Department of Transport and Regional Development
Bureau of Air Safety Investigation

INVESTIGATION REPORT
9503057

Fairchild Aircraft Model SA227-AC VH-NEJ, Tamworth, NSW 16 September 1995

BASI Bureau of Air Safety Investigation

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ISBN 0 642 25638 1 May 1997

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TERMS AND ABBREVIATIONS

AMSL	Above Mean Sea Level
AOC	Air Operators Certificate
ATPL	Air Transport Pilot Licence
CAA	Civil Aviation Authority
CASA	Civil Aviation Safety Authority. The CAA ceased to exist in July 1995 and was replaced by CASA and Airservices Australia.
CPL	Commercial Pilot Licence
CVR	Cockpit Voice Recorder
DFDR	Digital Flight Data Recorder
DFOM	CASA District Flying Operations Manager
DME	Distance Measuring Equipment
EST	Eastern Standard Time
FOI	Flying Operations Inspector
hPa	Hectopascal(s)
ILS	Instrument Landing System
kt(s)	Knot(s)
MAOC	Manual of Air Operator Certification
MAUW	Maximum All-Up Weight
MTOW	Maximum Take-Off Weight
NDB	Non-Directional Beacon
NTS	Negative Torque Sensing
NTSB	National Transportation Safety Board (USA)
OAT	Outside Air Temperature
RPM	Revolutions Per Minute
RPT	Regular Public Transport
VMC	Visual Meteorological Conditions
Critical engine	The engine, the failure of which is most disadvantageous to aircraft performance due to asymmetric effects, loss of system power or other adverse factors.
V_1	Take-off decision speed. The indicated airspeed defining the decision point on the take-off roll after which, should one engine fail, the pilot should continue the takeoff.

V_1 cut	The simulated failure of an engine during takeoff or initial climb at any stage between V_1 speed and V_{yse} speed.
V_2	Take-off safety speed. The lowest indicated airspeed at which an aircraft complies with those criteria associated with climb following failure of one engine. The aircraft is required to attain this speed before entering an area commencing at the end of the runway at a height of 35 ft.
V_{MCA}	Minimum control speed in flight in the following configuration: Gear up and flaps extended 1/4, take-off power on the operating engine, windmilling propeller on the inoperative engine with NTS operative, no more than 5 degrees bank towards the good engine.
V_R	Rotation speed on takeoff. It is not less than 1.05 x V_{MCA}.
V_{yse}	Single-engine best rate of climb speed.
VOR	VHF Omnidirectional Radio Range

Synopsis

The flight was the second Metro III type-conversion training flight for the co-pilot. Earlier that night, he had completed a 48-minute flight.

During the briefing prior to the second flight, the check-and-training pilot indicated that he would give the co-pilot a V_1 cut during the takeoff. The co-pilot questioned the legality of conducting the procedure at night. The check-and-training pilot indicated that it was not illegal because the company operations manual had been amended to permit the procedure. The crew then proceeded to brief the instrument approach which was to be flown following the V_1 cut. There was no detailed discussion concerning the technique for flying a V_1 cut.

The co-pilot conducted the takeoff. Four seconds after the aircraft became airborne, the check-and-training pilot retarded the left engine power lever to flight-idle. The landing gear was selected up 11 seconds later. After a further 20 seconds, the aircraft struck the crown of a tree and then the ground about 350 m beyond the upwind end of the runway and 210 m left of the extended centreline. It caught fire and was destroyed. The co-pilot and another trainee on board the aircraft were killed while the check-and-training pilot received serious injuries.

The investigation found that the performance of the aircraft was adversely affected by:
- the control inputs of the co-pilot; and
- the period the landing gear remained extended after the simulated engine failure.

The check-and-training pilot had flown night V_1 cut procedures in a Metro III flight simulator, but had not flown the procedure in the aircraft at night. He did not terminate the exercise, despite indications that the aircraft was not maintaining V_2 and that it was descending. There were few external visual cues available to the crew in the prevailing dark-night conditions. This affected their ability to maintain awareness of the aircraft's position and performance as the flight progressed.

A number of organisational factors were identified which influenced the aviation environment in which the flight operated. These included, on the part of the operating company:
- an inadequate Metro III endorsement training syllabus in the company operations manual;
- inadequate assessment of the risks involved in night V_1 cuts; and
- assigning the check-and-training pilot a task for which he did not possess adequate experience, knowledge, or skills.

Organisational factors involving the regulator included:
- a lack of enabling legislation prohibiting low-level night asymmetric operations;
- deficient requirements for co-pilot conversion training;
- inadequate advice given to the operator concerning night asymmetric operations and the carriage of additional trainees on training flights;
- deficient training and approval process for check-and-training pilots; and
- insufficient quality control of the company operations manual.

The investigation also determined that there was incomplete understanding within the company, the regulating authority, and some sections of the aviation industry of the possible effects of engine flight-idle torque on aircraft performance. Inadequate information on the matter in the aircraft flight manual contributed to this.

1. FACTUAL INFORMATION

1.1 History of the flight

Two company pilots were undergoing first officer Metro III type-conversion flying training. Both had completed Metro III groundschool training during the week before the accident.

A company check-and-training pilot was to conduct the type conversions. This was his first duty period after 2 weeks leave. Before commencing leave, he had discussed the training with the chief pilot. This discussion concerned the general requirements for a co-pilot conversion course compared to a command pilot course but did not address specific sequences or techniques.

The three pilots met at the airport at about 1530 EST on 16 September 1995. During the next 2 hours and 30 minutes approximately, the check-and-training pilot instructed the trainees in daily and pre-flight inspections, emergency equipment and procedures, and cockpit procedures and drills (including the actions to be completed in the event of an engine failure), as they related to the aircraft type. The briefing did not include detailed discussion of aircraft handling following engine failure on takeoff.

The group began a meal break at 1800 and returned to the aircraft at about 1830 to begin the flying exercise. The check-and-training pilot was pilot in command for the flight and occupied the left cockpit seat. One trainee occupied the right (co-pilot) cockpit seat while the other probably occupied the front row passenger seat on the left side. This person had the use of a set of head-phones to listen to cockpit talk and radio calls.

The aircraft departed Tamworth at 1852, some 40 minutes after last light. Witnesses described the night as very dark, with no moon. Under these conditions, the Tamworth city lighting, which extended to the east from about 2 km beyond the end of runway 12, was the only significant visual feature in the area.

The co-pilot performed the takeoff, his first in the Metro III. For about the next 30 minutes, he completed various aircraft handling exercises including climbing, descending, turning (including steep turns), and engine handling. No asymmetric flight exercises were conducted. The check-and-training pilot then talked the co-pilot through an ILS approach to runway 30R with an overshoot and landing on runway 12L. The landing time was 1940. The aircraft had functioned normally throughout the flight.

After clearing the runway, the aircraft held on a taxiway for 6 minutes, with engines running. During this period, the crew discussed the next flight which was to be flown by the same co-pilot.

The check-and-training pilot stated that he was going to give the co-pilot a V_1 cut. The co-pilot objected and then questioned the legality of night V_1 cuts. The check-and-training pilot replied that the procedure was now legal because the company operations manual had been changed. The co-pilot made a further objection. The check-and-training pilot then said that they would continue for a Tamworth runway 30R VOR/DME approach and asked the co-pilot to brief him on this approach. The crew discussed the approach and the check-and-training pilot then requested taxi clearance. The aircraft was subsequently cleared to operate within a 15-NM radius of Tamworth below 5,000 ft. The crew then briefed for the runway 12L VOR/DME approach. The plan was to reconfigure the aircraft for normal two-engine operations after the V_1 cut and then complete the approach.

The crew completed the after-start checks, the taxi checks, and then the pre-take-off checks. The checks included the co-pilot calling for one-quarter flap and the check-and-training pilot responding that one-quarter flap had been selected. The crew briefed the take-off speeds as V_1 = 100 kts, V_R = 102 kts, V_2 = 109 kts, and V_{yse} = 125 kts for the aircraft weight of 5,600 kg. Take-off torque was calculated as 88% and water-methanol injection was not required.

The aircraft commenced the take-off roll at 1957.05. About 25 seconds after brakes release, the check-and-training pilot called 'V_1', and less than 1 second later, 'rotate'. The aircraft became airborne at 1957.32. One second later, the check-and-training pilot reminded the co-pilot that the aircraft attitude should be 'just 10 degrees nose up'. After a further 3 seconds, the check-and-training pilot retarded the left engine power lever to the flight-idle position. Over the next 4 seconds, the recorded magnetic heading of the aircraft changed from 119 degrees to 129 degrees.

The co-pilot and then the check-and-training pilot called that a positive rate of climb was indicated and the landing gear was selected up 15 seconds after the aircraft became airborne. The landing gear warning horn began to sound at approximately the same time. After 19 seconds airborne, and again after 30 seconds, the check-and-training pilot reminded the co-pilot to hold V_2. Three seconds later, the check-and-training pilot said that the aircraft was descending. The landing gear warning horn ceased about 1 second later. By this time, the aircraft had gradually yawed left from heading 129 degrees, through the runway heading of 121 degrees, to 107 degrees. After being airborne for 35 seconds, the aircraft struck a tree approximately 350 m beyond, and 210 m left of, the upwind end of runway 12L. It then rolled rapidly left, severed powerlines and struck other trees before colliding with the ground in an inverted attitude and sliding about 70 m.

From the control tower, the aerodrome controller saw the aircraft become airborne. As it passed abeam the tower, the controller directed his attention away from the runway. A short time later, all lighting in the tower and on the airport failed and the controller noticed flames from an area to the north-east of the runway 30 threshold. Within about 30 seconds, when the emergency power supply had come on line, the controller attempted to establish radio contact with the aircraft. When no response was received, he initiated call-out of the emergency services.

1.2 Injuries to persons

	Crew	Passengers	Other	Total
Fatal	1	-	1*	2
Serious	1	-	-	1
Minor/none	-	-	-	-
Total	2	-	1*	3

* This person was the other trainee who was in the aircraft cabin.

1.3 Damage to aircraft

The aircraft was destroyed as a result of impact forces and post-impact fire.

1.4 Other damage

After striking the first tree, the aircraft severed powerlines situated on the north-eastern side of the Tamworth–Gunnedah road. Later in the impact sequence it caused damage to fencing bordering the same road.

1.5 Personnel

	Check-and-training pilot	**Co-pilot trainee**
Age	31	23
Licence category	ATPL	CPL
Medical certificate	Class one	Class one
Instrument rating	Multi-engine command	Multi-engine command
Total hours	4,132	1,317
Total on type	1,393	0.8
Total last 90 days	133	160.6
Total on type last 90 days	102	0.8
Total last 24 hours	0.8	0.8
Total night hours	802	124
Last flight check	18 May 1995	28 August 1995

The other trainee on board the aircraft had attained approximately the same experience level as the co-pilot trainee.

1.5.1 Previous 72-hour history

Check-and-training pilot

The check-and-training pilot returned to Tamworth on 15 September after 2 weeks leave, the last 2 days of which involved learning hang gliding and camping on location. He stated that at about 1600 on 15 September he joined other company personnel for drinks. He later went with friends to a restaurant and then a nightclub before retiring at about 0100 the following morning. At about 0630, the check-and-training pilot was woken by a telephone call from the company operations staff who asked if he was available to crew a flight to Sydney later that morning. He declined the flight and returned to sleep, rising by about 0930.

Co-pilot

The co-pilot spent 14 and 15 September attending Metro III groundschool classes at Tamworth. He arrived at the airport at about 0900 on the day of the accident and remained there until commencing the conversion flight training at about 1530.

During the investigation, the check-and-training pilot advised that the co-pilot had a head cold on the day of the accident. He was not aware if the co-pilot was taking any medication and had observed no indication during the initial flight that the co-pilot's performance was affected by the head cold.

1.5.2 Relevant operational experience

Check-and-training pilot

The check-and-training pilot had gained all his Metro III experience with Tamair. He was issued with a category E check-pilot approval on 27 June 1994. His flying experience at the time was 3,362 hours, including 670 hours on Metro III aircraft. The approval was extended on 24 February 1995 to category A and C approval; this enabled him to perform type conversion training and to conduct flight proficiency tests involving emergency or abnormal manoeuvres on Metro III and Piper PA31 aircraft. His experience at this time was 3,812 total flying hours, including 1,083 hours on Metro III aircraft.

The check-and-training pilot's logbook showed that, at the time of the accident, he had performed over 300 flight hours of check-and-training duties. However, most of this experience was obtained conducting route and base checks and instrument rating renewals. Only about 14 hours were flown while conducting type conversions. This occurred in June 1995 while the check-and-training pilot was temporarily transferred to another operator, away from Tamworth, to conduct Metro III training. It was associated with training two pilots as pilot in command of Metro III aircraft. These pilots had 21,000 hours and 12,000 hours flying experience respectively. The experience of both pilots included significant flying hours on twin-engine turbo-prop aircraft above 5,700 kg MTOW. The accident flight involved the first co-pilot conversion training the check-and-training pilot had conducted.

The check-and-training pilot had completed a number of V_1 cuts in the Metro III aircraft during daylight, but none at night. Some of this experience was gained during the command conversion training conducted away from Tamworth, referred to in the previous paragraph. The check-and-training pilot indicated that it was his choice whether V_1 cuts for that training were conducted at night or during daylight. He had chosen daylight as he did not feel totally comfortable about night V_1 cuts. On the day of the accident, he chose to conduct night V_1 cuts. He explained that he was aware that Tamair check-and-training pilots were conducting night V_1 cuts and felt that this may have influenced his decision. There was, however, no company policy requiring pilots to conduct V_1 cuts at night, nor was there evidence of any directive or advice concerning V_1 cuts having been given to the check-and-training pilot before the flight.

The experience of the check-and-training pilot involving engine failures on takeoff included 1 hour in a Metro III flight simulator in the USA in May 1994. The full-motion simulator was equipped with a night visual display system. The check-and-training pilot 'flew' the simulator for 1 hour and completed about 16 engine-failure sequences, including engine failures below, at, and just after, 'V_1'.

The check-and-training pilot did not hold a flying instructor qualification, nor had he undertaken any training towards such a qualification. He had no flying instructional experience other than that gained as a check-and-training pilot with Tamair. He had limited experience in taking over control of an aircraft during training and had never taken control during a simulated asymmetric situation after takeoff.

The check-and-training pilot was described by others who knew and/or worked with him as a very keen pilot who had a high level of self confidence.

Co-pilot

All the co-pilot's flying training had been conducted with Tamair. In the period before the accident he was flying Cessna 310 and Piper PA-31 aircraft on single-pilot charter and regular public transport tasks. All his flying experience was in piston-engine aircraft below 5,700 kg MTOW. He completed a base check on 4 July 1995 in a Piper PA-31 aircraft, and a base check in a Cessna 310 aircraft on 28 August 1995. Both these checks included engine-failure drills and asymmetric flight. His exposure to turboprop operations included a short test flight in a Metro III aircraft as an observer (in which he occupied the right cockpit seat), a number of Metro III flights observing/listening to cockpit activities from the front-row passenger seat, and the initial 48-minute flight in the aircraft on the night of the accident, which included one normal takeoff and one normal landing.

1.6 Aircraft information

1.6.1 Significant particulars

Registration	VH-NEJ
Manufacturer	Fairchild Aircraft Incorporated
Model	SA 227-AC
Common name	Metro III
Serial no.	AC-629B
Country of manufacture	USA
Year of manufacture	1985
Engines	2 AirResearch Garrett TPE-331, Model 11U-611G
Engine type	Turboprop

Certificate of airworthiness

No.	CAN/10021
Issued	28 March 1995
Category of operation	Normal (SFAR 41)

Certificate of registration

Holder	Tamair Pty Ltd
No.	CAN/10021
Issued	1 September 1993

Maintenance release

No.	544
Issued	30 August 1995
Valid to	28 November 1995 or 15,160.7 hours (whichever came first)
Total airframe hours	15,105.4

1.6.2 Weight and balance

The aircraft all-up weight was about 5,600 kg at takeoff. The maximum allowable take-off weight was 7,260 kg. The centre of gravity was within limits.

