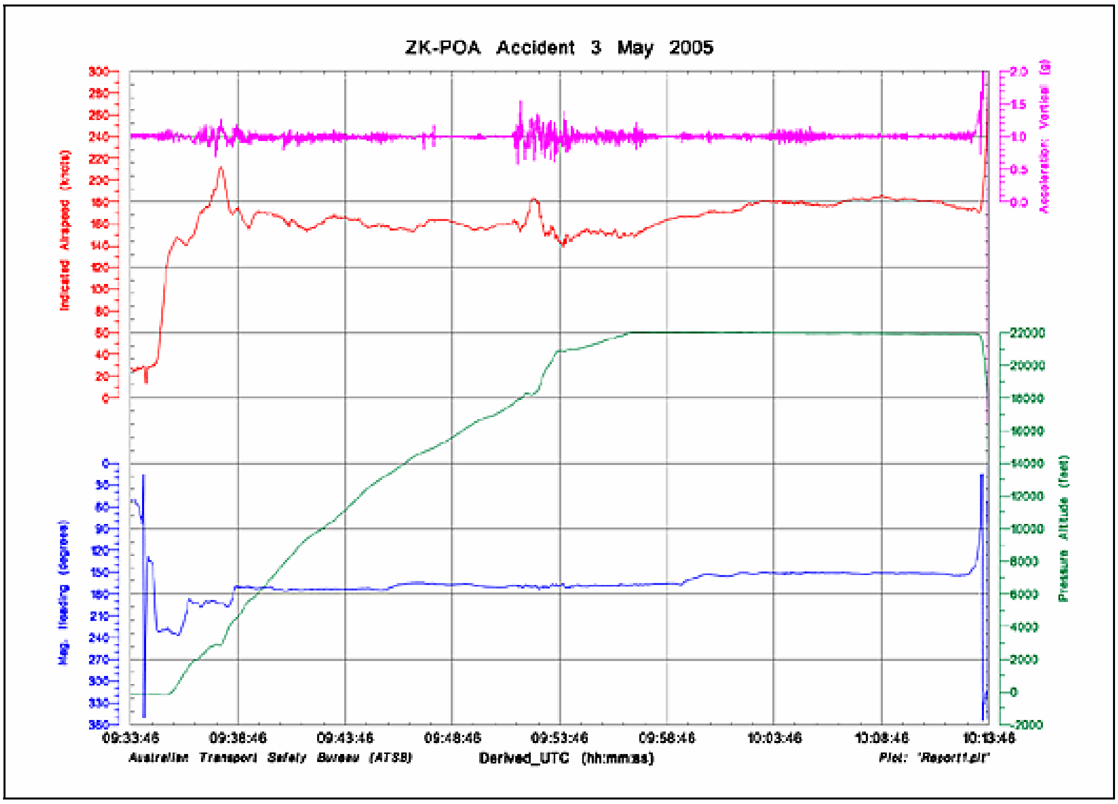


Figure 1
ZK-POA plot of FDR data – whole flight

[5] When a transponder return is missing or outside certain criteria, the radar system extrapolates the previous track and groundspeed to produce the estimated aircraft position, for up to 3 sweeps.

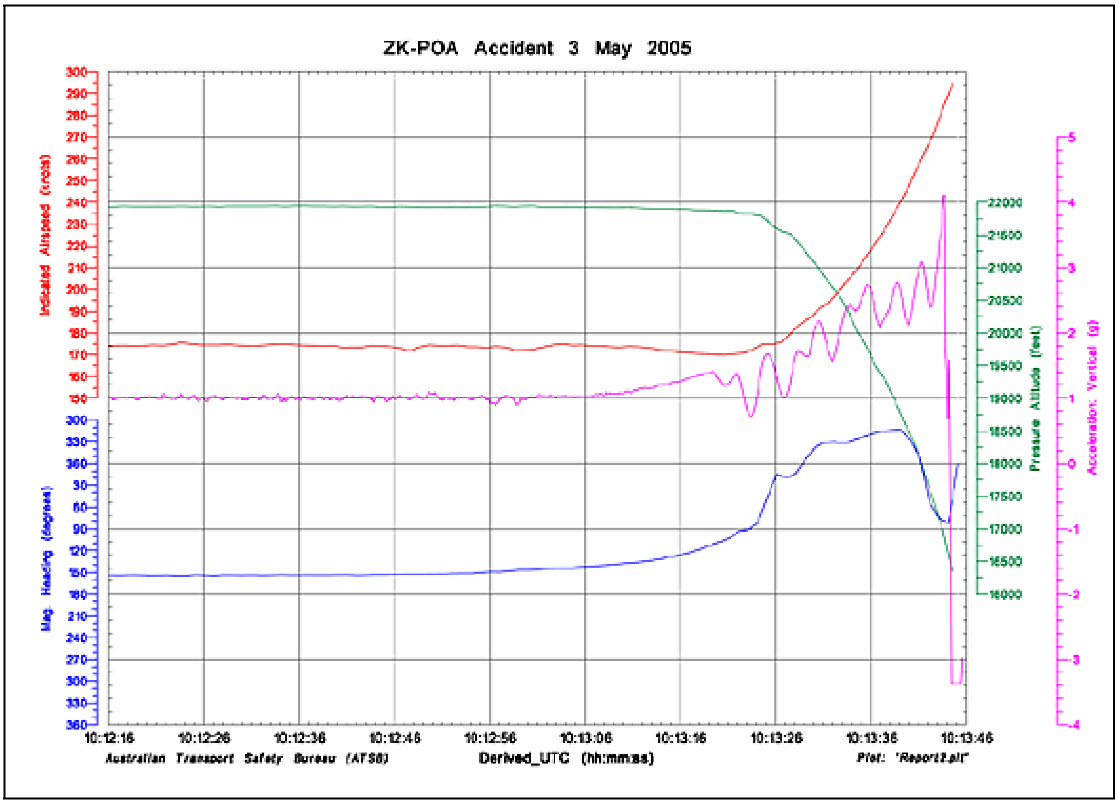


Figure 2
ZK-POA plot of FDR data – last 90 seconds

1.11.8 The A100 CVR recorded each pilot's audio and cockpit area sounds on an endless tape. The recording duration was 30 minutes and 45 seconds, therefore the record began about 7 minutes after Post 23 had departed from Auckland. The quality of the recording was excellent. The Commission produced a transcript, and relevant excerpts are included in section 1.1 of this report.

