Appendix A: Technical Analysis Report

Flight Data Recorder Factual Report
SA227-DC VH-TFU
Lockhart River, Qld
7 May 2005

TECHNICAL ANALYSIS REPORT 21/05

Released in accordance with section 25 of the *Transport Safety Investigation Act 2003*

CONTENTS

Scope A-3

Flight data recorder (FDR) requirements A-3

Aircraft installation A-4

FDR details A-4

FDR system maintenance A-5

FDR recovery, transport and download A-5

Rear connectors A-11

Data frame format A-13

Parameters A-14

- Pressure altitude A-16
- Indicated airspeed A-21
- Magnetic heading A-23
- Pitch attitude A-24
- Roll attitude A-24
- Horizontal stabiliser position A-25
- Elevator position A-27
- Flap position A-28
- Rudder position A-29
- Aileron position A-30
- Right engine propeller RPM A-31
- Left engine propeller RPM A-31
- Right engine torque A-32
- Left engine torque A-32
- Vertical acceleration A-33
- Longitudinal acceleration A-34
- Pilot microphone keying (COM 1) A-35
- Copilot microphone keying (COM 2) A-35

End of recording A-35

Timing correlation A-39

Flights landing at Lockhart River A-39

Sequence of events A-39

Findings A-49

Parameter serviceability A-49

Scope

Recorded flight data was read out to assist in the accident investigation. In particular the scope of the factual report was to:

- Document the recovery and downloading of the flight data recorder (FDR)
- Describe the FDR system fitted to the aircraft
- Describe the parameters recorded by the FDR and examine their accuracy
- Produce a graphical representation of the FDR data for the accident flight
- Produce a sequence of events for the accident flight.

Flight data recorder (FDR) requirements

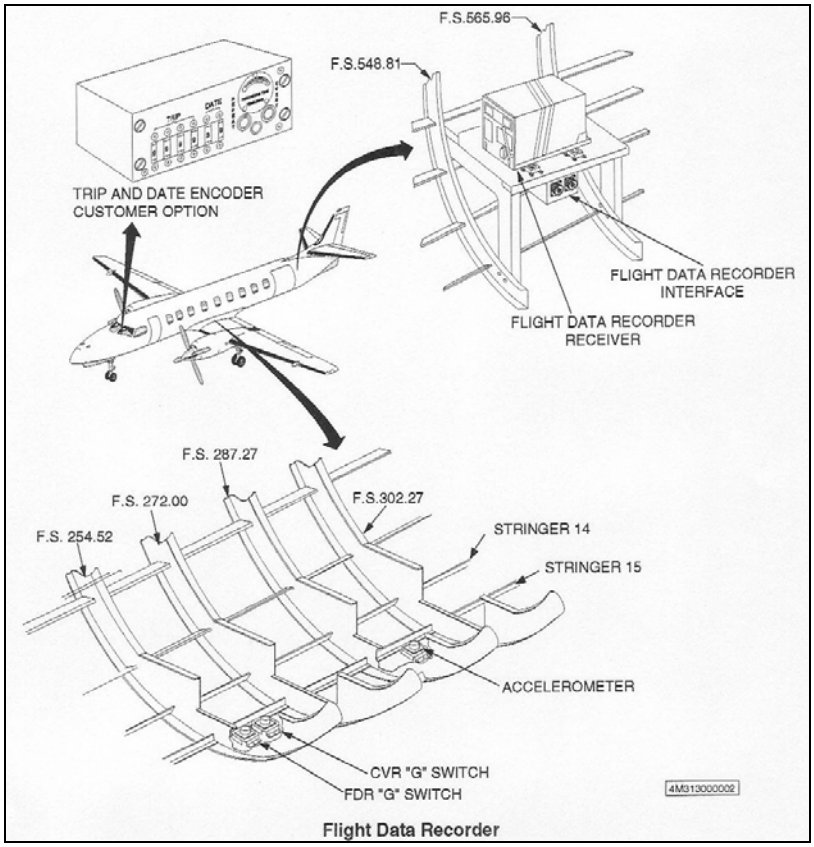
Flight data recorder carriage requirements for Australian-registered aircraft are specified in Civil Aviation Order (CAO) 20.18. As the maximum take-off weight of VH-TFU was greater than 5,700 kg, it was required to carry an approved FDR. The FDR fitted to VH-TFU was an approved unit.