1.7 Meteorological information

The Bureau of Meteorology provided the following information concerning the weather conditions at Tamworth Airport at the time of the accident:

Wind	143 degrees at 8 kts
Visibility	10 km or greater
Weather	Nil significant
Cloud	Broken altostratus 10,000 ft or above
Temperature	17.8 degrees Celsius
Barometric pressure	1,023 hPa

Information from the Tamworth automatic weather station between 1940 and 2010 on the night of the accident indicated that there were no sudden changes in wind direction or speed, and no rainfall during this period. There was no indication of any thunderstorm activity near Tamworth.

1.8 Aids to navigation

Not relevant

1.9 Communications

Communications between the aircraft and air traffic services were recorded by automatic voice recording equipment. The quality of these recorded transmissions was good.

1.10 Airport information

Tamworth Airport is operated by the Tamworth Council. It is situated about 9.5 km west of Tamworth township and is 1,334 ft AMSL at the aerodrome reference point. NEJ took off from runway 12L. This runway is 2,200 m long. It is level for the first 500 m and then slopes up at 0.8 %. Consequently, the runway 30R threshold is 13.04 m (43 ft) higher than the runway 12L threshold.

1.11 Flight recorders

1.11.1 Digital flight data recorder

The aircraft was equipped with a Loral Data Systems (Fairchild) model F1000 digital flight data recorder which was designed to record a minimum of 25 hours of flight time. The parameters recorded were:

- magnetic heading;
- pressure altitude;
- indicated airspeed;
- vertical acceleration;
- longitudinal acceleration;
- radio press-to-transmit; and
- elapsed time.

Inspection of recorder unit

Inspection of the recorded data revealed that all pressure altitude and indicated airspeed information was flawed. Examination of the recorded data showed that an erroneous static pressure signal had been recorded. This was probably due to a restriction in the static pressure supply line to the airspeed/altitude transducer inside the recorder. However, the cause of the restriction could not be determined.

Examination of data

Appendix 1 shows recorded vertical acceleration data for three takeoffs. Graph A was recorded during a takeoff from Tamworth by an experienced company pilot on an RPT flight. Graph B shows vertical acceleration during the takeoff by the co-pilot on the initial 48-minute flight. Graph C is a record of the vertical acceleration during the accident flight. Each graph shows 61 seconds of recorded data from the commencement of the take-off roll. This was the duration of the accident flight.

The graphs show:

(a) Significant variations in the time taken for rotation with Graph A indicating about 10 seconds and Graph C about 3 seconds.

(b) Graph C shows relatively large variations in vertical acceleration over cycles averaging about 4 seconds. Graphs A and B indicate smaller and more frequent changes in vertical acceleration, consistent with small attitude adjustments as the aircraft accelerated on climb-out.

1.11.2 Cockpit voice recorder

The aircraft was equipped with a Loral Data Systems (Fairchild) model A100A cockpit voice recorder. The recording duration was about 30 minutes. Sound was recorded from a cockpit area microphone and the headsets of the pilot in command and the co-pilot. The quality of the recording was good.

Parts of the record of communications from the cockpit voice recorder are reproduced on the flight data recorder graphical presentation at appendix 2 and the transcript at appendix 3. This is not a complete transcript of the recording during this period: only those words pertinent to the analysis of the flight have been included. Elsewhere, the recorded conversation has been paraphrased.

1.12 Wreckage and impact information

1.12.1 Accident site description

The accident occurred on flat terrain adjacent to the Tamworth–Gunnedah road, approximately 400 m east of the runway 30R threshold (figure 1).

The elevation at the initial impact with the tree was approximately level with the upwind end of runway 12L, i.e. about 1,326 ft AMSL.

1.12.2 Impact information

The aircraft was banked about 11 degrees left and tracking 113 degrees when it struck the tree. After passing through the top of the tree, the aircraft crossed the Tamworth–

Gunnedah road and rolled rapidly left, striking and severing high-voltage powerlines on the north-eastern side of the road. By this stage it had rolled about 90 degrees. The left wingtip then contacted the ground shortly before the aircraft struck other trees as it continued to roll left. The right propeller and the right forward fuselage then struck the ground. The aircraft then collided with the ground inverted and slid about 70 m before coming to a stop.

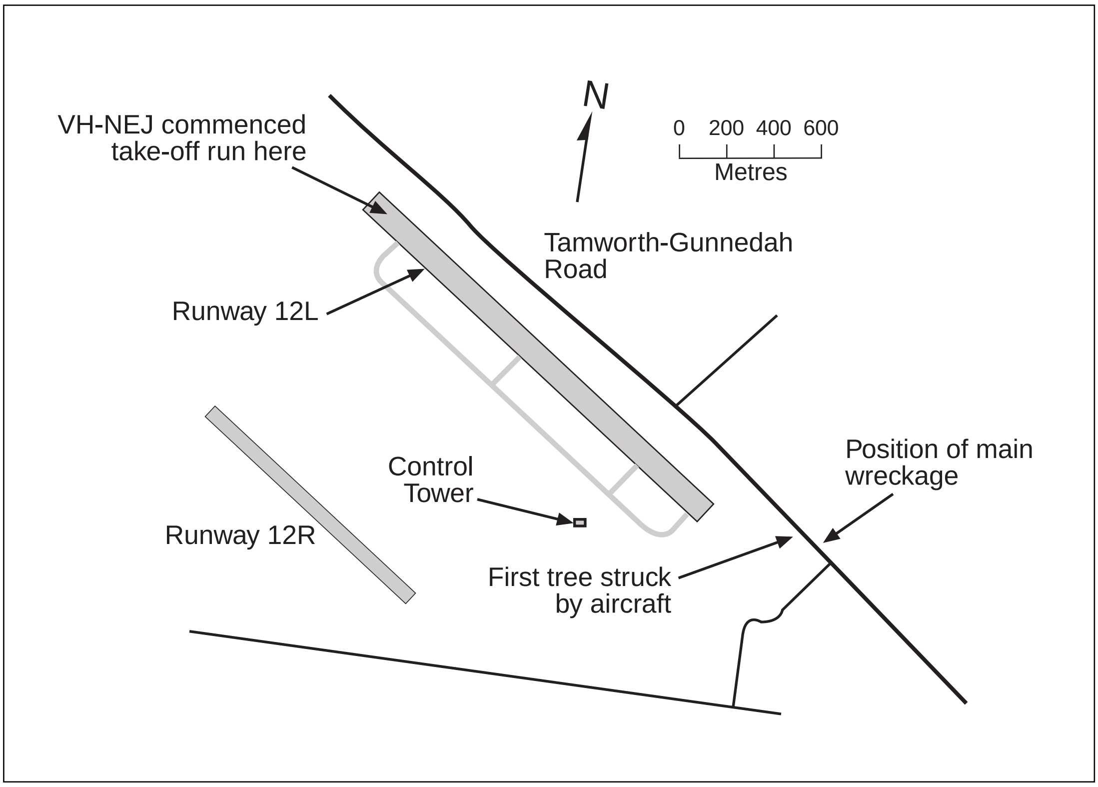


FIGURE 1 Tamworth Airport and surrounds, showing accident location in relation to runway 12L

1.12.3 Aircraft wreckage description

Except for the empennage and the nose section forward of the windscreen, the fuselage and wing centre section were burnt out, and the flaps partially destroyed. There were no witness marks on the remaining flaps structure to indicate their pre-impact position. The left wing flap actuator ram extension was 45 mm while the right ram extension was 19 mm.

FIGURE 2 Wreckage viewed back along the impact path

Examination of the cockpit revealed the following:

(a) The flap selector was between the ONE-QUARTER extended and UP positions.

(b) The landing gear selector was in the UP position.

(c) The emergency landing gear release handle was in the STOWED position with the locking pin engaged.

Engines

Examination of the engines revealed that the torque shaft assembly in each engine, located within the high-speed pinion gear, had sheared in torsional overload. Advice from the manufacturer indicated that shaft failure could result from the sum of the steady engine torque plus the momentary torque spike, caused by the impact, combining to exceed the pinion gear ultimate stress limit. The likelihood of such a failure would be greater at high propeller RPM than at low RPM.

Propellers

Detailed examination of the propeller hubs established that, at initial ground contact, the blade angle of the left propeller was 8.5–9 degrees, while that for the right propeller was 12.5–13 degrees. These angles were consistent with the right engine being at a high power setting and the left engine at a reduced power setting.

Landing gear

The position of the landing gear at impact could not be positively established.

A video recording taken shortly after the accident, while the aircraft was still on fire, showed the left main gear leg in what appeared to be the extended position. The right gear leg was not visible (see figure 3).

FIGURE 3 Image from video recording, showing the left main landing gear leg extending upwards from the inverted left wing

1.13 Medical and pathological information

Post-mortem examination of the co-pilot could not confirm that he was suffering from an upper respiratory tract infection at the time of the accident, or from any other condition which might have affected his performance.

1.14 Fire

Witnesses reported seeing a large blue flash, followed by two fireballs at about treetop height, and then hearing two loud explosions. A trail of fire was observed extending forward from the fireballs to the aircraft. It is likely that fuel lines and/or tanks were disrupted when the aircraft struck the first tree and that ignition followed shortly thereafter.

Witnesses who attended the crash site brought with them a number of hand-held fire extinguishers. When they arrived at the scene, the wings and fuselage centre section were on fire. The extinguishers were immediately activated in an attempt to prevent the fire reaching the cockpit area. However, the fire quickly intensified and spread, rendering the extinguishers ineffective. The fire was accompanied by a number of explosions which created a hazardous situation for those operating the extinguishers. By the time the first fire appliance arrived, the fuselage was burning fiercely.

1.15 Survival aspects

1.15.1 General

The forward fuselage came to rest on its right side. The angle of impact was relatively shallow onto flat ground. The check-and-training pilot, who had limited recall of the impact sequence, believed he climbed out through the left-side pilot's window.

The post-mortem examination report on the co-pilot, and the degree of damage to the right side of the cockpit, indicated that he was unlikely to have survived the impact. There was evidence that the other trainee survived the impact but was overcome by the effects of smoke and fire.

During the impact sequence, the aircraft structure received progressively more damage as it contacted trees, powerlines, and the ground. Evaluation of the impact forces under such conditions was not practicable due to the difficulty in assessing the values of the different collisions during the crash sequence. Survivability was, however, compromised by the damage to the right side of the cockpit and by the fire (see figure 4).

1.15.2 Emergency services response

The aerodrome controller activated the Common Crash Call at 1959. The hospital, ambulance and police answered almost immediately and the Tamworth Fire Brigade answered after about 2 minutes. Police and ambulance vehicles arrived at the crash site about 5 minutes after the call, at 2004. The first fire-fighting appliance was on site at about 2011.

There was no dedicated rescue/fire-fighting capability at Tamworth Airport at the time of the accident.

FIGURE 4 Nose section of aircraft, showing impact damage to right side

1.16 Tests and research

As the investigation progressed, it became evident that the absence from the DFDR data of the parameters of altitude and airspeed would limit the conclusions which could be drawn regarding aircraft performance. The decision was therefore taken to conduct flight tests in a similar aircraft to obtain a more complete picture of aircraft behaviour during the accident flight.

The tests addressed two areas:
(a) aircraft climb performance with one engine inoperative; and
(b) evaluation of NEJ performance during the accident flight.

The aircraft used for the tests was of a similar build standard to that of NEJ and was configured so that weight and centre of gravity closely resembled those of NEJ. The flight-idle torque indication for the left engine in the test aircraft was between 0% and -2 %.

According to the pilots who flew NEJ shortly before the accident, the indicated flight-idle torque was approximately 6-8%. However, due to the degree of damage to the aircraft, the actual flight-idle torque could not be determined.

1.16.1 One-engine-inoperative climb performance

The one-engine-inoperative climb performance tests revealed that the single-engine climb performance with an engine at flight-idle could be significantly different to that available when an engine was shut down and the propeller feathered or when the propeller was operating in the NTS mode (see para. 1.21). This depended on the condition of the aircraft and the flight-idle torque setting. There was no data available for single-engine climb performance other than with the propeller in the NTS mode.

In the test aircraft, with the landing gear retracted, one-quarter flaps extended, the left propeller feathered and 86% torque set on the right engine, the rate of climb at an indicated airspeed of 110 kts was in excess of 400 ft/min. By comparison, under the same conditions but with the 'failed 'engine at flight idle, the rate of climb was 110–140 ft/min.

1.16.2 Evaluation of NEJ takeoff

The aim of these tests was to evaluate the vertical and horizontal acceleration profiles recorded during the accident flight. Within the bounds of safe practice, the following restrictions were applied:

(a) All published airframe and engine limitations were observed.

(b) Minimum altitude was 3,000 ft.

(c) All control inputs were applied smoothly, particularly when they were large and/or rapid compared to control movements normally used during flight.

(d) No attempt was made to replicate the 10-degree heading change which occurred in NEJ immediately after the simulated engine failure was initiated.

The following points concerning the tests were relevant:

(a) Control column movements in the order of 10 cm forward and aft of the central position were required to generate pitch oscillations and thus vertical acceleration profiles similar to those recorded in NEJ. Considerable pilot effort was required to initiate and sustain the pitching manoeuvre.

(b) The frequency of the vertical accelerations was about 4 seconds per cycle, similar to that recorded in NEJ.

(c) Approximately three-quarters right rudder input was required to control yaw. To maintain a wings-level attitude, up to three-quarters aileron deflection was required within 1 second of the power lever reaching the flight-idle detent.

(e) When the left power lever was retarded to flight-idle, the rate of increase of indicated altitude fell to about zero. After this, during one simulation, the indicated altitude remained steady initially, before falling slowly by about 50 ft during the pitch oscillations. On a second simulation, altitude changes of 40–80 ft up and down were recorded during the pitching cycles, but there was no significant net altitude gain.

(f) The indicated airspeed increased by about 4 kts after the landing gear was retracted.

(g) The pitch oscillations created changes of about ± 5 degrees on the aircraft attitude indicator.

1.16.3 Information from the aircraft manufacturer

The conclusions from the flight tests were forwarded to the aircraft manufacturer for comment. The manufacturer advised that the differences in performance achieved during the flight tests compared to the aircraft flight manual performance data were due to flight-idle torque not being at the optimum level of 10–12%. The manufacturer was aware that some operators adjusted flight-idle fuel flow settings to outside the recommended range. (The Tamair policy was for flight-idle fuel flow to be set within the manufacturer's recommended range). The manufacturer stated that its flight test reports, performance data and test pilot experience indicated that the flight manual data was correct.

1.17 Aircraft systems and equipment

1.17.1 Powerplants

The engines and propellers on Metro III aircraft operate at selected, constant RPM. The normal take-off setting, referred to in the checklist as 'high RPM', is 100% RPM indicated by the cockpit instrumentation. The power settings (torques) used during flight are achieved by changing the propeller blade angles rather than by significant changes in engine rotational speed.

Flight-idle is the lowest power setting available during flight. Movement of the power lever below this position requires the operation of a latch mechanism.

1.17.2 Landing gear warning system

The Metro III Flight Manual stated that the aircraft was equipped with a warning horn which sounded whenever the following conditions were met:
(a) Any landing gear downlock switch has not been closed, and
(b) Either engine power lever is at the flight-idle gate (Note 1), or
(c) The flaps are extended beyond the 1/2 (18 degrees) position (Note 2).