1.11.9 Four aural alerts were recorded during the last 2 minutes of the CVR recording, as follows:

Aural Alert	Start Time	Stop Time	Comments
Continuous pitch trim activation (sonalert, one-second beeps)	49 seconds *(before the end of the recording).*	22 seconds *(before the end of the recording)*	Indicated movement of the horizontal stabiliser
"bank angle" *(repeated 7 times at3-second intervals)*	21 seconds *(before the end of the recording)*	*Continued to the end of recording*	Generated by the GPWS[6] when the aircraft bank angle exceeded 40°
Selected altitude deviation *(one 2-second chime)*	19 seconds *(before the end of the recording)*		Indicated departure from selected altitude at 300 feet below
Landing gear horn	5.5 seconds *(before the end of the recording)*	*Continued to the end of recording*	Operated when the power levers were at flight idle with the gear retracted

[6] Ground proximity warning system (GPWS).

1.11.10 The cockpit area microphone track contained a clear, steady sound of the engines and well synchronised propellers. Apart from when power was reduced from a climb to a cruise setting, there was no perceptible change in the frequency, volume or synchronisation of this sound until about 7 seconds before the end of the recording. An uneven change in the sound at that time was similar to that produced by an abrupt retardation of the power levers.

1.11.11 The CVR did not record UTC, so time correlation was done by matching CVR-recorded radio communications with those recorded by ACNZ, which were time-stamped with UTC. That process showed that the CVR tape had been moving 5.1% faster than the nominal speed. This was confirmed by analysing the frequency of the sounds produced by the propellers, as they were governed in a narrow range around the nominal speed of 1591 revolutions per minute. The CVR times were then adjusted to an accuracy of ± 2 seconds.

1.11.12 The CVR was estimated to have stopped recording at 2213:41, about 4 seconds before the FDR stopped. The cessation was consistent with power being removed once only.

1.11.13 The ATSB produced a computer animation of the flight, using the FDR, CVR and ACNZ radar data, synchronised with CVR audio, and overlaid on a topographic map (see Figure 3).

Figure 3
Computer presentation of ZK-POA radar track and FDR data at 2213:00

1.11.14 The recorded flight data showed ZK-POA experienced moderate turbulence between FL180 and FL210 during the climb and generally smooth conditions thereafter. After levelling at FL220, the IAS increased slowly from 150 kt to a maximum of 185 kt while climb power remained set. The aircraft heading was generally steady except for changes to comply with ATC instructions.

1.11.15 After the power reduction at about 2211, the aircraft slowly decelerated and the airspeed was 172 kt at 2213, during the fuel balancing.

1.12 Wreckage and impact information

1.12.1 The major separated sections of the aircraft were found on rolling farmland within 250 m of the right wing (site datum). The highest elevation in the immediate area was about 950 ft, with the area gully floor at about 700 ft (see Figure 4).

1.12.2 The left elevator was the most eastern item in the wreckage field. It was found about 600 m east of the site datum. Lighter pieces of the wreckage, such as the tail fin mid-section, most of the horizontal stabiliser, emergency escape hatches, pieces of fuselage skin and freight items were scattered over paddocks and small forestry plantations up to 2 km northwest of the site datum.

1.12.3 Lighter items from the aircraft, such as cabin window scratch panes, thin fuselage skin and documents, were found up to 4 km northwest of the site datum. Pages from manuals and logs that were typically kept behind the pilots' seats were found more than 15 km to the northwest. Some items showed evidence of heat damage, for example melted plastic or light charring.

Figure 4
ZK-POA flight deck, and wings in distance

1.12.4 The right wing was lying on a small spur, with the extended MLG embedded in the ground. The wing had separated between the engine nacelle and the fuselage. Most of the nacelle was attached but the engine and propeller were separated. The aileron was present but the right flap and the wing tip outboard of the leading edge fence were detached. There was chord-wise compression of the outermost 3.5 m of wing that remained. Fuel had been ejected from the wing upon impact. The fuel cap was in place but unlocked, and its seal appeared to be in good condition.

1.12.5 The right engine and propeller were found buried in soft ground in a copse about 200 m to the east of site datum. The propeller was in place but the driveshaft was fractured. The right wing tip was located approximately 1100 m northwest of the wing itself, and the right flap (in 2 pieces) a further 600 m away in the same direction. The upper engine and exhaust cowls were found further to the northwest.

1.12.6 The left wing was embedded into the ground at its root end, approximately 100 m northwest of site datum. The flap and aileron were attached. The complete engine nacelle was missing. The left wing tip was partially separated outboard of the leading edge fence, and rotated rearwards and downwards approximately 30°. The leading edge de-icing boot had 3 slashes at about mid-span. The MLG had extended but was dislocated from the trunnion.

1.12.7 The whole of the left wing was damaged by over-pressurisation of the integral fuel tank and by a fire whose origin appeared to be forward of the landing gear. Both tyres were fire damaged but otherwise appeared intact and inflated. Diagonal span-wise streaming of the soot indicated that the wing had fallen root-end-first while burning. Molten metal could be seen inside part of the wing structure, inboard of the MLG. The fire had not extended to the surrounding grass after impact. The fuel cap was in place but unlocked, and its seal appeared to be in good condition.

1.12.8 The left wing had separated inboard of the nacelle, but approximately 1.5 m of the rear spar inboard of the skin break was still attached. The fire had not extended inboard of the break.

1.12.9 The left engine and nacelle, with the propeller in place but with a fractured driveshaft, were found about 250 m to the southeast of the left wing.

1.12.10 The cabin and rear fuselage had separated from the flight deck along the aft frame of the entry door and landed on its right side approximately 200 m north of site datum. The lower half of the door frame had been compressed downwards and rearwards. Ground impact marks indicated that the cabin had fallen with a small velocity component towards the northwest.

1.12.11 The cabin was split along the keel line, and the left cabin wall from seat row 6 to seat row 10 was found torn open. The rear fuselage was also torn open at the cabin frame aft of the locked cargo door.