The FDR parameters that are required to be recorded (i.e. mandatory parameters) are specified in Appendix I of CAO 103.19[28]. The FDR fitted to VH-TFU was required to record at least the first six parameters listed in Appendix I i.e. time, altitude, airspeed, vertical acceleration, heading and press to transmit for the radio transceivers. The FDR fitted to VH-TFU exceeded this minimum requirement as the six mandatory parameters and an additional 13 parameters were recorded.

28 CAO 103.19 was last updated in 1986.

Aircraft installation

Figure A-1: FDR system diagram[29]



The FDR system was installed in December 1992 during aircraft manufacture. The FDR was located aft of the rear cargo bulkhead between fuselage station (FS) 548.81 and FS 565.96. A G switch was mounted near FS 254 under the passenger centre aisle. The G switch was designed to interrupt power to the FDR and preserve the recording if excessive G force was experienced.

The FDR was powered by 28 VDC via two circuit breakers, one on the left avionics bus and one on the right avionics bus.

FDR details

The aircraft was equipped with a Loral Data Systems solid-state FDR. Reported details of the FDR were:

Model	F1000
Part number	S703-1000-00
Serial number	00393

29 Fairchild Aircraft SA227 Series Maintenance Manual (Mar 01/02).

When the FDR was recovered the data plate was missing and the serial number could not be confirmed. Examination of the FDR at the ATSB confirmed that the reported model and part number were correct.

FDR system maintenance

Examination of the aircraft maintenance log showed that FDR serial number 00393 was removed on 2 April 2004 after the aircraft FDR circuit breaker repeatedly tripped. The unit was sent to the FDR manufacturer's authorized repair agency in Melbourne. Fault-finding showed that the FDR's aircraft interface circuit board and the power supply circuit board were faulty and they were replaced. A functional test of the FDR, as specified in the manufacturer's component maintenance manual, was successfully completed by the repair agency. The FDR was returned to the operator and re-installed on 21 April 2004.

A maintenance worksheet showed that on 6 April 2005 water was drained from the FDR static pressure line and a leak check carried out.

FDR recovery, transport and download

1. The cockpit voice recorder (CVR) and FDR were recovered from the accident site on 8 May by ATSB investigators.
2. The CVR and FDR were transported between Lockhart River - Weipa - Cairns - Sydney - Canberra accompanied by an ATSB investigator. Liaison with security and airline staff allowed the recorders to travel inside the passenger cabin of the aircraft.
3. The FDR was examined on 9 May and the memory module was visually inspected. The FDR was then stored until the CVR disassembly and initial replay were completed.
4. On 10 May, the FDR was disassembled and the polystyrene foam block containing the memory board was removed from the crash-protected enclosure.
5. Some heat damage was evident on the polystyrene foam block.
6. The manufacturer was sent several digital photos showing the condition of the foam block and subsequently advised that the crash-protected enclosure had experienced 'less than 30 minutes at 1,100 degrees C (or some similar combination of lower exposure)'.
7. A new connector was crimped onto the memory board cable at the ATSB FDR laboratory in accordance with Loral Data Systems documentation[30].
8. On 11 May, an ATSB flight recorder specialist hand-carried the memory board to an authorised repair agency of the FDR manufacturer in Melbourne.

30 'Procedure for Crash Data Recovery for Flight Data Recorder Fairchild Model F1000 with Solid-State Memory'. Document FAR 0389 Revision 4.