Notes

1. The microswitches at the flight-idle gate are adjusted to sound the aural warning at the gate and through power lever travel approximately 3.2 mm forward of the gate. That range corresponds to flight-idle power.
2. If the landing gear warning is generated because the wing flaps are extended beyond the half position, and any landing gear is not down and locked, the warning cannot be silenced by either power lever manipulation or the mute button.

Under normal operating conditions, the landing gear warning horn will not activate during gear retraction. However, if either power lever is retarded and the landing gear is in a position other than down and locked, the horn will activate and continue to sound until the landing gear is down and locked, or the power lever is moved sufficiently forward of the gate.

The warning horn will normally cease to sound about 6 seconds after the landing gear has been selected up.

The landing gear emergency release handle and the gear uplocks are connected by cables running below the cabin floor on either side of the fuselage until they branch into the wings. A locking pin prevents accidental activation of the emergency release handle. Activation of the emergency release prevents the normal retraction cycle from operating and causes the horn to continue to sound if the landing gear is selected up under such conditions.

1.17.3 Aircraft instruments

VH-NEJ instrument fit

The instrument fit in NEJ met the regulatory requirements. It included two AIM 510-8D attitude indicators. Pressure instruments included two airspeed indicators, two altimeters, and two vertical speed indicators. The aircraft was not fitted with an instantaneous vertical speed indicator, radio altimeter, or ground proximity warning system. There was no auto-pilot or flight director fitted to the aircraft.

Pressure instrument errors

Pressure altimeters and vertical speed indicators are subject to errors. The most significant of these is lag, whereby the instrument indication does not instantaneously reflect the performance of the aircraft.

1.18 Flight simulator training

The nearest Metro III flight simulator suitable for training was in the USA. Some senior Tamair pilots, including the check-and-training pilot on NEJ, had undergone simulator training while in the USA taking delivery of Metro III aircraft.

Flight simulators provided the obvious safety benefit of enabling emergency procedures training to be conducted without risk. Flight simulator fidelity was such that full type-conversions were authorised in many cases. This included the conduct of emergency procedures such as V_1 cuts. However, there was no regulatory requirement for simulators to be used in pilot training. In practice, the larger regular public transport operators used simulators for type-conversion and recurrent training of crews. This contrasted with the situation facing smaller operators, such as Tamair, which did not have ready access to a simulator and therefore conducted emergency procedures training in the aircraft itself.

1.19 Metro III handling

1.19.1 General handling

Pilots who had flown the Metro III described it as having a heavier feel and a slower response to control inputs compared to smaller twin-engine aircraft such as the Cessna 310 and Piper PA31. There was also a significant increase in operating speeds compared to these aircraft. Their consensus was that it was ‘a big step’ for pilots progressing from a light twin to the Metro III. There was also the concept of V_1, V_R and V_2 speeds which applied to the Metro III but which were not relevant for aircraft below 5,700 kg because of the different certification standards applying to aircraft above and below 5,700 kg maximum all-up weight (MAUW).

1.19.2 Take-off speed schedule

V_1, V_R, and V_2 are a function of aircraft weight, outside air temperature (OAT), and pressure altitude. They may be determined from charts within the flight manual, or from printed cards carried within the aircraft. At an aircraft weight of 5,600 kg, a pressure altitude of 1,000 ft, and an OAT of 20 degrees Celsius, the chart indicated the take-off speed schedule to be V_1 100 kts, V_R 102 kts, and V_2 109 kts. These were the speeds briefed by the crew before takeoff.

1.19.3 Metro III single-engine take-off performance

Data on the Metro III single-engine take-off performance was extracted from the aircraft flight manual. At a take-off weight of 5,600 kg, a pressure altitude of 1,000 ft, engine anti-ice and bleed air off, and with landing gear and flaps up, the aircraft should have been capable of a rate-of-climb of about 750 ft/min. The single-engine best rate of climb speed (V_{yse}) was 125 kts. The data indicated that the take-off distance required, that is, the distance required to accelerate from a standing start to V_2 and to attain a height of 35 ft following recognition at V_1 of the failure of the critical engine, was 1,463 m. The right engine is the critical engine in the Metro III.

Application of the above calculated performance data to Tamworth runway 12 revealed that, if the aircraft maintained V_2 from the 35-ft point, it would have crossed the upwind end of runway 12 at a height of about 226 ft (69 m) above ground level. No data was available for aircraft speeds below V_2. However, if V_2 was not maintained, climb performance would have been substantially degraded. Had the aircraft flown level after reaching the 35-ft point, its ground clearance at the upwind end of runway 12 would have been about 15 ft (4.5 m).

1.19.4 Take-off and V_1 cut technique

The take-off technique appropriate to the Metro III, and common to aircraft above 5,700 kg MAUW, involved the pilot transferring his visual reference from outside the cockpit to the aircraft flight instruments at the commencement of rotation and conducting the takeoff and initial climb predominantly by reference to the cockpit instruments. Rotation should have been initiated at V_R at the rate of about 2 degrees per second to a pitch attitude of 10 degrees nose up, which was held as the aircraft became airborne and accelerated. This technique applied to all takeoffs, irrespective of weather or light conditions. The long nose section of the Metro III restricted forward visibility such that, in a normal (10 degrees nose-up) climb attitude, the horizon ahead of the aircraft was not visible.

Information from experienced Metro III check-and-training pilots was that, for co-pilot endorsees who were progressing from aircraft below 5,700 kg MAUW to the Metro III, particular attention had to be given to take-off technique. Detailed briefing and as many as seven takeoffs were required before trainees were able to perform the correct technique in the Metro III. The check-and-training pilots considered that it was important for the trainees to reach this standard before being given a V_1 cut.

The V_1 cut procedure itself required precise control of the aircraft. Aircraft performance would have been rapidly eroded if the attitude was not set accurately and if appropriate yaw and roll inputs were not made. It was important to retract the landing gear early to reduce drag.

1.20 Aircraft endorsements

1.20.1 Regulatory requirements

The requirements for the issue of command and co-pilot endorsements were detailed in CAO 40.1.0 appendixes III and V respectively. Each involved the completion of a syllabus or approved schedule of training of at least 5 hours duration.

Among other things, the conversion syllabus requirements for the issue of a command endorsement included:
(a) stalling in various configurations;

(b) in relation to asymmetric flight, 'the attainment of optimum performance following engine failure on takeoff after critical speed has been reached (at least twice)'; and
(c) at least four night circuits.

This compares with the conversion syllabus requirements for a co-pilot endorsement which included:
(a) stalling—nil;
(b) in relation to asymmetric flight, flight with one engine inoperative during cruise; and
(c) at least three night circuits.

1.21 Practice asymmetric operations

Simulated engine failure—piston engine aircraft

When simulating an engine failure in a piston-engine aircraft, it is appropriate to retard the throttle to IDLE and only move it forward to a 'zero thrust' position when the crew has simulated feathering the propeller. This technique simulates an actual piston-engine failure where the propeller 'windmills' in a high-drag condition until it is feathered by the crew.

The negative torque sensing (NTS) system

The engines fitted to Metro aircraft are equipped with a NTS system which automatically adjusts propeller blade angle when a negative torque condition is sensed. However, there is no automatic feathering of the propeller. In the event of an engine failure, the NTS system substantially reduces drag which would otherwise arise from the windmilling propeller. This reduction in drag enhances the aircraft's climb performance in the critical period between the engine failure and the crew's action in feathering the propeller.

Zero thrust

For obvious safety reasons, industry practice is for engines not to be shut down during training in asymmetric flight. Instead, what is commonly referred to as 'zero thrust' is set on the 'failed' engine to simulate the aerodynamic drag of the propeller in the feathered configuration.

The aircraft manufacturer advised that 'zero thrust' was equivalent to approximately 10–12% indicated torque with the aircraft at take-off speed.

Some experienced Metro operators were aware of this information, and that the figure would vary slightly depending on temperature and altitude. Determination of an appropriate zero thrust setting also depended on factors such as the condition of the engine and airframe as well as the accuracy of the torque-indication gauge.

Rigging of the propeller-engine combination and the idle fuel-flow setting directly affected the indicated torque when the power levers were at flight-idle. This flight-idle torque could be different to 'zero thrust' torque. Therefore, simulation of an engine failure should be conducted by retarding the power lever to an indicated torque equivalent to zero thrust rather than to flight idle.

1.21.1 Metro III flight manual

The Metro III FAA Approved Airplane Flight Manual contained information concerning operations with one engine intentionally inoperative. This included the following:

> The intentional one engine inoperative speed V_{sse} is the speed above which an engine may be intentionally and suddenly flamed out for pilot training purposes and must not be confused with the demonstrated minimum control speed (V_{mca}). V_{sse} is to be used as the starting speed when training pilots to recognise the low speed, single engine, handling qualities and performance of the Metro III. After ensuring proficiency in controlling the airplane at V_{sse}, it is permissible to slow down with one engine inoperative toward Vmca to further increase the trainee's awareness, proficiency, and confidence.

Note

Retarding a power lever to the flight-idle stop to simulate a failed engine at low airspeed will provide approximately the same control and performance problems as will rendering an engine inoperative intentionally. Power lever chops do not adversely affect the engine. With the failed engine at flight-idle power, it is readily available to be used to recover from excessive loss of airspeed, altitude, control, or possible difficulties with the operating engine.

WARNING

FAIRCHILD AIRCRAFT CORPORATION RECOMMENDS THAT THE INHERENT SAFETY MARGINS IN SIMULATING ENGINE FAILURE , RATHER THAN ACTUALLY RENDERING IT INOPERATIVE, BE USED DURING PILOT TRANSITION AND CHECK OUT.

> If it is deemed necessary to intentionally render an engine inoperative during initial climbout for pilot training or checkout, the following conditions define the circumstances under which the chosen V_{sse} is valid. Check Takeoff Weight Limitation Charts in Section 4 for conditions more critical than those shown.
>
> Prior To Intentional Engine Failure

Airport Density Altitude	5,000 ft Maximum
Minimum Altitude	100 ft above ground
Both engines	Take-off power (engine anti-ice off)
Landing gear	Retracting or retracted
Gross weight.	14,000 lb maximum
Bleed air.	On or off
Airspeed (V_{sse})	115 kts Minimum

1.21.2 Tamair interpretation of Metro III flight manual

The interpretation of the flight manual conditions by Tamair was that they applied to situations where the engine was actually shut down, and not to simulated engine failure situations. Further, the company considered that if the parameters listed in the flight manual were adopted, then the regulatory requirements for command endorsements would not be satisfied. Its interpretation of the CAO 40.1.0 requirement concerning ‘engine failure on takeoff after critical speed’ was that the critical speed was V_1. Engine failure exercises conducted in the Metro III at 115 kts would not allow compliance with the ‘critical speed’ requirement.

1.21.3 Tamair policy and practice

Section C-3 of the Tamair Operations Manual, Standard Operating Procedures, included, at para. C3.5, ‘Method of simulating engine failure for training’. This paragraph stated, in part: ‘The simulation of an engine failure shall be carried out by slowly retarding the throttle/power lever of the engine required’. There was no reference in the section to setting ‘zero thrust’.

When Tamair acquired its first Metro III, the chief pilot underwent type-conversion training conducted by a pilot from the manufacturer. The chief pilot indicated that the pilot did not adopt the flight manual minimum conditions listed at para. 1.21.1 for simulated engine failures. He made no reference to ‘zero thrust’ during the training and set flight-idle power when simulating an engine failure, including during V_1 cuts. The chief pilot also stated that he had never received any formal advice concerning the setting of ‘zero thrust’ in the Metro III. Based on his experience in another turboprop aircraft type, he was conscious of the possible effect of flight-idle power on aircraft performance. He therefore adopted the technique during V_1 cuts in the Metro III of initially setting flight-idle on the ‘failed’ engine, and then advancing the power lever forward so as to extinguish the gear warning horn after the flying pilot had called for the propeller to be feathered. This usually resulted in a torque indication of about 10%. At the time of the accident, other Tamair check-and-training pilots, including the check-and-training pilot in NEJ, used a similar technique, although the ‘zero thrust’ torque setting used varied from 10% to 15%. The check-and-training pilot in NEJ used 15%.

1.21.4 Other practices

Discussions with other Metro operators and CASA FOIs, who were endorsed on the aircraft, revealed different methods of engine handling during simulated engine failures. While some pilots were aware that flight-idle torque may not be equivalent to zero thrust, there were differing views on what the zero-thrust setting was.

The technique employed by one operator was to initially set flight-idle torque, and adjust torque to between 10% and 12% when the pilot called for the propeller to be ‘feathered’. Another operator, who had extensive experience in operating Metro aircraft, initiated a ‘failure’ by reducing torque to the zero-thrust setting. One overseas operator used between 3% and 5% torque as zero-thrust but the failure was not initiated until the landing gear retraction cycle had begun, while another used flight-idle throughout the procedure. One CASA FOI set flight-idle torque throughout the procedure while another set flight-idle initially and, after the propeller was ‘feathered’, advanced the throttle until the landing gear warning horn ceased.

The pilot who conducted the flight tests referred to in para. 1.16 above, and a CASA FOI, each indicated that an appropriate technique to simulate an engine failure on takeoff, which took account of performance and instrument variations for each aircraft, would be as follows:

(a) Determine from the aircraft flight manual the one-engine-inoperative climb performance for the prevailing atmospheric conditions and aircraft weight.

(b) In flight, at V_2 speed and with one engine set at take-off power, measure the torque required on the other engine to produce the one-engine-inoperative rate of climb taken from the flight manual. This torque setting should be equivalent to zero thrust for that engine.

(c) When conducting simulated engine failure exercises, the failure should be simulated by reducing engine torque to not below the zero-thrust torque figure earlier determined.

1.21.5 Other Garret-powered aircraft

The flight manuals of other aircraft types powered by Garrett TPE -331 engines contained different information to that in the Metro III flight manual concerning the use of flight-idle power. For example, one stated that at low airspeed, 'a feathered propeller condition could be simulated by reducing the power on either engine to zero thrust', approximately 10% torque at low altitudes and indicated airspeeds between 105 kts and 125 kts. Another warned that the 'use of flight-idle power to simulate a failed engine will result in significant asymmetric drag'.

1.22 Leg-for-leg operations

1.22.1 Background

Leg-for-leg operations involved the pilot in command and co-pilot taking turn about as flying pilot on a sector-by-sector basis. Leg-for-leg operations were employed in most companies which operated multi-crew aircraft.

1.22.2 CASA policy

There was no CASA policy specifically addressing leg-for-leg operations and there was no regulatory requirement for V_1 cuts to be included as part of co-pilot type-conversion training. However, the CASA FOI responsible for oversighting Tamair indicated that, as future pilots in command, co-pilots needed to build skills and knowledge in operating the aircraft. Hence, it was necessary for them to fly leg-for-leg and to be proficient in handling V_1 cuts.

1.22.3 Tamair policy

Tamair operated a leg-for-leg policy for its Metro III operations. The company considered it necessary for co-pilots to comply with its interpretation of the requirement of CAO 40.1.0 for the attainment of optimum aircraft performance following engine failure on takeoff. Hence, the company included V_1 cuts as part of co-pilot type-conversion training. Some co-pilots had received only one V_1 cut during their training and had not been confident, until they had gained considerable experience on the aircraft, of being able to adequately handle an actual engine failure during takeoff. One co-pilot had not completed any V_1 cuts during training before commencing leg-for-leg operations.

1.23 Night asymmetric training

1.23.1 Background

Asymmetric flight during the takeoff and initial climb phases is one of the most demanding situations a pilot may face. In such circumstances, whether simulated or real, many aircraft are close to their performance and controllability limits and the actions of the flying pilot are critical to ensure that control of the aircraft is maintained. Under such conditions, perceptions of the aircraft's attitude and its proximity to obstacles assume even greater importance than usual. Consequently, the absence of adequate visual definition of the horizon and surrounding topography will increase pilot workload.