1.12.12 The cabin contained freight from seat row 4 aft. Freight forward of that row had been ejected, and the cabin walls and floor were compressed together. Five cargo restraint nets had been fitted. Their found position and condition were as follows:

Net #	Fitted position	Where found	Condition
1	Immediately aft of entry door	Ahead of cabin	Good. No signs of heat stress
2	Seat row 3	Entangled outside cabin	Webbing present. Most of black nylon panels burnt or melted
3	Seat row 5	In place, attached by 2 cleats	Webbing present. Much of black nylon panels burnt or melted
4	Immediately forward of cargo door	In place, attached by most cleats	Slight heat stress visible
5	Forward of electronic racks in rear fuselage	In place, attached by all cleats	Good. No signs of heat stress

1.12.13 The horizontal stabiliser and most of the tail fin, except the rear spar, had separated from the fuselage. The rudder remained attached to the rear fin spar at 2 hinges.

1.12.14 The flight deck was lying on its left side approximately 225 m northeast of the site datum with the NLG extended. Both pilots were strapped into their normal seats; the captain in the left and the FO in the right seat. Neither pilot was wearing an oxygen or smoke mask.

1.12.15 About 97% of the manifested freight was recovered within 3 days of the accident. A few plastic-wrapped items showed signs of brief exposure to heat e.g. shrivelled or melted plastic, but none was scorched.

Wreckage examination

1.12.16 The aircraft wreckage was recovered to storage, and examined with the expert assistance of a representative from the present holder of the aircraft type certificate, M7 Aerospace Corporation. The following significant observations were made.

Right wing

1.12.17 The right wing main spar caps had failed in tensile overload, with the upper cap end bent down, consistent with failure in upward bending; the rear spar caps and web showed tensile overload and rearward bending.

Figure 5
ZK-POA right wing

1.12.18 The right wing upper surface outboard of the nacelle showed diagonal compression buckling running from forward inboard to aft outboard, consistent with torsional overload from upward aileron deflection as well as from a high positive g load and high airspeed.

1.12.19 The complete engine and nacelle had separated downward and to the left from the right wing. The engine control cables, aileron trim cables and electrical wires had failed in tension at the wing root, where the aileron push-pull tube had also failed but in bending.

1.12.20 There was no evidence of fire on the right wing.

1.12.21 The right wing tip attachments had failed in forward bending, and the tip section showed evidence of forward compression from its trailing edge.

Left wing

1.12.22 The left wing main spar lower cap had failed in tensile overload, and the upper cap in buckling. The rear spar lower cap had failed in tensile overload, and was also damaged by fire outboard of the fracture. The rear spar upper cap had not failed, but had pulled the attached centre section structure out of the fuselage. None of these fractures showed evidence of any structural weakening due to fire damage before the fractures occurred.

Figure 6
ZK-POA left wing

1.12.23 The left wing upper surface showed diagonal buckling at mid-span running from aft inboard to forward outboard, consistent with torsional overload from downward aileron deflection as well as from a high positive g load and high airspeed. The 3 leading edge slashes, at about mid-span, were consistent with contact with a rotating propeller, probably the right one.

1.12.24 The engine and most of the nacelle had separated downward from the left wing. Associated cables and wires had failed in tension.

1.12.25 The left wing tip remained attached, but folded downward, consistent with the ground impact.

1.12.26 The left wing was sooted overall from fire, and the upper and lower wing skins containing the fuel tank were bulged out from overpressure within the tank. The most intense fire damage was in the bay inboard of the nacelle, where some alloy structure had melted or burned away.

Right engine and propeller

1.12.27 The right engine was deformed from the ground impact, preventing rotation. The first stage impeller and the aft turbine wheel showed no evidence of rotation at impact. There was no evidence of foreign object damage.

Figure 7
ZK-POA right engine

1.12.28 The right propeller blades all showed leading edge scrape marks and forward bending at the tip consistent with striking a metal object while rotating at speed. One blade also had a rearward bend consistent with the ground impact.

Left engine and propeller

1.12.29 The left engine was deformed similarly to the right engine, and was also probably not rotating at ground impact. There was no evidence of foreign object damage.

1.12.30 The actuator motor was broken off the fuel firewall shut-off valve, showing that the valve was open. There was light sooting inside its protective cover. The nacelle showed evidence of a brief fire, aft of the firewall only. The extinguisher bottle was still charged.

1.12.31 The left propeller blades all showed severe leading edge damage and forward bending consistent with heavy strikes on a metal object while rotating under power. The rear faces of 2 blades showed marks characteristic of contact with teleflex cables. Two blades also had rearward bending and trailing edge scrapes consistent with the ground impact.

Figure 8
ZK-POA left engine

Horizontal stabiliser

1.12.32 The left half of the stabiliser was attached to a small portion of the right half and the stabiliser trim attachment fitting; the outer half of the left elevator also remained attached by its hinges. The eye ends of the stabiliser trim jacks were in place; their actuator rods had failed in bending. A hole torn in the upper skin showed smear marks indicative of some object striking the stabiliser while moving down and inboard. Most of the right half of the stabiliser and the rear spar pivot attachments were not found. The right trim jack was not found; the left one had broken from its housing in the fuselage in tensile overload. It was at about 70% extension.

1.12.33 No sooting was present on the horizontal stabiliser.

1.12.34 Each elevator was broken into 2 sections; each inboard edge showed outward crushing consistent with the stabiliser half moving down and rearwards as it failed.

Fin and rudder

1.12.35 The major part of the fin forward of the rear spar was not found. A separated piece of fin mid-section, with VOR aerials attached, was found; it showed no sooting. The fin rear spar remained attached to the fuselage, with the rudder attached by its hinges. The damaged ends of the forward fin spar and the small recovered piece indicated that the missing part had failed in bending to the right, with indications that it may have been struck from the left. The lower rudder was buckled on each side in proximity to the elevator.

Fuselage and flight deck

1.12.36 The flight deck had completely separated from the rest of the fuselage at the aft edge of the entry door, which showed local evidence, on both parts, of strikes from the left propeller. The cabin and rear fuselage had been partially separated into 3 sections, which fell together. The left side fuselage skin had been torn open in front of the cargo door, apparently by rudder cables and by engine control cables pulling through the structure during the break-up. Most of the centre section belly and wing spar carry-through structure had separated from the fuselage and the wings, and showed tensile fractures similar to the wing spar fractures.