9. Under the control of the ATSB flight recorder specialist the memory board was connected to a ‘known good’ FDR. Details of the FDR were:
   - Part number S703-1000-01
   - Serial number 01907
   - Mod. Status 2-14
   - Program Revision R17.
10. An electronic component (described as Q1 on the Flash/Store Interface card) was removed from the known good FDR to prevent any possibility of writing to the memory board from VH-TFU.
11. The data was downloaded using a standard Data Retrieval Unit (DRU) and normal indications were observed during the download.
12. The download was successful and a compressed data file, of size 8,193 kilobytes, was obtained. This file was named TFU.fdt.
13. The download file was decompressed using the manufacturer’s Readout Support Equipment (ROSE) Software Version 3.6 and a TFU.dat file was produced. The file size was 45,721 kilobytes.
14. These two files were transferred to the ATSB flight recorder specialist’s laptop computer and analysed using Insight Analysis Version 1.5.0.50. Analysis showed that the download was successful and that data from the accident flight had been recovered.
15. The two files (TFU.fdt and TFU.dat) were deleted from the authorised repair agency’s computer.
16. The memory board was hand-carried back to Canberra by the ATSB flight recorder specialist.

Figure A-2: Comparison (undamaged) FDR – Exterior

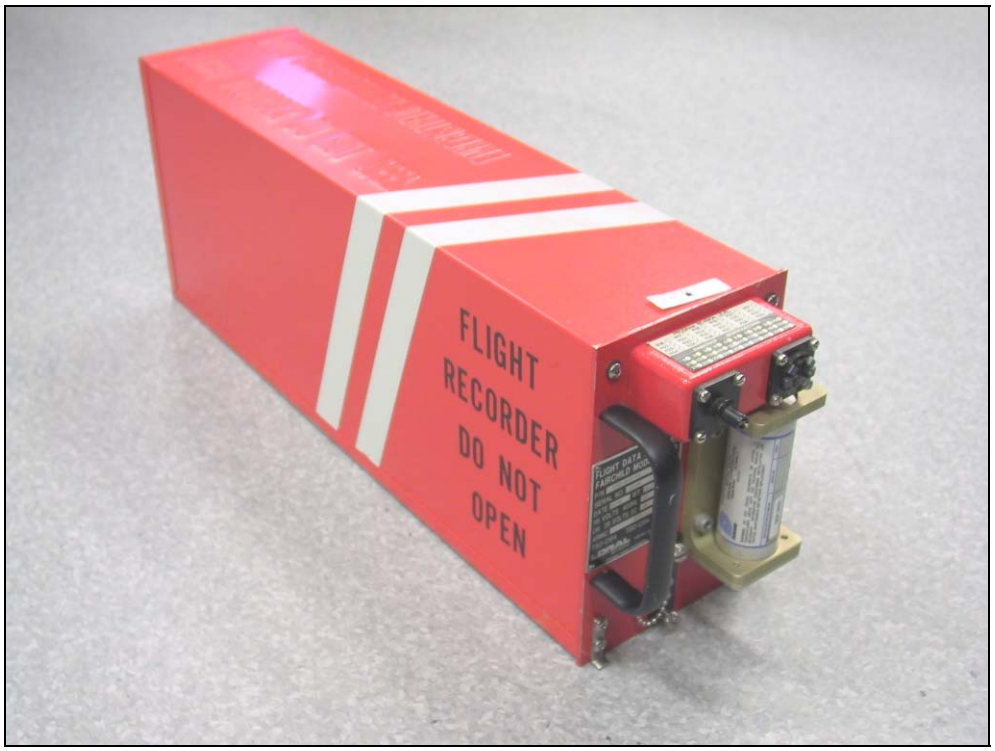


Figure A-3: Comparison (undamaged) FDR - Interior