1.23.2 Aeronautical Information Publication (AIP) Australia, Operations, Special Requirements, para. 77—Circuit Training at Night

On 10 July 1978 a Partenavia P68B aircraft crashed shortly after takeoff near Essendon Airport, Victoria. The accident occurred at night following a simulated failure of one of the engines. It was in response to this accident that AIP (OPS), Special Requirements, para. 77, Circuit Training Operations at Night was introduced. This paragraph stated:

> Aircraft engaged in training operations at night in the circuit area shall not, when below 1,500 ft AGL, carry out any manoeuvres which involve:
> a. the simulation of failure of an engine; or
> b. flight in a simulated one-engine-inoperative condition; or
> c. the intentional shut-down of a serviceable engine.

At the time of the accident involving NEJ, there was no definitive legislation which gave legal effect to AIP (OPS) para. 77.

1.23.3 Tamair Operations Manual reference

The Tamair Operations Manual, sub-section C2.5.3 Flight Checks, which was current at the time of the accident involving NEJ, stated: 'Night asymmetric operations shall be conducted within 10 nautical miles of an airport suitable for landing at not less than 2,500 ft AGL'.

1.23.4 History of night asymmetric training within Tamair

The company advised that, since it began RPT operations, pilot turnover had been an ongoing concern. Between November 1994 and September 1995, seven of the 12 Metro III captains in the company had resigned. Most of these had gained employment with larger RPT operators. By March 1995, the company concluded that a high pilot turnover rate was likely to continue. In turn, this meant a substantial ongoing commitment to Metro III training. At the same time, Tamair had only one Metro III aircraft at Tamworth. This aircraft was heavily utilised during daylight hours on scheduled flights to/from Sydney. The company determined that, to meet the predicted training commitments, some training would have to be conducted at night, in addition to the 'at least three' night circuits required by the regulation.

The initial type-conversion training of company pilots on the Metro III was conducted by a pilot from the manufacturer. This training included night asymmetric flying and night V_1 cuts.

In early 1995, the company requested data on night accidents involving training in multi-engine aircraft from the US National Transportation Safety Board with a view to arguing to the CAA that, because accidents involving asymmetric flight occurred at night, then night asymmetric training was justified. The Tamair chief pilot and a company check-and-training pilot conducted a number of V_1 cut procedures at night and assessed that the exercise could be conducted safely. At around the same time, night asymmetric training was discussed at a Tamair pilots meeting and then raised in writing with the Tamworth District CAA office. The letter to the CAA, dated 7 March 1995, stated:

> Tamair requests approval, to be reflected in our Operations Manual, to extend night asymmetric operations.
>
> Requested, is approval to conduct simulated asymmetric operations without altitude restrictions. Provisions obviously must be accepted. Tamair suggests the following:
>
> a) must be VMC
>
> b) no multiple system emergencies except those common to the simulated failed engine (in other words, no failed system such as artificial horizon nor double hydraulic failure for example).
>
> Due to the nature of Tamair's operations, aircraft are usually not available for training purposes until late at night. As you are aware, asymmetric operations are required to satisfy standards for endorsement, currency and instrument renewals.

On the same day, the then Tamworth DFOM referred the request to the Manager Flying Operations, CAA, Canberra. The memo indicated that the Tamworth District Office was considering granting the request subject to conditions (which were not stated). However, before proceeding further, the DFOM wished to establish whether there was any CAA policy regarding such training. The Manager Flying Operations responded by referring him to AIP (OPS) para. 77, and stated: 'As far as we can determine it, unfortunately, doesn't have a head of power but has, nevertheless, been "policy" for a considerable period of time'[*sic*].

Tamair was then advised by the responsible FOI that AIP (OPS) para. 77 had no legislative power and was therefore not legally binding. The FOI suggested that Tamair submit an amendment to the section of its operations manual which dealt with night asymmetric training. The FOI indicated that this response to Tamair was informal. There had been no written response to the request. As a result of this discussion, the chief pilot advised company pilots that the operations manual was being amended to allow night asymmetric flight below 1,500 ft AGL.

The FOI, who at the time of the accident was DFOM, awaited the proposed operations manual amendment. This was the situation at the time of the accident. He indicated that, while he was aware that Tamair included V_1 cuts as part of co-pilot type-conversion training, he was not aware that such exercises were being conducted at night. His opinion was that, while night V_1 cuts might be appropriate for command training, they should not be given during co-pilot type conversions. He had not expressed this view to Tamair and had given no other advice to the company concerning night asymmetric operations beyond informing them that AIP (OPS) para. 77 had no legislative power and that an operations manual amendment should be submitted.

The chief pilot's intention was to include the operations manual amendment in the re-write of the complete manual. His view was that, because the regulator accepted rather than approved operations manuals, the authority of the document was reduced. Thus, it was acceptable to commence night asymmetric training on the basis of his intention to amend the manual, even though such training contravened the manual current at the time.

The check-and-training pilot in NEJ believed, at the time of the accident, that it was legal to conduct V_1 cuts at night. This belief was based upon advice from the chief pilot concerning the lack of authority for AIP (OPS) para. 77 and that the operations manual had been amended, although he had not seen the amendment.

It was reported that other company check-and-training pilots had conducted V_1 cuts at night during training. This included instances of pilot in command and co-pilot endorsees being given V_1 cuts on their first takeoff in the Metro III. There was no evidence that any special training (other than the flight simulator training referred to at para. 1.18.) had been undertaken by check-and-training pilots who were so involved, or that any restrictions were placed on who should undergo training in night V_1 cut procedures.

1.24 Additional information from the check-and-training pilot

The check-and-training pilot said that he was certain the co-pilot had been joking when he responded to the check-and-training pilot's statement that they were going to do a V_1 cut. He judged this from the way he spoke and his facial expression. Further, the check-and-training pilot indicated that the V_1 cut had been briefed before the initial flight and the co-pilot had raised no objection at that stage. The check-and-training pilot was therefore not concerned about what the co-pilot had said.

The recollection the check-and-training pilot had of the accident sequence was incomplete. However, he did provide the following information:

(a) NEJ had no maintenance requirements and was available for his use for the whole weekend. Because of the groundschool examination during the morning, he planned to begin the training at about 1430 hours. Each trainee had to complete three night circuits so he planned to do some night flying on 16 September, and some the next night. In any event, the training was not required to be completed until the end of the following weekend.

(b) His understanding from the chief pilot was that asymmetric flight at night below 1,500 ft AGL was 'perfectly legal' as the AIP prohibiting the procedure had no enabling legislation.

(c) He was told by the chief pilot that para. C2.5.3 of the operations manual was being removed.

(d) The check-and-training pilot did not see any written confirmation of the advice he had received from the chief pilot concerning night asymmetric operations below 1,500 ft AGL.

(e) He was aware that the co-pilot had recently completed base checks in Cessna 310 and PA-31 aircraft and knew that simulated engine failures during takeoff were part of the check procedure. On this basis, he believed the co-pilot was in current practice with respect to asymmetric flight. He had been impressed with the co-pilot's handling of the aircraft on the initial flight and thought he had flown accurately.

(f) At lift-off, the co-pilot over-rotated the aircraft to an attitude of about 16 degrees nose-up. This had prompted his call for the co-pilot to set 'just 10 degrees'.

(g) Power on the right engine was not adjusted from the 88% torque set for the takeoff.

(h) He could not remember aircraft heading or the position of the skid ball on the turn-and-balance indicator.

(i) He did not follow the co-pilot through on the controls and could not recall how much rudder or aileron the co-pilot had applied.

(j) After selecting the landing gear up, he recalled no indication that the retraction cycle did not operate normally.

(k) He remembered seeing a rate of descent at some stage and thought that he had started to advance the left throttle at this point.

(l) For his check-and-training approval, he presented a section of the Metro III groundschool to a CASA flying operations inspector. He then completed some flying training with the chief pilot, which included V_1 cuts. He was then flight-checked by CASA in both the left and right cockpit seats and awarded check-and-training approval.

1.25 Engine failure rates

The engine manufacturer advised that, worldwide, there were 10 in-flight shut-downs of Garrett TPE-331 engines in the 12 months to June 1996. During this period, the engine type operated for almost 900,000 flying hours, for an average in-flight shut-down rate of one in 90,000 hours

1.26 Corporate culture

By 'corporate culture', we mean:

> Shared values (what is important) and beliefs (how things work) that interact with an organisation's structure and control systems to produce behavioural norms (the way we do things around here) (Uttal, 1983).

1.26.1 Background

The company was purchased by its current owners in 1985 as a small flying training and charter organisation. From 1985 to 1991, both these areas expanded and additional aircraft were purchased. In 1991, Tamair began operating turbine powered aircraft with the purchase of a Turbo Commander aircraft. Tamair began RPT operations in 1992 on the Tamworth to Bankstown route and in 1993 gained a licence to operate a regular public transport service on the Tamworth to Sydney route. It purchased a Metro III aircraft to operate the service. In the meantime, the flying training and charter sections of the company continued to operate.

At the time of the accident, Tamair operated up to seven Metro III return flights from Tamworth to Sydney each day. The number of passengers carried during the 1994/95 fiscal year exceeded 40,000.

The majority of Metro III pilots in Tamair had gained most of their flying experience with Tamair. Tamair preferred to employ pilots it had trained. In 1993, the managing director of Tamair was quoted in *Australian Flying* as saying:

> We only employ people we train at our flying school. We don't usually consider qualifications, like hours and ratings, we're looking for the right type of character, for young pilots who are intelligent and highly motivated (Elder, 1993).

The view was that pilots trained by Tamair, because they were familiar with the company, were easier to train and fitted in better with company norms. Pilots trained outside Tamair, while there were no problems with their flying abilities, understandably took time to adjust to Tamair's corporate culture.

The attitude towards V_1 cuts varied across the company pilot population. Experienced pilots accepted the procedure as an integral part of training and believed they were proficient at the procedure. However, most co-pilots had completed only one V_1 cut during their endorsement training (one co-pilot had not completed any). Some had flown the exercise at night and others in daylight and the position of the aircraft when the V_1 cut was initiated varied from a few feet to 300–400 ft above ground level. Most felt that they had had insufficient exposure to the procedure either to feel comfortable with it or to handle an actual engine failure after V_1 on takeoff.

A further view, common to both pilots in command and co-pilots, was that conversion training placed too much emphasis on emergency procedures at the expense of learning how to operate the aircraft normally. A number of pilots expressed the view that the first time they conducted an 'emergency free' flight in the aircraft was on their initial flight as a line pilot. For the more experienced pilots, this method of training was considered demanding but thorough. One pilot in command described his Metro III training at Tamair as the best type-conversion training he had ever received. Most co-pilots, however, felt that they had insufficient time in which to gain familiarity and confidence in normal operations before simulated emergency situations were introduced.

The company believed that, since the introduction of the Metro III at Tamair, increasing emphasis had been placed on training in abnormal conditions and configurations. When it introduced the Metro III, the company decided that it would arrange training through the manufacturer of the aircraft. This was the result of an accident involving a company aircraft in early 1991 in which the company felt that training had been an issue. The training provided by the manufacturer had strongly emphasised abnormal and emergency procedures and the Tamair training method reflected this.

Tamair management pilots were aged in their mid-thirties or less. Their flying experience was in the order of 5,000–6,000 hours. They had completed almost all this flying with Tamair, progressing to larger, more complex aircraft as the company developed. Similarly, the type of flying they conducted progressed through freight and passenger charter to RPT operations. Seven Metro III pilots in command had left Tamair in the 12 months prior to the accident. This resulted in significant recruitment from outside the company. Replacement pilots who were recruited from outside Tamair had been with the company for up to 18 months at the time of the accident. These individuals had substantial flying experience, including airline experience in some cases, and one was a Metro III check-and-training pilot at the time of the accident.

From within and outside the company, Tamair was described as a close-knit organisation with very high morale. Most company personnel interviewed during the investigation rated camaraderie and morale as the most positive aspects of their employment with Tamair.

1.26.2 Safety culture

By 'safety culture' we mean:

> the set of beliefs, norms, attitudes, roles and social and technical practices within an organisation which are concerned with minimising the exposure of individuals, both within and outside the organisation, to conditions considered to be dangerous (Pidgeon & O'Leary, 1995).

The concept of safety culture is not composed totally of tangible factors. There are many subtle factors which relate to the 'frame of mind' of company personnel which develop over time. The creation of a safety department is often an important step in the development of a company safety culture.

At the time of the accident, there was no CASA policy concerning safety departments or safety officers.

Tamair had no safety department or safety officer position at the time of the accident. However, the company was in the process of gaining ISO 9002 accreditation and considered this to be equivalent to having a safety department or safety officer. (ISO 9002 is a quality of service assurance accreditation program.)

Company management believed that Tamair was safety conscious. The managing director and chief pilot advised that they had an 'open door' policy and believed that company pilots who had a concern about any safety matter would feel able to raise the concern with management. However, this policy was not documented. Discussions with line pilots revealed that, while some felt that they were able to raise issues of concern with management, others stated that they would not always approach management on a safety issue.

The company advised that the flow of information within Tamair concerning operational policy and procedural changes was usually by way of written instructions to pilots. However, the issue of night asymmetric training was not advised in writing. Check-and-training staff, who met regularly, were aware of the changes in this area.

1.26.3 Relationship with CASA

Company management expressed the view that, after November 1994, regulatory interpretation had become narrow, as CASA placed greater emphasis on compliance. As a result, a system had arisen within Tamair which focussed on a literal interpretation of the regulations.

The company reported that it enjoyed a good relationship with the Tamworth District Office of CASA.

1.27 Regulatory aspects

1.27.1 Surveillance of Tamair

Surveillance activities on Tamair in the period before the accident included the following:

(a) a route check on the check-and-training pilot on 1 May 1995 (conducted at night in poor weather);

(b) a ramp check on a Metro aircraft at Tamworth on 1 August 1995; and

(c) a surveillance check flight conducted on the company chief pilot on 3 July 1995.

No deficiencies of note were recorded from these activities. There were numerous other contacts between CASA and Tamair, both formal and informal.

1.27.2 Relationship with Tamair

The Tamworth District office of CASA indicated that Tamair always cooperated and complied with any CASA requirement placed upon the company. The consistent impression was that the company was striving to improve its operations and procedures. In overview, however, CASA considered that Tamair needed experience from outside the company to improve its knowledge base. This had begun in late 1994 / early 1995 when the company recruited Metro III pilots externally. It was felt that, as these pilots integrated into the company, they would increasingly be able to influence company policy and procedures. At the time of the accident, however, this process was at an early stage.

1.27.3 Tamworth district flight operations manager (DFOM)

The Tamworth DFOM who was overseeing Tamair in the 9 months before the accident had been employed by the regulator since January 1995. The DFOM was an experienced pilot in both general aviation and RPT operations. His regulatory experience was limited to what he gained at Tamworth. His duties included oversighting Tamair and some 50-plus general aviation operators within his area of responsibility. His view of Tamair was that it was a young organisation, relatively low in experience, which nonetheless cooperated well in meeting regulatory requirements. His assessment was that the company was ‘trying hard’ and ‘doing its best’ in the RPT role, but that its knowledge base would benefit from more cross-fertilisation with the wider aviation industry.

1.27.4 Surveillance of Metro III operators

There were at least 12 operators of Metro type aircraft in Australia. Between them, they operated almost 50 Metro aircraft in both the RPT and passenger and freight charter roles.

CASA surveillance was undertaken by FOIs in the various offices responsible for these operators. There was no Metro ‘type specialist’ within CASA; nor was there any formal arrangement within the organisation for exchange of information between these FOIs. Of the FOIs spoken to during the investigation, all but one had completed Metro conversion training with the operator for whose surveillance they were responsible.