Figure 9
ZK-POA fuselage

1.12.37 The fuel crossflow valve and actuator, normally located in the centre section belly, had fallen separately. The valve was in the open position, as driven by its actuator. The complete crossflow tube had also fallen separately. These items showed some impact crushing, but no evidence of fire.

1.12.38 External sooting and heat crazing of windows was confined to the left side with the greatest intensity aft of the wing root, and extended aft to the rudder. Evidence of internal heat and sooting on liner material and on plastic freight items in the vicinity of the left wing root suggested a brief exposure to fire.

1.12.39 Because of ground impact damage, and probable movement of the controls by the separation of control cables, there was little useful evidence of control positions or trim settings.

1.12.40 The instrument panel had separated at ground impact to become embedded face-down in the ground. As a result no switch or circuit breaker position provided useful evidence. Because of damage there were only a few trapped readings on instruments. These were:

- both ADIs 140-170° right bank, 90° nose up
- captain's altimeter 15 800 feet; set to 1013 hPa
- both VSIs maximum down.

1.13 Medical and pathological information

1.13.1 The post-mortem and toxicological examinations of the pilots did not disclose any abnormalities that might have affected their ability to conduct the flight. The post-mortem reports concluded that both pilots had died from multiple and extensive injuries.

1.13.2 Nothing on the CVR recording suggested that either pilot was unwell or not performing normally during the flight. It indicated that both pilots were alert and trying to correct the aircraft upset at the moment the recording ended.

1.14 Fire

1.14.1 An in-flight fire had occurred, as indicated by eyewitness reports and wreckage evidence. The left wing was the most fire-damaged component, consistent with a sustained fire fed by fuel from the wing tank while the separated wing was falling. The fire extinguished itself either before or on reaching the ground. Evidence of sooting and light charring or melting of items in the fuselage adjacent to the left wing root was consistent with the fire starting shortly before the separation of the left wing. There was no evidence that fire continued on any component other than the left wing.

1.14.2 The seat of the fire was in the wing bay inboard of the left engine nacelle, which contained electrical cables and the aircraft battery. The source of the fire was not evident, but may have been associated with arcing from electrical wiring adjacent to broken fuel pipes during the break-up sequence of the aircraft.

1.15 Survival aspects

1.15.1 The accident was not survivable because of the free-fall to the ground of the separated flight deck.

1.15.2 The emergency locator beacon case was shattered, which had allowed the batteries to fall out, preventing any emergency signal.

1.16 Organisational and management information

1.16.1 The operator held a CAR Part 119 Air Operator Certificate for air transport operations and also a Part 141 Aviation Training Organisation Certificate that allowed it to conduct training for its own and other persons.

1.16.2 The operator typically assessed the employment potential of pilots who paid for its aircraft type rating courses, and might offer an individual pilot part- or full-time employment at any time subsequent to the course.

Crew resource management training

1.16.3 CRM in aviation has been evolving in scope and training since the late 1970s. There is no universally accepted definition of CRM, but it might be considered as the dynamic application of appropriate on-board and external human, hardware and software resources, in order to achieve safe and effective crew performance and safe flight operation.

1.16.4 CRM training should involve all crewmembers. The training typically addresses crew attitudes and behaviours, considers more effective styles of internal and external communication and teaches methods for trapping or mitigating errors.

1.16.5 As targeted behavioural change is often one intended outcome of CRM training, time must be allowed to achieve some goals. Training courses are, therefore, usually progressive and build on an individual's operational experience, but where an operator is the first to introduce a pilot to the crew environment, introductory CRM can be effectively included as a part of the initial transition course. Training may be out-sourced or a proven course tailored for an operator's needs.

1.16.6 The operator made an assessment of each pilot's CRM performance during each flight crew competency check and route competency check.

Unusual attitude training

1.16.7 The International Civil Aviation Organisation (ICAO) reported[7] that, between 1997 and 2003, in-flight loss-of-control was the leading category of fatal accidents for turbine aircraft above 5700 kg weight. The proportion of loss-of-control accidents had increased, offsetting the reduction in controlled-flight-into-terrain accidents that followed widespread fitting of terrain awareness and warning systems to aircraft.

1.16.8 The above statistics, and training initiatives to reverse the trend, are dominated by the large turbofan aircraft segment of the industry, but they are applicable to air transport operations generally. The generally accepted industry definition[8] of an "airplane upset" and "loss of control" includes the following elements:

- aircraft pitch attitude greater than 25° nose up or 10° nose down
- aircraft bank angle greater than 45°
- aircraft within the above parameters but flying at airspeeds inappropriate for the flight conditions
- the aircraft condition was unintended.

1.16.9 In New Zealand, an applicant for an initial or recurrent (minimum annual) flight test for an aeroplane instrument rating is required to demonstrate the *Immediate recognition and correct recovery [to straight and level flight] from steep climbing turns and spiral dives as appropriate to the aircraft size and type*[9]. The scope of this training has been limited to recovery from "very nose high" and "very nose low" attitudes, and any additional training specific to an aircraft's flight characteristics. There was no additional training specified for the Metro aircraft type.

1.16.10 All but one of the instrument rating flight test reports held by the operator for the captain, and that for the co-pilot, indicated that "full panel unusual attitudes" had been tested on those check flights.

Use of rudder

1.16.11 In February 2002, the operator issued a Notice to Pilots on the subject of "Rudder Usage on Transport Category Aircraft". The notice repeated a safety recommendation made by the United States National Transportation Safety Board (NTSB) to the Federal Aviation Administration (FAA) following an NTSB investigation of an in-flight structural failure of an Airbus A300 tail fin. The NTSB recommended that the FAA require United States operators of transport category aircraft to implement a pilot training programme to explain that full or nearly

[7] ICAO Accident and Incident Data Reporting (ADREP) System, turbine aircraft above 5700 kg MCTOW, 1997-2003.
[8] Airplane Upset Recovery Training Aid, Air Transport Industry working group, August 2004.
[9] CAA AC61-1.17, Rev.3, 23/06/04, and CAA Flight Test Standards Guide, Instrument Rating, April 2005.

full rudder deflection in one direction, followed by full or nearly full rudder deflection in the other direction, or certain combinations of sideslip angle and opposite rudder deflection, can result in potentially dangerous loads on the vertical stabiliser, or tail fin. The operator's Notice to Pilots was current at the time of the accident. The operator's 6-monthly crew competency check included a check item for each pilot's knowledge of current Notices to Pilots.