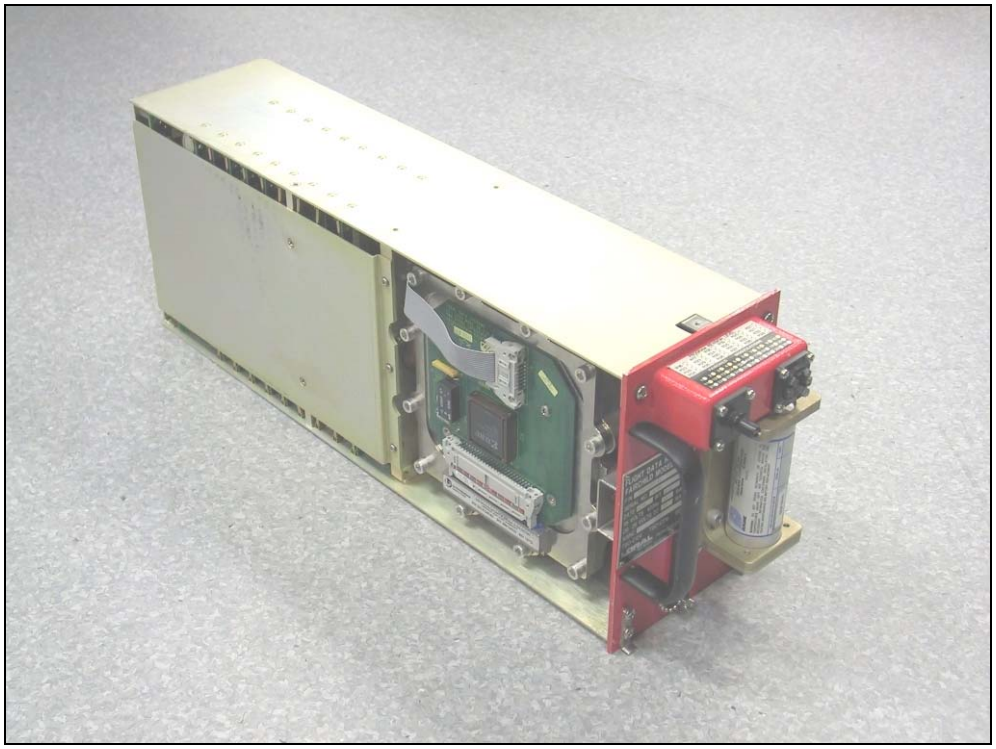


Figure A-4: FDR at the accident site



Figure A-5: FDR (foreground) at the ATSB laboratory in Canberra



Figure A-6: FDR with the crash-protected memory module visible



Figure A-7: Crash-protected memory module with a comparison unit



Figure A-8: Polystyrene foam block enclosing the memory board

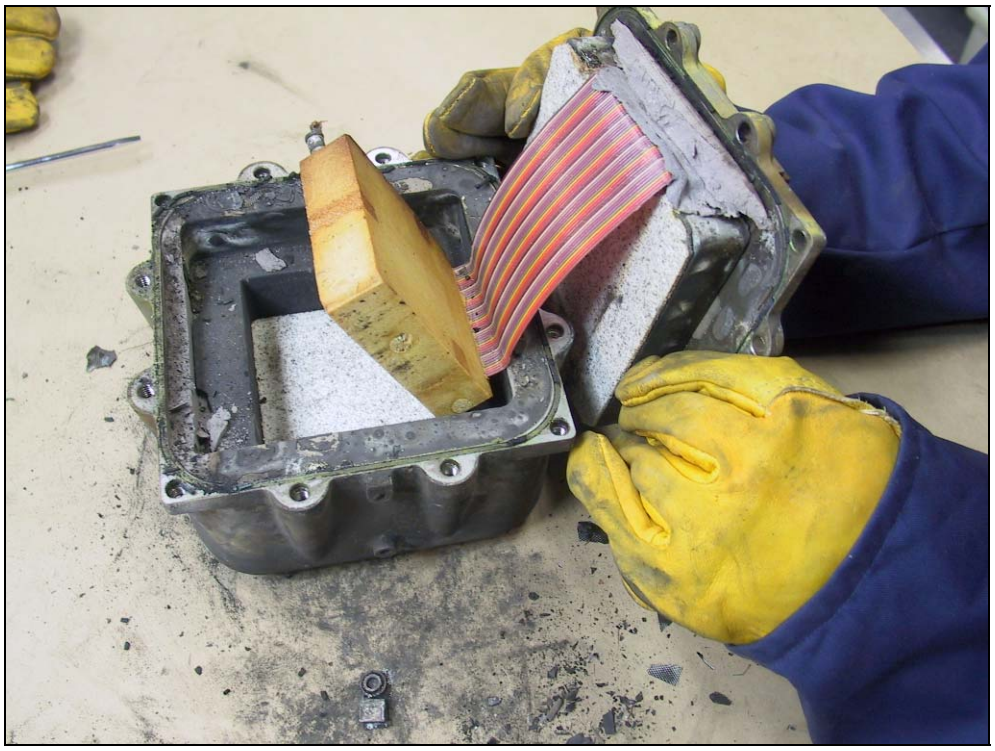
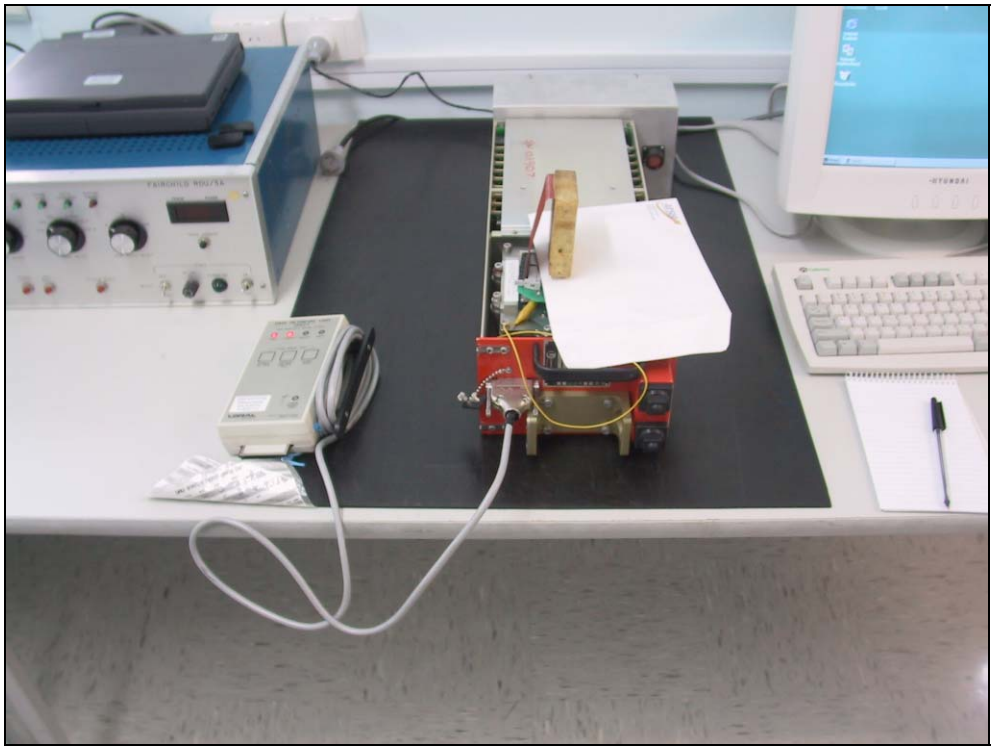


Figure A-9: Memory board being downloaded using a 'known good' FDR



Rear connectors

The FDR rear connectors (refer to Figure A-10), as well as the raw data, were scrutinized to ensure that all the recorded engineering parameters were detected.

Examination of the rear connector showed that a trip and date encoder was not fitted.