1.28 Manuals

1.28.1 Regulatory requirements

CAR 215 required an operator to provide an operations manual for use by operations personnel and stated that these personnel must comply with instructions contained in the manual.

CAO 82.3 applied to air operators certificates authorising regular public transport operations in other than high-capacity aircraft. Paragraph. 3.3 stated that an applicant for an AOC 'must, at least 60 days before the proposed commencement of operations, provide to the authority for its *approval* an operations manual' [emphasis ours].

1.28.2 Manual approvals

The Tamair Operations Manual current at the time of the accident was developed from the manual it operated under before it began RPT operations.

The Tamair Operations Manual had been checked and accepted by the CAA at the time the company was granted its AOC for RPT operations. Previous BASI investigations and discussions with CAA/CASA staff during this investigation indicated that it was CAA/CASA practice to accept rather than approve operations and training and checking manuals. In 'accepting' the manuals, CAA/CASA appeared to only check that the required sections were included and did not formally sanction the contents of each section. This practice is not in accordance with the requirements of CAO 82.

1.28.3 Tamair Operations Manual

At the time of the accident, the Tamair Operations Manual was being re-written. Rather than submit each individual change to CASA, the intention was to finish the re-write and submit the complete manual. The company intended to incorporate the amendment concerning night asymmetric flight as one of many changes which the new manual would include.

Section A1.4.2 of the operations manual listed the responsibilities of the chief pilot. These reflected the requirements of CAOs and included 'ensuring that all company operations were conducted in compliance with the CARs and CAOs'.

A general examination of the operations manual revealed the following:

(a) The manual appeared to be a compilation of a number of different manuals because page formatting varied and there were different printing sizes and styles.

(b) The manual contained references to superseded CARs and CAOs.

(c) There were references in the manual to section C2.4.1.4 which was not included in the document.

(d) The safety briefing sections for Cessna 310 and Turbo Commander aircraft made reference to aborting a takeoff in accordance with section B1.11.3.3. However, this section addressed how NDB and VOR approaches should be flown in the applicable aircraft.

(e) The section of the manual on each aircraft type stated that the minimum requirement for co-pilots to adopt the flying-pilot role was 10 sectors. The check-and-training section stated 10 hours or 10 sectors, whichever occurred last.

(f) Section C2.1.2 listed areas which should be covered by the ground engineering course, but there was no engineering groundschool syllabus in either the generic sense or specific to the Metro III.

(g) Deficiencies were also noted in the check-and-training section of the manual (see 1.29.2).

1.29 Check and training

1.29.1 Regulatory requirements

CAO 82.3 appendix 2 detailed the requirements of training and checking organisations in other than high-capacity aircraft. One of the requirements was that the operator provide a training and checking manual acceptable to the regulating authority. Paragraph 4.3 stated, in part, that the training and checking manual must include:

> course outlines, syllabuses and completion standards for each flight or simulator training programme currently in use (sub-paragraph (d));
>
> special procedures and limitations relating to the conduct of practice and simulated emergency and abnormal flight operations (sub-paragraph (f)).

The Manual of Air Operator Certification (MAOC) was a CASA document which consolidated the legislative and regulative requirements which were applicable to commercial operations. It incorporated the recommended practices for the guidance of both airline operators and CASA officers but was not intended as a legal document.

Volume 1 part A chapter 10 of MAOC described specific inspections. It had attached a number of appendixes containing instructions and checklists for inspections. The appendixes included:

(a) Syllabus review—appendix B1. Paragraph 1.2 referred to 'each *approved* syllabus' (emphasis ours). Paragraph 1.4 of this appendix listed the aspects which would be considered during the inspection. These included the following: 'Does the syllabus adequately cover the subject?', and 'Is there proper balance of topics within the subject?'.

(b) Appendix C3 was titled 'Approval of Check Pilots'. Paragraph 1.4 'Method of Conducting Approval' stated: 'The inspector must satisfy himself that the applicant has satisfactorily completed the course of instruction specified for his CAR 217 organisation before proceeding further.'

There were no guidelines as to what the 'course of instruction' should comprise. CASA gave informal advice that the intent was for prospective check-and-training pilots to undergo some training/preparation with the company before the formal check-and-training approval process began.

There was no reference in the appendix to the instructional technique of the applicant, either by way of considering any training done in the area, or by assessing the applicant's competence. CAR 217(4) stated that 'a pilot may conduct tests or checks for the purpose of an approved check-and-training organisation without being the holder of a flight instructor rating'. Among other things, flight instructors must complete a training course 'of at least 12 hours duration in instructional principles and methods' (CAO 40.1.7 appendix I). There was no syllabus of training for check pilots to complete as part of their approval process.

1.29.2 Tamair check-and-training system

The company's check-and-training system had been in place for about 5 years. The system had changed little during that period.

There was only one type-conversion syllabus in the manual (see copy at appendix 4). This syllabus applied to all aircraft operated by Tamair and did not address, in other than very broad detail, the processes and sequences to be covered at each phase of an endorsement. As such, and as the syllabus for Metro III type-conversion training, there were a number of deficiencies:

(a) The syllabus did not include the content of the pre-flight briefing.

(b) There was broad detail only concerning most of the in-flight sequences.

(c) The duration for each session was not stated.

(d) Engine failure during takeoff was not mentioned. The intent may have been for these procedures to be included as part of 'circuits—asymmetric' in Session III but this was not stated.

(e) Low-speed handling was not included in any session.

(f) The non-specific use of some terminology was inappropriate.

(g) The first reference to night circuits was in Session IV. The references to circuits in Sessions II and III did not specify day or night conditions.

(h) The syllabus did not contain sufficient information concerning completion standards for type-conversion training exercises, as required by CAO 82.3.

The manual also did not contain a course of instruction, or reference to other required training, for prospective check-and-training pilots to complete prior to approval.

The Tamair chief pilot indicated that the sequencing and content of conversion flight exercises was up to the individual check-and-training pilot. No specific directions were given concerning the stage of training at which night flying and/or V_1 cuts were to be introduced.

The chief pilot believed that the NEJ check-and-training pilot had completed 'methods of instruction' training. However, there was no record on his flight-crew history that he had completed this training. The check-and-training pilot advised that he had attended a Technical And Further Education (TAFE) course on instructional methods in 1987, before he joined Tamair.

1.29.3 Check-and-training approval of the check-and-training pilot

A search of CASA files revealed a copy of an electronic memorandum from the FOI who conducted the check-and-training approval for the check-and-training pilot as the only record of the approval. The memorandum advised that the check-and-training pilot was recommended for check-and-training approval. No check pilot report form, as required by MAOC, could be found.

The FOI who conducted the approval could not recall whether he had completed a report form but stated that he did not always follow the MAOC procedures. He said that its use was not compulsory, and that there had been frequent changes to the document since it was introduced, which had discouraged him from using it. He had a standard procedure for check-and-training approvals which included the check items contained in MAOC. The FOI could not recall other than very general detail of the approval. He indicated that he accepted the company's assurance that the check-and-training pilot had 'completed the course of instruction specified' as required in appendix C3 of MAOC. He did not check that there was a 'course of instruction' in the company's operations manual.

The flight(s) undertaken for the approval was not recorded in the FOI's pilot logbook. However, his diary indicated that he had conducted two flights totalling 3 hours in Metro III VH-NEK on 27 January 1995. The logbook belonging to the check-and-training pilot showed that he had flown with the FOI for 1.5 hours in NEK on 27 January 1995.

1.30 Carriage of additional trainees on training flights

1.30.1 Background

The practice of trainees—in addition to the normal crew complement—being carried on training flights is well established. Many multi-crew aircraft are equipped with one or more 'jump seats', either in the cockpit area itself, or in the cockpit entrance. Because jump seats are crew seats, they are fitted with full safety harnesses.

In some aircraft, the size of the cockpit and its entrance precludes the fitment of a jump seat. As a result, if additional trainees are carried on flights in such aircraft, they must occupy a passenger seat. Whereas jump seats provide a close view of cockpit activity, the view from the front row passenger seats is limited.

The interior configuration of the Metro III aircraft includes a partition immediately behind the cockpit seats. A central opening allows crew access to the cockpit. Probably because of the limited space available, there is no jump-seat fitted. The normal procedure in Tamair was for additional trainees to occupy the front left passenger seat. This allowed a limited view of the cockpit (see figure 5). Trainees also wore headphones to listen to crew activity but were not provided with a microphone.

FIGURE 5 View into cockpit from front row, left side passenger seat

1.30.2 Regulatory requirements

CAR 249 prohibited the carriage of passengers on flights which involve the practice of emergency procedures.

CAR 2 contained the following definitions:

“crew member” means a person assigned by an operator for duty on an aircraft during flight time, and any reference to “crew” has a corresponding meaning;

“operating crew” means any person who:

(a) is on board the aircraft with the consent of the operator of the aircraft; and

(b) has duties in relation to the flying or safety of the aircraft.

[**NOTE:** This definition includes persons:

(a) who are conducting flight tests; or

(b) who are conducting surveillance to ensure the flight is conducted in accordance with these Regulations; or

(c) who are in the aircraft for the purpose of:
    (i) receiving flying training; or
    (ii) practising for the issue of a flight crew licence.]

"passenger" means any person who is on board an aircraft other than a member of the operating crew.

1.30.3 Tamair policy

On 21 March 1995, Tamair wrote to the CAA as follows:

> Tamair seeks approval to carry Metro endorsement trainees as passengers on training flights in which emergency procedures are practised.
>
> The reason for this request, is to enable the trainee to observe and learn. Of particular interest here is the two crew patter with its practical implementation.
>
> CAR 249 (1)(b) prohibits this procedure. CAR 250 (2) (b) whilst doesn't [*sic*] appear strictly applicable; I am wondering whether the authority for this exemption can be found in this regulation.

The Tamworth DFOM replied to the letter on 29 March 1995. This reply stated in part:

> With reference to your letter concerning carriage of trainees as passengers on training flights, I direct you to the definition of "passenger" and "crew"...in the CIVIL AVIATION REGULATIONS.
>
> It is quite apparent that, if a person is assigned for duty, by the operator, on board an aircraft then that person is a crew member.

The reply made no reference to operating crew or emergency procedures. On receipt of the letter, Tamair commenced carrying additional trainees on training flights in which emergency procedures, including asymmetric flight, were practised.

There were reported instances where trainees occupied seats at the rear of the cabin (for centre-of-gravity purposes) during training flights. Long extension leads were fitted to again allow the trainee to listen to cockpit activity. Some pilots who had experienced this training considered the 'passenger' time of benefit. Others thought that it was of little benefit.

2. ANALYSIS

2.1 Introduction

The factors contributing to the accident which were identified during the investigation were wide ranging and included the following:

(a) The organisational environment, that is, the regulatory and company systems in which the flight operated.

(b) The performance of the crew before and during the flight.

(c) Aircraft operation and performance, including the procedure for simulating an engine failure during takeoff in the Metro III aircraft.

2.2 The regulatory system and processes

Pre-existing conditions concerning the regulation of flying operations which shaped the system in which the flight operated were night-asymmetric training, type-conversion training, check-and-training, MAOC procedures, carriage of additional trainees on training flights, and FOI type-specific training.

Night asymmetric training

When the Tamworth DFOM sought advice from the CAA Manager Flying Operations concerning the Tamair request for approval to extend night asymmetric training operations, the response did not provide any information beyond the legal status of AIP (OPS) para. 77. The response from the FOI to the company reflected the advice from the Manager Flying Operations and was similarly incomplete. This was the trigger for the company to commence low-level night asymmetric training. Thus, the safety net that AIP (OPS) para. 77 was intended to provide failed. It failed at three levels:

(a) There was no definitive covering legislation for AIP (OPS) para. 77. Had there been such legislation, the advice to the company should have been different.

(b) The Manager Flying Operations did not comment on the appropriateness of the request; nor did he qualify his response to the DFOM concerning the purpose of the AIP and the need to emphasise the risks associated with disregarding its guidance. Such advice would likely have resulted in a different response from the FOI to the company and in turn a different reaction from the company.

(c) In advising Tamair of the status of para. 77, the FOI made no reference to the conditions suggested by the company which might be applied to night asymmetric training operations. He also gave no indication as to what restrictions he believed Tamair should incorporate in the operations manual amendment. This response added to the picture created by the advice concerning para. 77 and contributed to further downplaying of the significance of the company proposal.

Type-conversion training

CAO 40.1.0 did not specify the level of training which should be given to co-pilots who were to participate in leg-for-leg operations. It allowed local interpretation concerning the conversion training sequences that co-pilots would be given. The result was that, in the case of Tamair, some co-pilots had experienced only one V_1 cut during their training (one co-pilot had not completed any), and then proceeded to fly leg-for-leg operations. It is unlikely that competent handling of an engine failure after takeoff could have been achieved from this level of training. Therefore, CAO 40.1.0 was deficient in that the training it required did not ensure an adequate level of proficiency for co-pilots who were to participate in leg-for-leg operations.

Check and training

When the company was granted its air operators certificate for RPT operations, it was not required to submit a new operations manual for approval but rather submitted a modified version of its previous manual. This manual was accepted by the regulator although it contained a number of deficiencies, including a type-conversion syllabus which was not of a standard appropriate to either the Metro III aircraft or the holder of an air operators certificate for RPT operations. The failure to identify these deficiencies can be attributed to the policy of the regulator to 'accept' rather than 'approve' operations manuals. The deficiencies contributed to the framework in which the accident flight operated. They allowed, for example, interpretation by individual check-and-training pilots concerning the sequence and structure of conversion training exercises.

There was no syllabus of training specified by the regulator for check-and-training pilots to complete as part of their approval. Specifically, applicants were not required to undergo training in instructional techniques. This contrasts with the detailed requirements for flight instructor training, yet the type-conversion and flight instruction functions are similar. As a result, pilots could gain check-and-training approval on the basis of completing the course of instruction specified by the operator (for which there were no guidelines) and the assessment of the inspector conducting the approval. Guidelines contained in MAOC made no reference to instructional technique. There was, therefore, no assurance that check-and-training pilots would receive any training in instructional technique, or be assessed on this aspect. Thus, the possibility existed for pilots who lacked instructional expertise to receive approval in the check-and-training role.

Procedures—MAOC

The MAOC contained administrative guidance for CASA officers which was intended to ensure that complete and consistent procedures would be applied during the regulatory process. Recording of compliance with these procedures during regulatory activities was an integral part of this process.

The circumstances of the accident suggested that the instructional technique adopted by the check-and-training pilot was inappropriate. The FOI who conducted the check-and-training approval for the check-and-training pilot indicated that all requirements for the approval had been met. However, because he did not follow the MAOC guidelines regarding the recording of the check-and-training approval procedures, it was not possible to confirm that the check-and-training pilot had demonstrated adequate ability in all sequences.

Carriage of additional trainees on training flights

The CASA advice to Tamair concerning the carriage of additional trainees on training flights did not fully address the regulatory aspects of the issue. It made no reference to 'operating crew' which was relevant to the issue since the regulations require that if a person is not a member of the 'operating crew', then that person is a passenger and may not be carried on flights which involve the practice of emergency procedures. In determining whether an additional trainee would be a member of the 'operating crew', the question of whether he had 'duties in relation to the flying or safety of the aircraft' and/or was in the aircraft for the purpose 'of receiving flying training' should have been addressed. There was no evidence that this had occurred. Further, the conduct of emergency procedures, which was referred to in the Tamair letter and which had safety implications, was not addressed in the CAA response. As a result, it was open to Tamair to conclude that there were no restrictions concerning emergency procedures.

A further issue concerned the training benefit available to a trainee occupying the front left passenger seat, or a rear passenger seat, which was the case in some instances. While there was value in trainees listening to crew activity via headphones and what they could see through the cockpit opening, this was limited. Additionally, a trainee in a passenger seat was not provided with a crew restraint. These learning-benefit and safety-harness issues should have formed part of the considerations concerning the carriage of additional trainees on training flights involving emergency procedures. However, there was no evidence that this occurred at either the company or the regulator level.