1.16.12 In April 2002, the operator reinforced the rudder usage message by providing its pilots with copies of an article "How much rudder is too much?" from the US magazine *Business and Commercial Aviation*.

1.17 Additional information

1.17.1 The 1790 kg of freight loaded into ZK-POA did not contain any declared dangerous goods. No dangerous goods were found during the freight recovery operation at the accident site.

Other occurrences

1.17.2 In August 2004, there was a loss-of-control event involving a Fairchild-Swearingen Merlin aircraft in Australia. The Merlin was an earlier aircraft type than the Metro with essentially the same fuel system, including a crossflow tube. During the cruise phase of a night flight the Merlin pilot had applied rudder to correct a fuel imbalance, trimmed out the rudder forcethen engaged the autopilot. About 2½ minutes after autopilot engagement, the autopilot suddenly disengaged and the aircraft departed from controlled flight. The aircraft descended 11000 ft before the single pilot regained control.

1.17.3 ATSB reported[10] that unintentional opening of the crossflow valve and subsequent failure of the autopilot to compensate for an unbalanced fuel load had probably led to the Merlin incident. Preventative action was taken by the Merlin operator reminding its pilots to ensure that fuel was balanced and that the aircraft was in trim before the autopilot was engaged. The ATSB also published the report on its website for the education of the aviation industry.

1.17.4 On 8 February 2006 a loss-of-control accident involving a Swearingen SA226 Metro II aircraft occurred in the United States. The aircraft was on a freight flight at FL 160 by day, in visual conditions, with a single pilot. The pilot requested clearance for turning manoeuvres, then radar vectors to the closest airport. He was so cleared, and asked if he had an emergency, to which he reported an asymmetric fuel condition. About a minute later he made a repeated "Mayday" call. The aircraft dived steeply into the ground at high speed.

1.17.5 The NTSB investigation into this accident is incomplete, but in-flight fuel-balancing procedures may be implicated.

[10] ATSB Aviation Safety Report 200403209

2 Analysis

2.1 This accident occurred during a regular scheduled night cargo flight, operated by an established air transport operator and training organisation. The aircraft type, the SA227-AC Metro III, was a twin-turboprop pressurised commuter airliner with a substantial global operating record of several hundred aircraft over more than 20 years. The crew was appropriately qualified, with the captain experienced on the type and the operation, and approved as a line training captain, while the FO was recently trained on the type and not very experienced on it.

2.2 The accident occurred during the cruise phase of the flight, statistically the lowest-risk phase. While the weather forecast for the route from Auckland to Blenheim was for occasional turbulence and isolated severe icing, the analysis by MetService and evidence from the crew on the CVR both indicated that the aircraft had passed the area of convective cloud producing these effects into clearer weather above lower cloud. The preceding company aircraft on the route also reported no significant icing. There was no indication that weather was a factor in the accident. However, the night was dark, with no moon, and the aircraft was probably flying above cloud which would have obscured any ground lights.

2.3 The CVR evidence showed the events leading to the accident. About 2 minutes before the end of the recording the engine power had been reduced from climb to a cruise setting, and the crew had completed the standard cruise checks. The captain then decided to balance the fuel tanks, presumably because of differing quantities indicated on the left and right fuel gauges. There was no evidence of how much imbalance he was responding to, but the stage of flight was appropriate for attending to an imbalance, if it was sufficient to warrant action.

2.4 The captain instructed the FO, who was the PF, to "… open the crossflow again…", which involved operating an electrical switch on the instrument panel. He also said, "… sit on the left ball and trim it accordingly", which he clarified to mean the application of pressure to the left rudder pedal, followed by left rudder trim control to maintain the rudder input without the pedal pressure. The FO made the comment, "I was being a bit cautious" after responding to the captain's repeated instruction, "Get the ball out to the right as far as you can… and just trim it". The FO's comment probably represented some concern felt by the FO that the rudder input called for was excessive, but he apparently complied with the instruction anyway.

2.5 The autopilot had been engaged earlier in the flight, and there was no evidence to suggest that it had been disengaged for this fuel balancing procedure. It was probably operating in ALT mode and either HDG or VOR/LOC mode, applying aileron and elevator control corrections to maintain the aircraft's barometric altitude and heading or course. When left rudder was applied the aircraft would have yawed left and tried to roll left as a result of normal aerodynamic yaw/roll coupling. The autopilot would have applied right aileron control to counter this rolling tendency, and would also have tried to maintain the heading (or course) by applying more right aileron so that the aircraft flew right-wing-down in a straight sideslip to the right.

2.6 If the autopilot had not been engaged, the PF would have had to apply right aileron manually in coordination with the left rudder input to achieve the same result. In manual flight the PF would have received continuous tactile feedback from the controls to indicate the control forces and displacements he was producing, and would have had to monitor closely the aircraft's attitude and heading on his instruments. With the autopilot engaged, and especially with the rudder trimmed out, he would not have had such feedback, because the autopilot would have been holding the control forces generated, and the PF might not have perceived a need to monitor the aircraft's attitude closely. In addition, both pilots may have been monitoring the fuel gauges to observe the success or otherwise of the fuel transfer. The amount of control wheel displacement by the autopilot would not have been readily apparent on a dark flight deck at night.

2.7 The radar and FDR data both showed that during this time the aircraft began to turn to the left, gradually at first, initially maintaining height. The aircraft then started to turn more quickly to the left and began to descend. This was shortly followed by the captain saying, "Doesn't like that one mate… you'd better grab it", the GPWS "bank angle" alert, and the chime tone which probably warned of an altitude deviation. The probable explanation for the bank angle excursion and the altitude loss is that the autopilot had disengaged automatically as a result of a servo reaching its torque limit, and with the autopilot constraint removed, the aircraft abruptly responded to the trimmed rudder input by rolling left and starting to yaw its nose down into a steeply banked diving attitude.