Figure A-10: FDR rear connectors



Figure A-11: Pin numbering

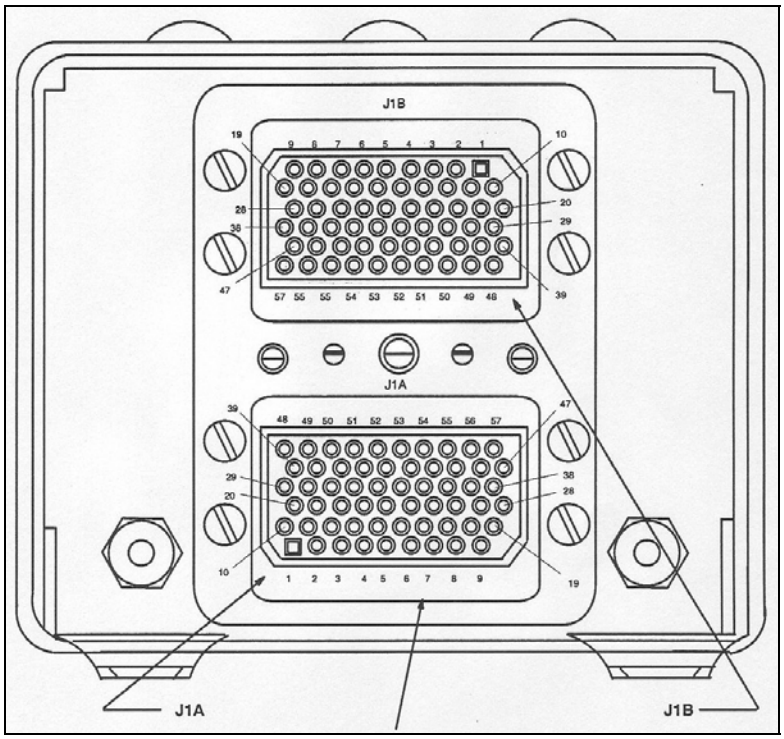
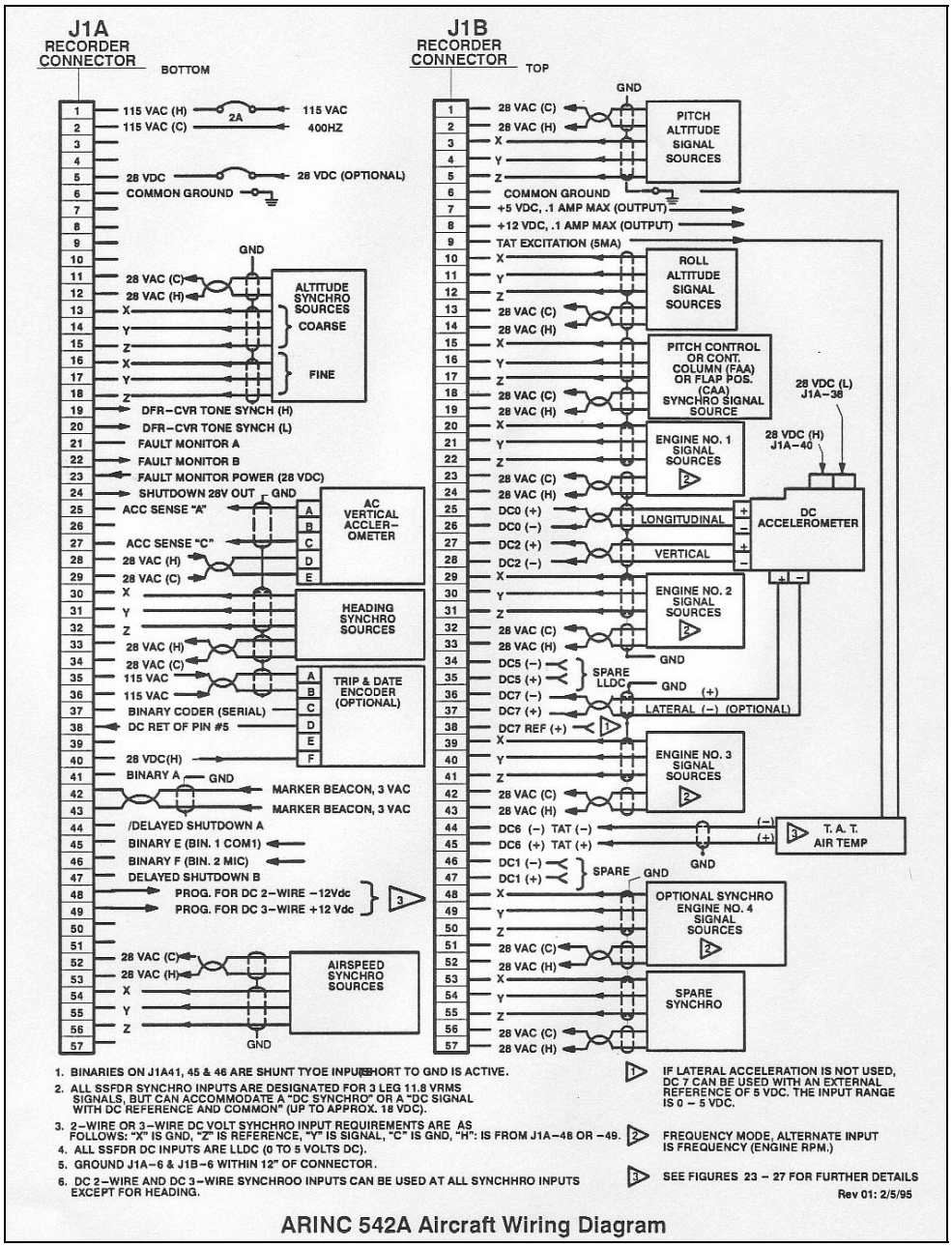