FOI type-specific training

The result of FOIs completing type-specific training with operators they would later conduct surveillance on was that deficiencies in aircraft knowledge and/or operating technique on the part of operators, and the FOIs themselves, were perpetuated. The absence of any formal arrangement for the exchange of information between these FOIs, such as a centralised type-specific office to monitor operational standards and procedures, limited the opportunity for deficiencies to be identified and corrected. This contributed to different standards and techniques—such as those for simulating engine failures—which in some cases were inappropriate, being applied by the various operators.

2.3 The company system

Corporate culture and knowledge

Because of its pilot recruitment policy, Tamair had remained somewhat isolated from the RPT and the wider general aviation community. Thus, company RPT operations were developed and managed by persons who had extensive Tamair experience but relatively narrow experience outside the company. The company knowledge base in the operation of aircraft with a maximum take-off weight greater than 5,700 kg was limited to that gained from operating the Metro III since 1993. As a consequence, the company's maturity and corporate knowledge was insufficient for it to fully and appropriately evaluate the issues which were identified during the investigation of this occurrence.

Since November 1994, Tamair had developed a culture which focussed on a literal interpretation of the regulations. This was evidenced by the company's actions concerning AIP (OPS) para. 77, its attitude to the authority of the operations manual, and its approach to CASA concerning the carriage of additional trainees during flights in which practice emergency procedures were conducted. Consequently, the company's approach to regulation, while compliant within its interpretation of the intent of the regulation, meant that company operational safety was dependent to a significant degree on the accuracy, relevance, and presentation of the specific regulatory material and the advice received concerning this material.

The 'open door' policy employed by company management as a method of gaining information on issues (including safety issues) which were of concern to employees was not appropriate for all employees. Some saw the option of 'fronting the boss' as potentially threatening. This could have precluded critical issues concerning type-conversion training and V_1 cuts from being brought to the attention of management.

Company management and supervision of flying operations

The investigation identified a number of deficiencies in the management and supervision of company operations which reflected, at least in part, the corporate knowledge and maturity of the company.

(a) There was no evidence that the decision to conduct emergency procedures training at night was accompanied by any consideration concerning recency and experience of check-and-training pilots, type of training, or of the experience level of the other crew member. After the procedure was deemed safe by the two company pilots and the advice concerning AIP (OPS) para. 77 was received from the CAA, there was no further risk assessment by the company concerning the procedure.

(b) The structure and content of the type-conversion syllabus allowed, and probably required, interpretation by individual check-and-training staff as to the content and sequencing of the training program. As a result, training standards and methods may have been inconsistent and/or inappropriate and not in accordance with company requirements. The omission by the check-and-training pilot of some 'Session II' sequences (such as stalling and asymmetric turns) during the first flight supports this conclusion.

(c) The company operations manual did not accurately reflect the manner in which company operations were being conducted. This was a direct consequence of inadequate guidance being provided by management both through the operations manual and through the direct supervision of staff, particularly check-and-training staff. The planned re-write of the manual would probably have addressed some aspects of this issue. However, pending production of the new manual, management should have ensured that company flying operations continued to be conducted in accordance with the operations manual which was current at the time. Although it was required by regulation, the company did not submit to CASA a proposed amendment to the operations manual concerning asymmetric flight at night below 2,500 ft AGL prior to the company commencing these operations. This lack of notification contributed to CASA apparently being unaware that such training was being conducted.

(d) The company incorporated new operating procedures without adequate risk assessment and without ensuring that the changes were properly promulgated to, and understood by, staff. The introduction of the new procedures without an amendment to the operations manual reflected the view of the chief pilot that the authority of the operations manual had been eroded since the adoption by the regulator of an acceptance rather than approval process for operations manuals.

(e) The chief pilot's practice to allow check-and-training pilots significant latitude in the conduct of type-conversion training was inappropriate in the context of company operating procedures at the time. The operations manual training syllabus was not sufficiently comprehensive to permit flexibility while maintaining an acceptable standard. Additionally, check-and-training staff were not adequately assessed to ensure a capability to properly conduct training without more definitive guidance.

(f) The advice to company pilots regarding the legality of night asymmetric training below 2,500 ft AGL was incorrect. The company ignored familiar, well established practice, most probably in order to address an operational problem brought about by high demands on aircraft availability for both training and RPT operations.

(g) The company classified as crew members trainees who were to observe, from the aircraft cabin, crew activity during training. This classification was one of convenience as it disregarded the observer-only function of the trainee. There was no provision for the trainees, from their positions in the cabin, and without a microphone, to contribute as crew members.

2.4 Crew experience

Check-and-training pilot

The check-and-training pilot was not 'at ease' with V_1 cuts at night. During the type conversions he conducted away from Tamworth, he elected to complete the low-level asymmetric sequences during daylight. His lack of experience and recency in the procedure may have contributed to this decision. It was against this background that, at the time of the accident, the check-and-training pilot reported feeling subtle pressure to include a night V_1 cut in the training. This seemed to be because he was at Tamworth, in the company environment, and knew that other company check-and-training pilots were conducting night V_1 cuts, even though aircraft availability would have allowed the V_1 cuts to be done during daylight. Such behaviour is consistent with the influence of peer group pressure.

The check-and-training pilot concluded that the co-pilot had currency in asymmetric flight because of the recent flight checks he had completed in piston-engine aircraft. This knowledge, and his opinion of the co-pilot's handling of the aircraft during the initial flight, probably influenced his assessment of the co-pilot's ability to fly the V_1 cut procedure. It may also have influenced the check-and-training pilot to allow the co-pilot greater latitude in handling the aircraft.

The type conversions the check-and-training pilot had conducted were for the issue of command endorsements to very experienced pilots. This may have given him a false expectation of how pilots new to the Metro III would handle a V_1 cut in the aircraft.

Co-pilot

The following issues concerning the co-pilot's experience are relevant:

(a) The co-pilot's limited familiarity with the handling qualities of the aircraft was formed during his exposure on the earlier flight. However, that flight did not include any asymmetric or low-speed handling. This experience was unlikely to have given him sufficient knowledge and experience to accurately fly a V_1 cut procedure.

(b) Two-crew operations and procedures were new to the co-pilot. He was hesitant and apparently confused during some challenge/response situations, including during the take-off sequence. Such a level of performance was consistent with his experience level.

Pre-flight briefing

Approximately 15 minutes before the accident, at 1942.45, when the check-and-training pilot told the co-pilot that they were going to do a V_1 cut, the co-pilot made four increasingly forceful remarks. However, the check-and-training pilot responded assertively and effectively stifled further discussion when he stated that 'there's actually nothing that can stop us'. This final statement reflected what the check-and-training pilot understood to be the company position—that is, it was not illegal to conduct V_1 cuts at night and the procedure was being conducted by other Tamair check-and-training pilots.

The check-and-training pilot's interpretation that the co-pilot was joking when he objected to the proposal to conduct a V_1 cut procedure does not seem consistent with the evidence from the CVR. There was no indication on the CVR that the issue had been discussed before the first flight and the co-pilot's response to the initial V_1 cut statement was immediate and spontaneous. If the co-pilot already knew that he was going to be given a V_1 cut, it is difficult to see why he should have raised the objections in the manner that he did.

There was no evidence that the ground-school training and/or the emergency procedures briefing on the afternoon of the flight addressed aircraft control and handling during a V_1 cut other than in a very broad sense. The briefing recorded on the CVR contained no information on the actions or technique appropriate for flying the procedure. When the V_1 cut was first mentioned, there was no amplification by the check-and-training pilot of the appropriate actions or technique to be followed. There was further reference to the procedure at 1945.05, and between 1952.45 and 1953.35. However, given the critical nature of the procedure, its context, and the dark night conditions, the co-pilot should have been given essential information including detail regarding aircraft behaviour, handling technique, instrument indications, and the role and function of each crew member. Even if the procedure had been pre-briefed, then at least a revision/summary of the important aspects of V_1 cuts should have occurred immediately before the takeoff. Other comments the check-and-training pilot made at 1945.05, 1952.45, and 1956.38 regarding possible alternative procedures may have confused the co-pilot as to what he should expect concerning the V_1 cut.

2.5 Crew performance during the flight

Check-and-training pilot

During the takeoff, the check-and-training pilot was dividing his attention between the role of non-flying pilot (by responding to the checklist calls of the co-pilot), monitoring aircraft performance, and prompting the co-pilot. The success of this time-sharing depended on his ability to direct his attention to the appropriate area of activity at the appropriate time. Factors which could have affected his ability to prioritise these tasks correctly included issues such as his experience and recency in conducting the procedure, his level of fatigue, and the level of performance of the co-pilot.

The CVR evidence strongly suggests that the check-and-training pilot had lost awareness of the position and performance of the aircraft. It indicates that his concept of time had been reduced. Examples of this include:

(a) His failure to prompt the call for the landing gear to be retracted before the co-pilot called 'positive rrr' (1957.44).

(b) The retraction of the landing gear 11 seconds after the power lever was retarded. Extension of the landing gear for this period would have had a significant effect on aircraft performance.

(c) Recorded comments on the CVR by the check-and-training pilot indicated that he was aware that the co-pilot was having difficulty in controlling the aircraft and attaining and maintaining V_2. These comments extended from 19 seconds to 30 seconds after the aircraft became airborne, yet the check-and-training pilot continued to go through the checklist actions and made no apparent attempt to take control of the aircraft.

(d) Other than to move the left engine power lever forward at least sufficiently to cancel the landing gear warning horn, there was no other reaction by the check-and-training pilot when he called 'we're descending' 2 seconds before the aircraft struck the tree.

During the takeoff, the check-and-training pilot was telling the co-pilot 'what to do' rather than 'how to do it'. It would have been appropriate for there to have been a demonstration and practice of asymmetric handling and V_1 cut techniques at a safe altitude before attempting the manoeuvre at low level. It also would have been appropriate for the check-and-training pilot to follow the trainee through on the flying controls during the takeoff. This would have added to the information available to him regarding what the aircraft and the co-pilot were doing, and enabled him to respond to and/or override the co-pilot's actions if necessary.

These deficiencies in the technique of the check-and-training pilot reflect his knowledge, training, skills, and experience in conducting type conversion training. They indicate that he was not adequately equipped for the task.

Co-pilot

The difficulty experienced by the co-pilot in controlling the aircraft was consistent with his experience level on the aircraft, considering the dark conditions which existed at the time. Similarly, his difficulty in both flying the aircraft and calling the checklist reflected his inexperience in the aircraft and in multi-crew operations.

2.6 Co-pilot fitness for the flight

Notwithstanding the post-mortem examination findings, there was evidence from the check-and-training pilot and from the CVR which indicated that the co-pilot was suffering from an upper respiratory tract infection at the time of the accident. This could have reduced his ability to control the aircraft during the V_1 cut procedure.

2.7 The external environment

In the dark conditions which prevailed at the time, there were few external visual cues available to the crew. Compared to clear daylight conditions, these circumstances would have:

(a) reduced the awareness of both pilots to the aircraft's attitude and proximity to the ground; and

(b) increased their workload.

2.8 Procedure for simulating engine failure

The investigation revealed a wide variation in the level of knowledge within Tamair, CASA, and the broader aviation industry, of the potential effects of flight-idle power on single-engine performance in the Metro III. There appeared to be a number of reasons for this:

(a) The information in the aircraft flight manual concerning the use of flight-idle power, while correct for torque settings in the zero-thrust range of 10–12%, was not correct for torque settings outside this range. Because this was not clearly stated in the flight manual, the information could have been misleading.

(b) Because no reference was made to zero thrust or the use of flight idle during the type conversion training conducted by the pilot from the manufacturer, the flight manual information concerning the use of flight idle was reinforced, not only to the Tamair chief pilot, but also to the FOI who observed the training.

(c) There were deficiencies in the level of knowledge of the correct technique for simulating engine failure in the Metro III.

These factors led to a variety of methods of simulating engine failure being employed across the industry.

Analysis of the referenced information from the aircraft manufacturer, from the flight manuals of other Garrett TPE-331 powered aircraft, and from the flight test results, confirmed the significance of flight-idle torque and zero thrust during simulated engine failure procedures. With respect to the Metro III, there was evidence that any torque setting less than that equivalent to zero thrust on a 'failed' engine would reduce the aircraft's climb performance to below the flight manual's one-engine-inoperative climb data. Therefore, it was not appropriate to use flight-idle torque to simulate an engine failure unless flight-idle torque was equal to zero-thrust torque. There was, however, a procedure to determine zero thrust for specific combinations of aircraft and operating conditions which allowed for variations in flight-idle torque settings and aircraft and engine condition to be overcome.

All Tamair check-and-training pilots simulated engine failure by initially setting flight-idle torque and adjusting to zero thrust only after the flying pilot called 'feather'. Given the right circumstances, it was possible that during a simulated engine failure procedure, aircraft climb performance could be significantly less than the one-engine-inoperative climb data contained in the aircraft flight manual. These circumstances existed during the accident flight in which the NEJ left engine indicated flight-idle torque was reported to have been less than 10–12%. Any other condition which affected performance, such as the slow completion of checklist-critical actions or inappropriate flight control inputs, could cause the situation to deteriorate to the extent that the aircraft would begin to descend.

The guidance in the aircraft flight manual on one-engine-inoperative procedures was not clear. While the Tamair interpretation was that the flight manual criteria referred only to situations where an engine was actually shut down, others saw the limits as also applying to simulated engine-failure exercises. On the one hand, the benefit in applying the flight manual criteria to V_1 cuts lay in the safety margin which the altitude, airspeed and landing gear position limits provided. On the other, there was validity in the argument that the closer to V_1 speed at which V_1 cuts were practised, the greater the potential training benefit. The issue then became one of balancing this benefit against the increased risk which lower speeds and altitudes involved. Such an assessment should have taken account of the high level of reliability which the TPE-331 engine provided. There was no evidence that such an analysis had been conducted by either the company or the regulator.

2.9 Aircraft configuration

Evidence from the investigation indicated that it was likely that the flaps were at the ONE-QUARTER position and that the landing gear retracted normally after takeoff. The following reasons support these conclusions:

(a) The sound of the landing gear warning horn on the CVR indicated that the landing gear was selected up and that the retraction cycle began. Considering the nature and extent of damage to the aircraft, it is possible that the landing gear retracted normally when it was selected up 15 seconds after the aircraft became airborne but that during the impact sequence, the emergency release cables were subjected to tension loads which caused the uplocks to be released. It is also possible that the integrity of the hydraulic system was compromised during the same period. Either or both of these events would have allowed the landing gear to extend during the impact sequence.

(b) The differences in flap actuator ram extension probably occurred after the flap interconnect was damaged, and could have resulted from either mechanical disruption or heat effects.

3. CONCLUSIONS

3.1 Findings

General

1. The flight was the second flight in a Metro III type-conversion training program for the co-pilot. The takeoff was the second he had conducted in the aircraft.
2. The flight was not affected by weather.
3. The flight was conducted in dark-night conditions.

The aircraft

4. No evidence was found of any aircraft unserviceability which might have contributed to the accident.
5. The aircraft flaps were most probably set at the ONE-QUARTER position for the takeoff.
6. The landing gear probably retracted normally after takeoff, but partially extended during the crash sequence due to disruption of the system by impact forces.
7. The actual flight-idle torque for the left engine could not be determined. Consequently, no conclusion could be drawn concerning the effect flight-idle power may have had on the performance of NEJ during the V_1 cut procedure.