2.8 The captain's comment to the FO, "… You'd better grab it" was effectively an instruction to take over manual control, and also implied that the captain was aware that the autopilot had been engaged up to that time. Some 23 seconds later, 2 seconds before the end of the CVR recording, he asked the FO to confirm the autopilot was off. This implied that he had not observed the AP DISC (autopilot disconnect) light, and probably also that the FO had remained as the PF.

2.9 The crew evidently did attempt to recover the aircraft from this unusual attitude. While the FDR did not record bank angle, it showed that as the turn rate started to increase, so did the airspeed and the g, while the altitude showed a rapid and increasing rate of descent. Over the last 20 seconds of recorded data the airspeed increased from 175 to almost 300 kt, the vertical acceleration increased from about +1.5 g to +4.2 g and over 5000 feet was lost. These data characterise a rapidly developing spiral dive. The heading change recorded during the last 15 seconds may not be reliable because of the steep nose-down attitude of the aircraft.

2.10 The FDR did not record control positions, so it is not possible to determine exactly what the crew did to try to return the aircraft to a normal attitude. The normal recovery action sequence for a spiral dive is:

- reduce power to minimise airspeed increase
- roll the aircraft to wings-level, then
- pitch the aircraft up to the horizon.

This action needs to be taken promptly, positively and smoothly and in that order so that flight envelope limitations are not exceeded.

2.11 Evidence from the area microphone channel of the CVR indicated that a power reduction was made about 7 seconds before the end of the recording, or 18 seconds after recovery action was begun. This was late in the development of the spiral dive, and the delay would have exacerbated the situation. The diagonal compression buckling in both wings was evidence that appreciable right-wing-down aileron was applied when the wings failed. This indicated that appropriate control input was being made to try to roll the aircraft to the right, towards wings-level, as the aircraft wing structure became loaded towards failure. Substantial up-elevator control was evidently also being applied, because of the increasing g loads recorded by the FDR. This elevator input would have been ineffective in pitching the aircraft up towards the horizon, however, because of the steeply banked attitude; it could only have further tightened the turn, escalating the spiral dive. The bank attitude needed to be reduced towards wings-level before the elevator control could raise the nose of the aircraft.

2.12 The reason why the applied right aileron control was not effective in rolling the aircraft towards wings-level was not conclusively determined, but it was likely to have been a direct result of the left rudder trim which had been applied, and which probably remained applied throughout. However there was no evidence available from the wreckage to determine the rudder trim position, because the separation of the flight deck from the rest of the fuselage disrupted the control cable system.

2.13 When the FO took over manual control from the autopilot he had quite recently applied rudder trim, probably a large amount as indicated by the CVR recording of the captain's instruction "Get the ball out to the right as far as you can… and just trim it". His new and immediate task would have been to assess the aircraft's attitude from the instruments and use the controls to restore it to normal. The aircraft was already banked steeply to the left, rolling further, and starting to pitch down. Unless he made a connection between the rudder trim and the upset that was developing, he probably would not have applied the large amount of right rudder pedal pressure needed to overcome the left rudder trim. His probable action would have been to apply some right aileron control with perhaps a small right rudder pressure, expecting a normal response from the aircraft. When this was not forthcoming, he would probably have increased the right aileron control, and perhaps applied more up-elevator control as the airspeed increased.

2.14 Twin-engine aircraft necessarily have powerful rudder and rudder trim controls to ensure controllability in the event of an engine failure. As a result a large amount of yaw could be induced, and the rudder pedal force trimmed out, if deliberate sideslipping flight as described here was set up. With an unexpected autopilot disconnect, the resulting roll could be surprising and disorienting to the crew, and once the bank angle became large the aircraft probably could not be rolled back to wings-level without removing the rudder-induced yaw which was maintained by the rudder trim.

2.15 The quantity of fuel transferred between tanks while the crossflow valve was open was unlikely to have precipitated the upset which occurred. The upset was to the left, while fuel transfer would have been from the left to the right tank, given the sideslip manoeuvre being performed. Any fuel transfer which had taken place would have therefore tended to reduce the likelihood of an upset occurring, or to assist slightly in any subsequent recovery.

2.16 The dark night conditions and probable cloud cover below would have prevented the crew seeing any external visual cues such as ground lights or terrain features to assist in orientation, or in early perception of the aircraft's departure from its normal attitude. There may have been a few stars visible. The crew's principal attitude reference would have been the flight instruments, and close attention to these would have been less likely while flying on autopilot than when flying manually.

2.17 The necessary intervention did not occur in time to prevent the aircraft wing structure failing in overload from excess g force and airspeed. The limit load was +3.02 g, with an ultimate load of +4.5 g; the maximum recorded at the end of the FDR record was +4.2 g, but torsional overload on the wings (rolling g) would have compromised the structure below the ultimate load. The manoeuvring airspeed, V_A was 181 kt, and the maximum operating airspeed (V_{MO}), was 227 kt; the maximum recorded airspeed was almost 300 kt.

2.18 Opportunity for the crew to make a safe recovery from the spiral dive probably ended as the airspeed rose significantly above V_{MO}. This occurred quickly, about 12 seconds after the captain's instruction to the FO to take over manual control. By that stage it was unlikely, even if they had then applied optimum control inputs, including reducing power and using right rudder pedal pressure to remove the left rudder input from the left rudder trim, that a normal attitude could have been regained without seriously overstressing the aircraft structure.

2.19 Before departure from Auckland the crew had the aircraft refuelled in the left tank only, rather than requesting a balanced refuel as was normal practice. This was probably to expedite their departure after the delayed loading. Evidently they had then balanced the fuel tanks before take-off by opening the crossflow valve, and by taxiing in a circle to assist the process. If the crossflow valve had been open from the start of refuelling, some 10 minutes would have been available before take-off, sufficient to transfer 500 lb of fuel through the 5 cm diameter crossflow tube. There was no evidence to suggest that any residual imbalance was outside limits at take-off, but the imbalance which the captain subsequently decided to address by instructing the FO to "open the crossflow again…" probably resulted from the asymmetrical refuelling rather than a difference in engine performance. The engine with the longer time since overhaul was still only half way through the overhaul period, and the flight time since Post 23 left Auckland was probably insufficient to develop much fuel imbalance. The imbalance may have been within AFM limits for the upcoming landing, but was sufficient for the captain to want to tidy up while the aircraft was in the cruise.