Figure A-12: Pin assignment[31]



Examination of the rear connectors showed no evidence of connections to the following pins:

J1A: 1-4, 7-20, 23-29, 35-37, 39, 44, 47 & 50-57.

J1B: 8-9, 20-21, 29-30, 41, 44-45 & 50.

The observed pin connections were consistent with the FDR installation detailed in the Fairchild Aircraft SA227 Series Maintenance Manual Mar 01/02.

31 'Installation and Operation Instruction Manual Fairchild Model F1000' L3 Communications, October 10 1994.

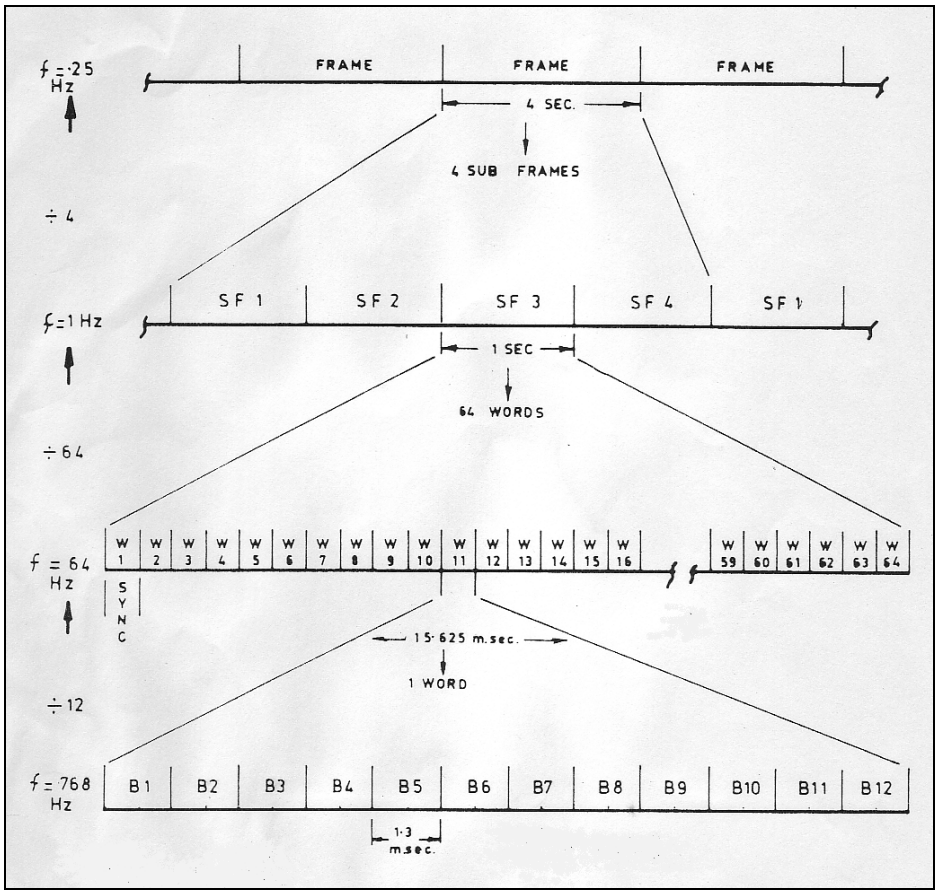
Data frame format

The FDR produces a data stream which is time division multiplexed with parameter identification established by means of position or time (word) slot addresses in the data stream. The data stream is a continuous sequence of four second data frames. Each frame consists of four subframes of 46 x 12 bit words with the first word containing a unique 12 bit synchronization (sync) word identifying it as subframe 1, 2, 3 or 4. The data stream is 'in sync' when successive sync words appear at the correct intervals.