Flight crew

8. The crew was correctly licensed to undertake the flight.
9. There was insufficient evidence available to determine that the pilot in command satisfied fully the requirements and standards for check-and-training approval.
10. The performance of the check-and-training pilot may have been affected by fatigue.
11. The check-and-training pilot had not previously flown a V_1 cut procedure in the aircraft at night.
12. The training was the first co-pilot type conversion training that the check-and-training pilot had conducted.
13. Because the aircraft was available for daylight flying throughout the week-end, there was no need for the check-and-training pilot to conduct the initial conversion flights and the V_1 cut at night.
14. When the check-and-training pilot briefed the co-pilot that he would be given a V_1 cut during the takeoff, the co-pilot objected but the check-and-training pilot overruled the objection.
15. The check-and-training pilot did not adequately brief the co-pilot during the briefing session in the afternoon or in the aircraft immediately prior to the last takeoff, about flying technique required in the event of a V_1 cut.
16. The check-and-training pilot retarded the left engine power lever to the flight-idle position about 4 seconds after the aircraft became airborne.

17. The co-pilot probably had an upper respiratory tract infection, which may have affected his performance.
18. The co-pilot over-controlled the aircraft in pitch and yaw after the left power lever was retarded.
19. The crew selected the landing gear up about 15 seconds after the aircraft became airborne. The landing gear warning horn began to sound at the same time and ceased 19 seconds later (1 second before impact).

Zero thrust

20. The aircraft flight manual guidance concerning operations with one engine inoperative lacked clarity. This guidance was concerned with both simulated and actual engine shutdowns.
21. The engine torque equivalent to zero thrust in the Metro III was reported to be 10–12%.
22. If the flight-idle torque of an engine was less than 10–12%, the single-engine climb performance with that engine at flight idle would be less than that available when an engine actually failed, or was intentionally shut down. In these latter circumstances, the propeller would either be operating in the NTS mode and therefore at a low drag setting, or would be feathered.
23. There was no performance data in the aircraft flight manual for flight with one engine operating at flight idle.
24. There was incomplete understanding within Tamair, CASA, and some sections of the aviation industry concerning the possible effect of flight-idle torque on aircraft performance.
25. Within Tamair, CASA, and across the aviation industry there were a variety of methods for simulating engine failures in Metro III aircraft.

Organisational—Tamair

26. There were a number of general deficiencies in the Tamair Operations Manual, including the lack of a type-specific conversion syllabus for the Metro III aircraft.
27. The supervision of flying operations by company management was inadequate.
28. The Tamair decision to conduct V_1 cuts at night did not take adequate account of the risk inherent in this procedure.
29. The safety environment within the company did not provide the most suitable conditions for the identification of safety issues.

Organisational—CASA

30. There was no enabling legislation for AIP (OPS) para. 77.
31. There were deficiencies in CAO 40.1.0 concerning the level of training required for a co-pilot type conversion. This was particularly evidenced by the lack of reference to RPT leg-for-leg operations.
32. The advice from the CASA Manager Flying Operations to the Tamworth DFOM concerning the Tamair request to extend night asymmetric training was deficient.

The advice contained no guidance concerning either the intent of AIP (OPS) para. 77 or the nature of the response to be given to Tamair.

33. The advice from the DFOM to Tamair concerning the Tamair request to extend night asymmetric operations was inadequate, in that it did not emphasise the intent of AIP (OPS) para 77.

34. Not all procedures in MAOC for the check-and-training approval of the check-and-training pilot were followed by CASA officers.

35. The CASA advice to Tamair concerning the carriage of additional trainees on training flights in which emergency procedures were practised was inadequate.

36. There was limited training benefit for trainees who occupied passenger seats during training flights in the Metro III.

3.2 Significant factors

1. There was no enabling legislative authority for AIP (OPS) para. 77.
2. CASA oversight, with respect to the company operations manual and specific guidance concerning night asymmetric operations, was inadequate.
3. The company decided to conduct V_1 cuts at night during type-conversion training.
4. The check-and-training pilot was assigned a task for which he did not possess adequate experience, knowledge, or skills.
5. The check-and-training pilot gave the co-pilot a night V_1 cut, a task which was inappropriate for the co-pilot's level of experience.
6. The performance of the aircraft during the flight was adversely affected by the period the landing gear remained extended after the simulated engine failure was initiated and by the control inputs of the co-pilot.
7. The check-and-training pilot did not recognise that the V_1 cut exercise should be terminated and that he should take control of the aircraft.

4. SAFETY ACTION

4.1 Interim recommendations

As a result of the investigation into this occurrence, the Bureau of Air Safety Investigation issued the following interim recommendations, each identified by its unique recommendation number. Where a response has been received from the action agency involved, this has been reproduced. The Bureau's classification of each response is also included following the response.

IR950224

The Bureau of Air Safety Investigation recommends that the Civil Aviation Safety Authority amend the Civil Aviation Regulations and the Civil Aviation Orders to ensure that when a provision of the Aeronautical Information Publication specifically prohibits certain manoeuvres and procedures, then this prohibition has legal force which is reflected in relevant Civil Aviation Regulations and Civil Aviation Orders.

The Bureau of Air Safety Investigation recommends that the Civil Aviation Safety Authority take appropriate steps to inform and educate the industry on the hazards involved in asymmetric training operations in conditions of low visibility and at night.

CASA response

I refer to your interim recommendation IR950224 concerning the accident involving SA227 AC, VH NEJ at Tamworth on 16 September 1995. I apologise for the delay in forwarding the following comments.

The Regulatory Structure and Validation Project (RSVP), which is the first stage of a two stage review of existing civil aviation regulations, is currently being finalised by CASA. The RSVP will, inter alia, rectify the problems identified in the first paragraph of the BASI recommendation.

In addition, CASA endorses the recommendation in the second paragraph of IR950224 and will produce an article in the summer issue of the Flight Safety Australia magazine on the hazards of asymmetric training operations in conditions of low visibility and at night.

Response classification: CLOSED – ACCEPTED

IR960034

The Bureau of Air Safety Investigation recommends that the Civil Aviation Safety Authority examine the need to publish a syllabus of training for check pilots. The syllabus should cover all areas of training, including but not limited to, principles and methods of instruction, human factors training and crew resource management training.

The Bureau of Air Safety Investigation recommends that the Civil Aviation Safety Authority review the current process for the approval of check pilots to ensure that candidates have undergone adequate training prior to seeking approval.

CASA response

I refer to your Interim Recommendation IR 960034 concerning the accident involving Fairchild Industries Inc SA227 AC, VH NEJ at Tamworth on 16 September 1995. I apologise for the delay in forwarding this response.

Summary

The Civil Aviation Safety Authority accepts that the approval process for the training and approval of check pilots needs to be improved.

Background

CASA Licensing Branch has written a multi-engine aeroplane training syllabus which will be published in the near future as a CAAP. The aim of this syllabus, for initial multi-engine training, is to provide a sound foundation for check pilots.

CASA has written a new manual to be known as the "Air Operator Certification Manual" which will be distributed to regional staff late in 1996.

This manual, inter alia, defines the selection, training and approval process of check pilots. Training organisations will be required to be included in the organisation's Training and Checking Manual which will be accepted by CASA. CASA will need to be satisfied with this manual before the training and checking organisation will be approved.

The syllabus of training will require an element on instructional technique as well as an element on role distinction between training and checking. CASA will assess the syllabus to ensure it meets the regulatory requirement of CAO 40.1.0.

Response classification: CLOSED – ACCEPTED

IR960035

The Bureau of Air Safety Investigation recommends that the Civil Aviation Safety Authority, as part of the current review of the multi-engine training syllabus, address the issue of endorsement training requirements in aircraft above 5,700 kg MTOW, where a simulator is not available. The review should cover the possible difference in flight training requirements when a simulator is used for training and for the conduct of emergency procedures.

The Civil Aviation Safety Authority should also address the issue of co-pilot training required for 'leg-for-leg' operation of aircraft above 5,700 kg on regular public transport operations.

CASA response

I refer to your interim recommendation IR960035 concerning the accident involving Fairchild Industries SA227-AC, VH-NEJ at Tamworth on 16 September 1995. The following comments are forwarded for your consideration.

Summary

The Civil Aviation Safety Authority accepts that the extant Civil Aviation Order CAO 40.1.0 is deficient.

The multi-engine training syllabus is being reviewed and a new syllabus has been drafted and will be published as a Civil Aviation Advisory Publication. CASA consultation with BASI and industry will take place prior to amending CAO 40.1.0.

Background to Response

Multi-Engine Training

The multi-engine training syllabus is being reviewed and a new syllabus has been drafted. Although there is no legislative power for CASA to mandate the use of a simulator, the new syllabus encourages the use of an approved type simulator for the conduct of endorsement training.

Whether or not there should be differences in flight training requirements, depending on the availability of a simulator, is currently under review. However, CASA would prefer to have only one syllabus. The syllabus mandates minimum requirements. Those operators who have access to an approved type simulator may well provide more training in critical areas of flight.

Leg-for-Leg Operations

Leg-for-leg operations are not addressed in the extant CAO 40.1.0. Clearly, co-pilots must fly leg-for-leg operations to retain currency and provide an effective safety pilot in the event of incapacitation of the aircraft captain. The extant CAO 40.1.0 does not require co-pilots to be trained in the same sequences as aircraft captains. In practice, the major airlines operating aeroplanes supported by approved flight simulators do train co-pilots in the same sequences as aircraft captains.

Part of the current review of multi-engine training is to produce a common syllabus for captain and co-pilot training. Pilots trained in accordance with this syllabus will be qualified for leg-for-leg operations.

CASA consultation with BASI and industry will take place prior to amending CAO 40.1.0.

Response classification: CLOSED – ACCEPTED

IR960036

The Bureau of Air Safety Investigation recommends that the Civil Aviation Safety Authority review the applicable regulations and definitions to ensure that only operating crew are carried on an aircraft when it is engaged in the practice of emergency procedures.

Guidance material should also be issued to operators and training organisations to ensure that the intent of the current regulations and definitions, in particular those of operating crew and passenger, are clearly understood.

CASA response

I refer to your recommendation IR960036 concerning the accident involving Fairchild Industries SA227 AC, VH NEJ at Tamworth, on 16 September 1995. The Authority wishes to forward the following response.

Summary

Flying Operations branch has carried out the review as recommended in the first paragraph of the BASI interim recommendation. CASA is satisfied that the current regulations and definitions associated with passengers and operating crew are clear and adequate.

Background to Response

Civil Aviation Regulation 249.(1)(b) clearly states that passengers are not to be carried during the practice of emergency procedures in aircraft. Civil Aviation Regulation 2.(1) states, inter alia:

"passenger" means any person who is on board an aircraft other than a member of the operating crew;

Civil Aviation Regulation 2.(1) also states, inter alia: "operating crew" means any person who:

(a) is on board an aircraft with the consent of the operator of the aircraft; and

(b) has duties in relation to the flying or safety of the aircraft;

[Note: This definition includes persons:

(a) who are conducting flight tests; or

(b) who are conducting surveillance to ensure that the flight is conducted in accordance with these Regulations; or

(c) who are in the aircraft for the purpose of:

(i) receiving flying training; or

(ii) practising for the issue of a flight crew license.]

BASI IR960036 was raised following the accident involving Fairchild Industries SA227 AC, VH NEJ at Tamworth, on 16 September 1995. The two pilots killed in this accident were in the aircraft for the express purpose of receiving flying training. Therefore, in accordance with CAR 2.(1), they were "operating crew".

Response classification: OPEN

IR960037

The Bureau of Air Safety Investigation recommends that the Civil Aviation Safety Authority assess the benefits of mandating a requirement for safety officers and/or safety departments for Regular Public Transport operators. The assessment should take account of developments in the United States of America and Europe, and recommendations from international civil aviation organisations.

CASA response

I refer to your interim recommendation IR960037 concerning the accident involving Fairchild SA227-AC, VH-NEJ at Tamworth, NSW on 16 September 1995.

CASA accepts BASI's recommendation to assess the benefits of mandating a requirement for safety officers and/or safety departments for Regular Public Transport operators. This assessment will take into account developments in the United States of America, Europe and recommendations from international civil aviation organisations.

Implementation will be incorporated in CASA's Regulatory Framework Review Program.

Response classification: CLOSED – ACCEPTED

IR960098

The Bureau of Air Safety Investigation recommends that the Civil Aviation Safety Authority immediately advise operators of Garrett-powered aircraft fitted with NTS systems, that if flight-idle power is used to simulate engine failure in practice situations, the resulting aircraft performance may be less than that derived from the aircraft operating handbook. The simulation of zero thrust should be in accordance with the aircraft flight manual. If the flight manual does not specify a particular setting then the thrust of the failed engine should be adjusted to achieve the second segment climb gradient with one engine operating.

CASA response

I refer to your BASI Interim Recommendation No IR 960098 concerning the accident involving Fairchild SA227-AC, VH-NEJ, at Tamworth NSW on 16 September 1995.

CASA agrees with the recommendation. All District Offices have been asked to bring the recommendation to the attention of Chief Pilots responsible for operating Garrett-powered aircraft.

Response classification: CLOSED – ACCEPTED

SAN960072

The Bureau of Air Safety Investigation suggests that operators involved in low capacity regular public transport operations consider the safety benefits in establishing positions within their companies of dedicated safety officers.

4.2 Safety Action taken by the Civil Aviation Safety Authority

During the course of the investigation, the definition of 'critical speed' came under review. There was no formal definition in either the Civil Aviation Regulations or Civil Aviation Orders and the Civil Aviation Safety Authority was asked to provide a definition. A response was received on 22 August 1996. The text of that response is reproduced below.