2.20 Why the captain thought such an extreme sideslip was appropriate to assist the fuel transfer is not known. The company did not have a written SOP for fuel balancing; and the manufacturer's AFM contained no detailed procedure for fuel balancing. Within the company, fuel balancing was taught to new pilots during type rating and route training, but because the procedure was not documented, the potential was there for individuals to adopt differing methods without this being realised by the operator. The gravity crossflow fuel system was unusual, and probably confined to the SA 226/227 family of aircraft; other types had either a pumped cross-feed system or a pumped crossflow system. Flying these other types of aircraft in a sideslip would not assist any pumped system to transfer fuel, so was not normally done. There was an evident need for specific procedures to be published for the SA 226/227 family of aircraft, with clear guidelines for the maximum amount of sideslip to use, such as perhaps "half a ball" on the slip indicator.

2.21 Both the captain and the FO should have been well aware from the operator's notices in 2002 of the dangers in applying large sideslip angles at relatively high speed. These notices related to a different type of event involving a large jet aircraft, but the message clearly cautioned against applying large rudder deflections except during engine failure or crosswind take-offs or landings, and was wise counsel for any size of aircraft. The FO was not employed by the operator in 2002, but the notices were still current, so he should have seen them during his recent Metro training.

2.22 Both the captain and the FO should have been aware that flying the aircraft above 20 000 ft with the autopilot engaged was in contravention of the AFM limitation. Had they disconnected the autopilot as the aircraft was climbed above 20 000 ft, so that the ensuing manoeuvre was manually flown, the upset probably would not have occurred. However, the AFM limitation on autopilot use was based on decreased stall margin of the aircraft, not on the performance of the autopilot. Before the upset occurred, ZK-POA was cruising at over 170 kt, well above stall speed, and was not displaying the reduced performance experienced by the flight test aircraft. Because of this, it is unlikely that the non-compliance with the AFM limitation on autopilot use was a factor in the upset.

2.23 The break-up sequence could not be determined in detail, but probably began with the upward failure of both wings. The wings probably did not separate completely from the fuselage at first; the left propeller came into contact with the entrance door area, which infers that the wing had folded upward to bring the propeller arc into the fuselage side. In addition, the fire which was centred in the inboard part of the left wing obviously remained adjacent to the fuselage for a short time to leave evidence of sooting and scorching. The propeller slashes in the left wing leading edge were probably caused by the right propeller, which infers that the wings came together before, or as they separated from the fuselage.

2.24 The left propeller strikes on the fuselage probably initiated the separation of the flight deck from the fuselage. When this separation occurred, it probably led to the belly and wing carry-through structure parting from the fuselage. Tearing of fuselage skin by control cables was evident, and necessarily had to occur as the wings and flight deck were separating. The landing gear would have extended in free-fall following disruption of the emergency release cables.

2.25 The stabiliser and fin were probably struck by the right wing tip as that wing folded over and back, leading to their falling separately. The wing tip had been compressed forward, indicating that it was moving rearwards when this occurred.

2.26 The engines and propellers probably separated from the wings as the wings were folding up and back, and while the engines were still rotating at high speed to bring gyroscopic forces into play. The engines would have lost power quickly in the sequence, as their fuel supply was interrupted and control and shut-off cables were disrupted by the initial wing failures. There was no subsequent evidence of engine power, which was consistent with the engines both running down while separating from the wings, then falling for an appreciable time before ground impact. The cockpit area microphone evidence from the CVR indicated that no audible change in power delivery had occurred until about 7 seconds before the end of the recording, when the crew probably retarded the power levers.

2.27 The break-up probably started when the aircraft was quite high, perhaps FL 199 when the radar data from its transponder ceased; certainly before the last FDR altitude of 16 400 ft. It may have continued progressively as the aircraft fell, but the distant spread of some lighter components suggests that the major events in the sequence occurred at altitude, allowing these items to be carried by the southeast wind. The ground pattern of the large items of wreckage suggested that the aircraft was already in a very steep descent when it broke up.

2.28 Although the fire which occurred in the left wing caused some damage to wing structure, this damage was outboard of the fractured spar structure, indicating that the fire damage followed the break-up, and was not a precursor to the structural failure. While the source of the fire was not determined, it was seated in the bay containing electrical wiring and the aircraft battery. Disruption of wiring and the nearby fuel lines during the break-up would have provided both fuel and an ignition source.

2.29 A major objective of CRM is to ensure that crew actions taken and decisions made are appropriate, and optimal for the particular circumstances, with all crew members expected to be able to interact to achieve this, or to intervene if necessary to prevent an unsafe occurrence. For CRM to be most effective each person should ideally be well trained and experienced on the aircraft and the operation, as well as being knowledgeable and skilled in their role in aviation. Training in CRM is also necessary, to facilitate the process.

2.30 The crew of ZK-POA was unevenly experienced; the captain was a moderately experienced line training captain, about to become a flight examiner, while the FO was newly qualified on the Metro, and employed by the company as a part-time pilot. In this senior/junior situation there was an inevitable cross-cockpit authority gradient, with the captain taking on an instructing role and the FO requiring confidence if he was to assertively query an instruction that he thought was wrong. The FO had received some introductory CRM training, but these courses were progressive during an individual's career with this operator. The FO's CRM training had evidently not enabled him to overcome his diffidence in the circumstances of this accident.

2.31 This accident could have been prevented by active CRM measures; by the FO assertively declining to fly the aircraft in such an extreme sideslip, especially on autopilot with an excessive amount of rudder trim applied. His comment "I was being a bit cautious" indicated his disquiet about the captain's repeated and insistent instruction, but that was as far as he went in indicating it to the captain.

2.32 There was an onus on the captain to not give any unsafe instruction to an FO, but this depended on the captain knowing and understanding what was safe and what was unsafe. In this case, although some sideslip was necessary for fuel balancing, he clearly did not understand that an extreme sideslip in cruising flight was undesirable, or that doing it by trimming the rudder while flying on autopilot was unsafe, and likely to lead to a flight upset if the autopilot disconnected. General pilot knowledge and experience might have been expected to provide this understanding, but could not be relied upon to ensure it.

2.33 There was no evidence to indicate that these actions of the crew resulted from other than the captain's repeated instructions to apply and trim a large rudder input and the FO's shared lack of understanding of the potential consequences. Whether or not there was any common misunderstanding, or a culture of non-conformance with procedures among the operator's other pilots before the accident, was not found. While some pilots reported using a small amount of rudder trim while flying on autopilot, it was of concern that the captain, as a training captain, should suggest an excessive amount of rudder trim. These variations of pilot technique probably resulted from the lack of a specific written SOP for in-flight fuel balancing.

2.34 Written SOPs are the normal method for an operator to detail to crews how to perform common tasks. This ensures that tasks are carried out in a safe and efficient manner, and that each crew member knows what is required. While the fuel balancing procedure might not be required on many flights, it clearly needed a written SOP. Because the gravity crossflow system was specific to the Metro family of aircraft, the appropriate procedure was unlikely to fall within pilots' understanding of good aviation practice.

2.35 The Metro family of aircraft did not have a record of in-flight upsets related to fuel balancing procedures and autopilot use, apart from the Australian incident in 2004, before this accident. However, these 2 events indicated that the AFM should include a limitation and a warning that the autopilot must be disconnected while in-flight fuel balancing is done, and should contain a procedure for in-flight fuel balancing. Such information in the AFM would also reinforce the need for operators of the aircraft to develop written SOPs for their operation.

3 Findings

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

3.1 The flight crew was appropriately licensed and rated for the aircraft, and qualified for the flight.

3.2 The captain was experienced on the type and the operation, and approved as a line training captain, while the FO was recently trained and not very experienced on the type.

3.3 The aircraft had a valid Certificate of Airworthiness and records indicated that it had been maintained in accordance with its airworthiness requirements. There were no relevant deferred maintenance items prior to dispatch of the accident flight.

3.4 Although the aircraft had been refuelled in one tank only, it probably took off with the fuel balanced within limits.

3.5 Some fuel imbalance led the captain to decide to carry out further fuel balancing while the aircraft was in cruising flight.

3.6 The captain's instructions to the FO while carrying out fuel balancing resulted in the aircraft being flown at a large sideslip angle by the use of the rudder trim control while the autopilot was engaged.

3.7 The FO's reluctance to challenge the captain's instruction may have been due to his inexperience and underdeveloped CRM skills.

3.8 The autopilot probably disengaged automatically because a servo reached its torque limit, allowing the aircraft to roll and dive abruptly as a result of the applied rudder trim.

3.9 The crew was unable to recover control from the ensuing spiral dive before airspeed and g limits were grossly exceeded, resulting in the structural failure and in-flight break-up of the aircraft.

3.10 The in-flight fire which occurred was a result of the break-up, and not a precursor to it.

3.11 The applied rudder trim probably contributed to the crew's inability to recover control of the aircraft.

3.12 The crew's other control inputs to recover from the spiral dive were not optimal, and contributed to the structural failure of the aircraft.

3.13 The flying conditions of a dark night with cloud cover below probably hindered the crew's early perception of the developing upset.

3.14 The AFM limitation on use of the autopilot above 20 000 ft should have led to the crew disconnecting it when climbing the aircraft above that altitude.

3.15 The crew's non-observance of this autopilot limitation probably did not affect its performance, or its automatic disengagement.

3.16 If the aircraft had been manually flown during the fuel-balancing manoeuvre, the upset would probably have not occurred.

3.17 The operator should detail the in-flight fuel balancing procedure as a written SOP for its Metro aircraft operation.

3.18 The AFM for the SA 226/227 family of aircraft should include a limitation and warning that the autopilot must be disconnected while in-flight fuel balancing is done, and should include a procedure for in-flight fuel balancing.

4 Safety Actions

4.1 On 30 May 2005, the operator issued a Notice to Pilots advising that forthwith the SOP was to give the refueller the volume of fuel to be put into each wing tank to achieve a balanced load prior to engine start, in accordance with the Pre-Start checklist, Metro Training Manual and AFM. The Notice emphasised that it was not acceptable to put the required fuel uplift into one tank only with the intention of balancing the fuel later. The importance of not compromising safety by rushing checks was also mentioned in the Notice.

4.2 On 30 June 2006 the operator amended the Metro checklist to add to the Line-up and Approach checklists the item "crossflow closed".

4.3 On 4 July 2006 the operator amended the autopilot Standard Operating Procedures section of the company Metro Training Manual to include:

Use of fuel crossflow switch

Providing Metro refuelling SOPs are complied with (i.e. wing tanks balanced prior to start and crossflow switch closed) in-flight crossflow should be only be required in the case of single engine operation. Disengage the autopilot and yaw damper prior to using the crossflow switch.

Cautions:
1. Monitor crossflow valve for correct annunciations.
2. Should fuel balance not be achieved or the balance worsens, close the crossflow valve and land asap.

5 Safety Recommendations

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

5.1 On 27 February 2006, the Commission recommended to the Director of Civil Aviation that he:

> acts, in concert with the FAA as the type certification authority, to amend the Aircraft Flight Manuals of the Metro and associated types to include a limitation and caution that the autopilot and yaw damper must be disconnected while in-flight fuel balancing is done.
> In addition, the AFM should contain a procedure for in-flight fuel balancing. (006/06)

5.2 On 25 May 2006 the Civil Aviation Authority replied:

> The Director has accepted this recommendation and has commenced correspondence with the FAA to request that they amend the flight manuals of the Metro and associated types to include a limitation and caution that the autopilot and yaw damper must be disconnected while in flight fuel balancing is done. In addition the aircraft flight manual should contain a procedure for in flight fuel balancing. This action was commenced in May however no final date for resolution of this matter can be agreed as this is dependent on the FAA internal processes.

Approved on 20 July 2006 for publication

Hon W P Jeffries
Chief Commissioner

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04-001	Piper PA23-250E Axtec, ZK-DGS, landing gear collapse during taxi, Paraparaumu Aerodrome, 9 January 2004
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