> *I am responding to your inquiries about endorsement training, as applicable to the Tamair Metro III accident at Tamworth on 16 September 1995.*
>
> *Investigations by Personnel Licensing of the Civil Aviation Safety Authority (CASA) have not been able to identify a formal definition of the term 'critical speed'. Air Navigation Order (ANO) Section 101.1.1.1.2 paragraph 4.1.1 dated 1 July 1950 refers to 'Critical Point as the point at which sudden complete failure of the critical engine is assumed to occur'. The Critical Point is the accelerate-stop point. In a later note in the ANO, it states that the 'pilot's airspeed indicator reading will normally be accepted for this purpose, but some other means may be required if the airspeed at the Critical Point is not changing sufficiently rapidly for this to be a reliable indication.'*
>
> *Personnel Licensing assume that the term 'critical speed' may have been derived from 'critical point', but there is no definition in ANOs for 'critical speed' Both the concept and term are obsolete.*
>
> *CASA will eliminate the term 'critical speed' from Civil Aviation Order (CAO) Section 40. l .0 Appendix III paragraph 1 (d), Syllabus of Flying Training For a Type Endorsement.*

4.3 Safety action taken by the operator.

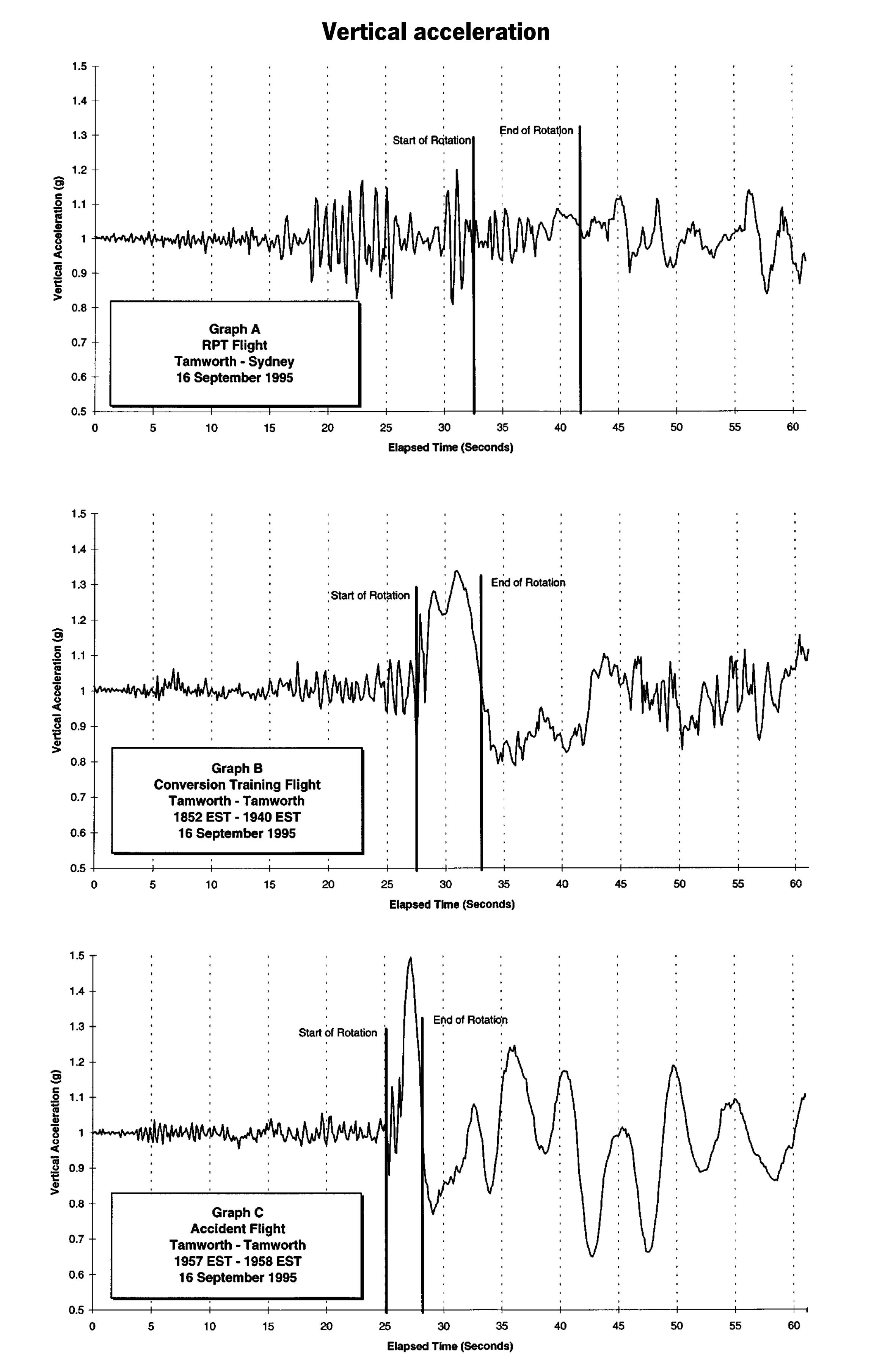
In a letter to CASA, the operator outlined the actions that the company were taking as a result of the accident. Sections of this letter are reproduced below.

Pending BASI's findings:-

1. *No supernumerary crew or passengers to be carried during endorsement training;*
2. *No night asymmetric training;*

3. *Initial type rating procedure be amended to allow for 3 normal take-offs and landings without simulated emergencies;*
4. *All Check and Training staff that have not held Instructor ratings to have conducted a PMI (Principles and Methods of Instruction) course;*
5. *Night sequences to be conducted after the 3rd Day Session;*
6. *Tamair Chief Flying Instructor to be part of Check & Training team;*
7. *All training sequences to be documented and made available to students prior to training flight.*

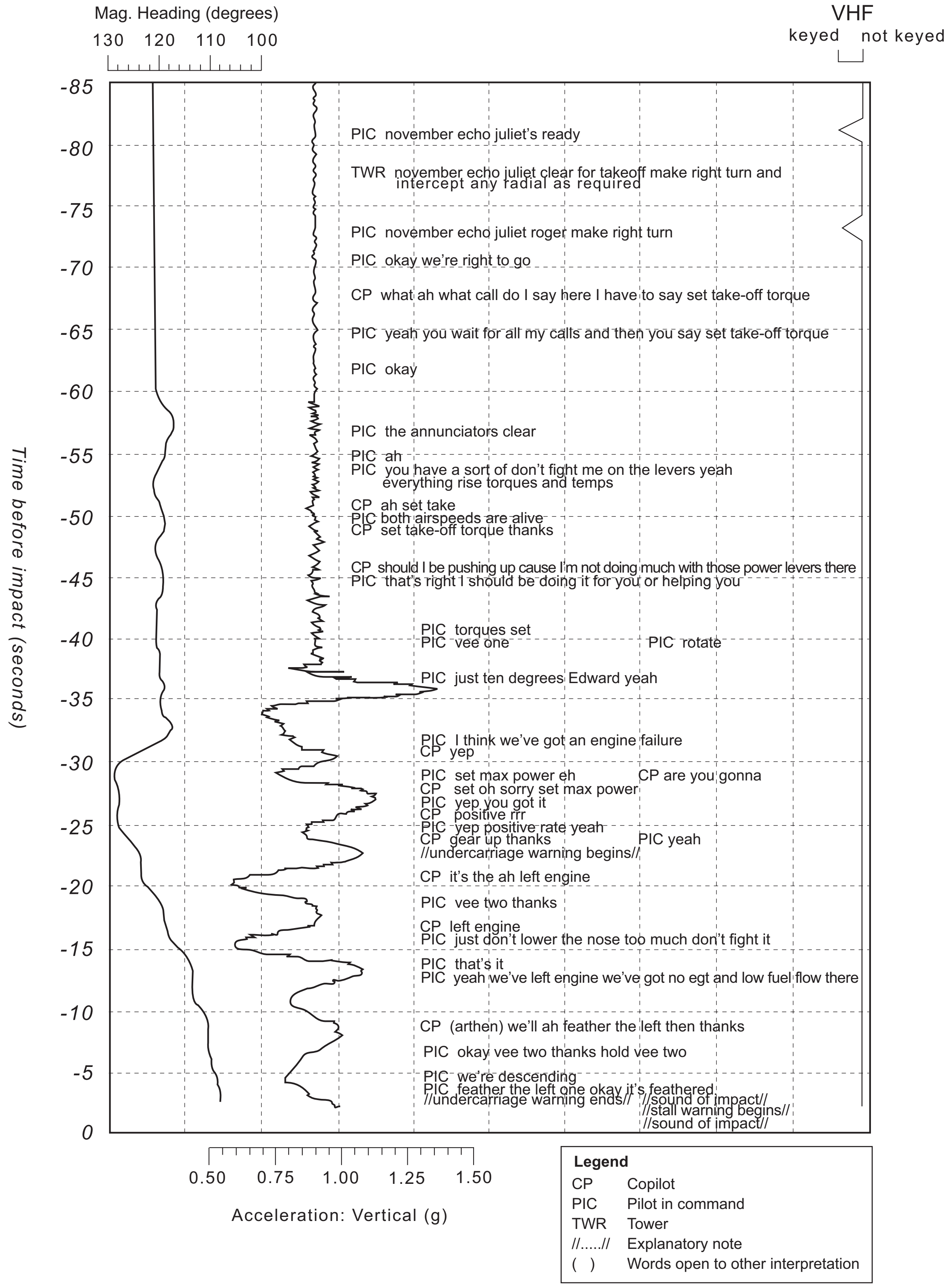
Appendix 1



Vertical acceleration
Vertical Acceleration (g)
Elapsed Time (Seconds)
Start of Rotation
End of Rotation
Graph A
RPT Flight
Tamworth - Sydney
16 September 1995
Graph B
Conversion Training Flight
Tamworth - Tamworth
1852 EST - 1940 EST
16 September 1995
Graph C
Accident Flight
Tamworth - Tamworth
1957 EST - 1958 EST
16 September 1995

Appendix 2

SA227-AC VH-NEJ Accident 16 September 1995



Appendix 3

Extract from Cockpit Voice Recording: Metro III Aircraft: VH-NEJ:
1942.33 - 1958.09 EST: 16 September 1995

The following is not a complete transcript of the recording; only those words pertinent to the analysis of the flight have been directly transcribed. Elsewhere, a paraphrase of the recorded conversation has been included. The transcript begins as the aircraft is parked on the taxiway after landing from the initial flight.

Legend

C&T	Check and training pilot
CP	Co-pilot
TWR	Tamworth Aerodrome Controller
NEJ	VH-NEJ

TIME (EST)	FROM	TO	TEXT
1942.45			The pilot in command informed the co-pilot that they were going to conduct a V_1 cut.
1942.49-1943.04			The co-pilot objected and questioned the legality of night V_1 cuts. The pilot in command replied that such a procedure was legal. The operations manual has been amended and there was no impediment to conducting the procedure. The co-pilot made a further objection.
1943.10-1945.02			The pilot in command then indicated that they would be taking off on runway 12 and would continue for a runway three zero right VOR/DME approach. The crew then briefed for that approach.
1945.04-1945.17			The co-pilot asked if they would be flying the approach on two engines. The pilot in command responded that after the V_1 cut, when the aircraft had climbed through 1,000 ft above ground level, he would probably return the aircraft to normal two engine operation.
1945.18-1945.30			The co-pilot, assisted by the pilot in command, then revised the procedure for the VOR/DME approach.
1945.41-1951.30			Because of other traffic, the runway 30 VOR/DME approach was not available. The crew was then given a clearance for the runway 12 VOR/DME approach and briefed for that approach. They then completed the after start checks and the taxi checks.
1951.32-1952.45			The pilot in command then asked the co-pilot for a crew briefing. The co-pilot could not remember the complete briefing and was assisted by the pilot in command. The pilot in command repreated that they were going to conduct a V_1 cut procedure, adding that it was for the purpose of demonstration so the co-pilot would know what to expect.
1952.56-1953.35			The co-pilot then revised the procedure for the V_1 cut - that he would call for maximum power, that the pilot in command would call positive rate of climb, and then the co-pilot would call for the landing gear to be selected up. The co-pilot continued that he

TIME	FROM	TO	TEXT
			would identify the failed engine and that the pilot in command would confirm the identification. He queried whether zero thrust would be set. This was confirmed by the pilot in command. The co-pilot continued that at V_2 plus five kts, flaps would be selected up and the climb speed after that would be Vyse to the acceleration altitude of nineteen hundred feet. This was corrected by the pilot in command to four hundred feet above ground level, that is, eighteen hundred feet.
1953.40-1956.38			The crew completed the line-up checks. The co-pilot asked the pilot in command which engine he was going to fail. The pilot in command responded that he might not simulate the failure of an engine. He then indicated that they would use eighty-eight percent engine torque and one hundred knots for V_1.
1956.49-1956.57			The crew then requested and was issued a takeoff clearance.
1957.00	C&T	CP	OK we're right to go
1957.03	CP	C&T	What ah what call do I say here. I have to say set takeoff torque
1957.05	C&T	CP	Yeah you wait for all my calls and then you say set takeoff torque. OK
1957.13	C&T		the annunciators clear
1957.15	C&T	CP	Ah you have sort of don't fight me on the levers yeah . Everything rise torques and temps
1957.18	CP	C&T	ah set take
1957.19	C&T	CP	both airspeeds are alive
1957.20	CP	C&T	set takeoff torque thanks
1957.22	CP	C&T	should I be pushing up cause I'm not doing much with those power levers there
1957.25	C&T	CP	that's right. I should be doing it for you or helping you
1957.29	C&T	CP	torque set
1957.30	C&T	CP	vee one. rotate
1957.33	C&T	CP	just ten degrees edward. yeah
1957.38	C&T	CP	I think we've got an engine failure
1957.39	CP	C&T	yep

TIME	FROM	TO	TEXT
1957.41	C&T	CP	set max power eh
1957.41	CP	C&T	are you gonna
1957.42	CP	C&T	set oh sorry set max power
1957.43	C&T	CP	yep you got it
1957.44	CP	C&T	positive rrr
1957.45	C&T	CP	yeah positive rate yeah
1957.46	CP	C&T	gear up thanks
1957.47	C&T	CP	yeah//sound of gear warning horn starts//
1957.50	CP	C&T	it’s the ah left engine
1957.51	C&T	CP	vee two thanks
1957.53	CP	C&T	left engine
1957.54	C&T	CP	just don’t lower the nose too much. don’t fight it
1957.55	C&T	CP	that’s it. yair left engine we’ve got no egt and low fuel flow there
1958.00	CP	C&T	(arthen) we’ll ah feather the left then thanks
1958.02	C&T	CP	ok vee two thanks hold vee two
1958.05	C&T	CP	we’re descending. feather the left one. ok it’s feathered
1958.06			// sound of gear warning horn stops //
1958.07			// non pertinent words // // sounds of impact//
1958.09			Recording ends

Electrical power to the Control Tower and airport was cut at 1958.08 EST.

Appendix 4

Extract from Tamair Operations Manual—Initial Air Training Syllabus

2.3 INITIAL AIR TRAINING

2.3.1 Pilots

The Check Captain or Chief Pilot is responsible for ensuring that each pilot is adequately trained in all aspects of normal and abnormal operations in accordance with the manufacturer's operating instructions and the approved flight manual.

The Checking Captain will complete the following airwork sessions and complete the endorsement form in Appendix 1 of this Section with the pilot to be trained:

*Session I

- Review the pilots Ground Engineering Exam.

- Aircraft Documentation - Manifests, Loading, Maintenance System.

- Conduct a Daily Inspection on the aircraft.

- Review the aircraft checklist, both normal and emergency in the aircraft.

- Conduct the standard passenger briefing in the aircraft.

- Discuss the pre take-off briefing.

*Session II

- General handling and systems management.

- Stalling - clean and landing configuration with power off - Emergency descent

- Turns - rate 1, medium and steep.

- Aircraft emergency procedures - fire, failure, etc.

- Engine shut down

- Turns - assymetric

- Engine restart

- Instrument flight - limited panel and approach(s).

- circuit

*Session III

- Aborted takeoff

- Unusual attitudes

- Aircraft emergency procedures - Phase 1

- Instrument approach

- Circuits - normal, flapless, short field, assymetric, bad weather maneuvering including right hand low visibility approach, missed approach and go-round.

*Session IV

- Aircraft emergency procedures - Phase 1 - Instrument approach

- Circuits - night (at least 3), T-vasis off, landing light off, taxi light off or a combination of above.

If any areas are found to be inadequate, additional training will be given. ie. If a pilot has trouble with the instrument flight sequence, then a simulator session will be organised and then the appropriate section training redone.

A Check Captain is to complete a base check form, when the appropriate standard has been reached at the end of the trainee’s endorsement training.

Should a pilot fail to achieve the required standard during training, he/she will be extensively briefed on the sequence involved, giver opportunity to practice the necessary skill. If the desired standard is still not attainable the endorsement may be abandoned or further training may be done at the pilots expense if desired.

Appendix 5

Explanation of human performance terminology

Fatigue
Fatigue can be influenced by an overall loss or deprivation of sleep, disruption of the normal sleeping schedule, and the quality of sleep. The quality of sleep can be affected by issues such as sleeping in an unfamiliar environment, physical exertion, psychological strain, and the consumption of alcohol. Fatigue can impair human performance. Its possible effects include degraded co-ordination, slowness in response and failure to recognise errors.

Situational awareness
Situational awareness can be defined as the awareness of the crew of the position and performance of the aircraft. Inadequate situational awareness has emerged as a significant factor in many accidents and incidents, both in Australia and overseas.

Peer group pressure
Pilot groups, like many others in society, frequently develop a strong sense of cohesiveness. Comparison with other group members is a powerful influence which can distort perceptions, judgements and actions. The fact that other pilots have successfully completed a certain procedure or manoeuvre, particularly if they are in the same company and operating the same aircraft type, can increase the pressure to conform. This effect is known as peer group pressure (Hawkins, 1993; O'Hare & Roscoe, 1990).

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