The F1000 P/N S703-1000 FDR assembles 46 (12 bit) words per second and then compresses the data before it is recorded. When the data is recovered, the raw compressed data file (.fdt file extension) needs to be decompressed before it is imported by the analysis software. The decompression software 'pads out' the 46 word per second data so that it conforms to the standard 64 word per second format expected by the analysis software (refer to Figure A-13). Accordingly zeros are always recorded in these 18 word positions (words 2, 3, 7, 15, 17, 25, 27, 33, 35, 39, 41, 43, 47, 49, 50, 59, 62 & 63).

Parameters can be recorded as multi-bit engineering parameters eg. pressure altitude or single-bit discrete parameters eg. microphone keying.

Figure A-13: Data frame format



Parameters

Examination of the data showed that the following aircraft parameters were recorded:

Parameter Name:	Units:	Sampling Interval: (seconds)
Elapsed Time[32]	hh:mm:ss	1
Pressure Altitude[33]	feet (reference 1013.2 hPa)	1
Indicated Airspeed	knots	1
Magnetic Heading	degrees M	1
Pitch Attitude	degrees	0.25
Roll Attitude	degrees	0.5
Horizontal Stabiliser Position	degrees	1
Flap Position	degrees	0.5
Elevator Position	degrees	1
Rudder Position	degrees	1
Aileron Position	degrees	0.25
Right Engine Propeller RPM	%	1
Left Engine Propeller RPM	%	1
Right Engine Torque	%	1
Left Engine Torque	%	1
Vertical Acceleration	g	0.125
Longitudinal Acceleration	g	0.25
Microphone Keying 1	discrete (keyed/not keyed)	1
Microphone Keying 2	discrete (keyed/not keyed)	1

For the F1000 P/N S703-1000 FDR, discrete parameters are only recorded in word 11 of each subframe. To ensure that all the recorded discrete parameters were detected all 12 bits of word 11 were scrutinized. This showed that two bits were used for Microphone Keying (bits 1 & 3). These were the only discrete parameters related to aircraft operation that were detected. In addition, four FDR status parameters were recorded:

32 Elapsed time from power-up of the FDR – incremented once per second.

33 Pressure altitude and IAS are sensed from a transducer package inside the FDR. The recorded values may differ from those observed by the crew.

Parameter Name:	Units:	Sampling Interval: (seconds)
A/D Fault	discrete (no fault/fault)	1
S/D Fault	discrete (no fault/fault)	1
Altitude/Airspeed Source	discrete (pneumatic/electric)	1
FDR Fault	discrete (no fault/fault)	1

Figure A-14: Operation of the FDR PWR FAIL warning light

The FDR PWR FAIL warning light is located on the pilot's instrument panel. The light remains illuminated for 45 seconds each time power is applied while FDR completes self-diagnostic test. Any one of the three items listed below may cause continued illumination of the FDR PWR FAIL warning light.

(1) Loss of 28 VDC power to FDR.

(2) Loss of 26 VAC magnetic heading excitation to FDR.

(3) Discrepant comparison of FDR altitude and airspeed pneumatic transducer calibration data in FDR memory and the pneumatic transducer calibration data from FDR central processor download during 45 second self-diagnostic test.

(4) To extinguish FDR PWR FAIL light after a comparison test discrepancy, the FDR must be powered OFF and ON at least twice for a minimum of 45 seconds. First to replace data in memory, and second, to complete satisfactory comparison of central processor download.

(5) After completion of 45 second self-diagnostic test, the FDR will continue to record data with FDR PWR FAIL light illuminated except during loss of 28 VDC power.

Pressure altitude

Signal Source:	FDR pneumatic transducer
Signal Type:	Pneumatic
Bits Used:	14
Word Locations:	26 (MSW[34]) 34 (LSW[35])
Resolution:	2 feet
Sampling Interval:	1 second

A printed circuit board (PCB) inside the FDR contains the pneumatic transducer and associated electronics for sensing and digitizing altitude and airspeed data. Figure A-15 shows an undamaged PCB while Figure A-16 shows the PCB from VH-TFU.

The transducer measures the difference between static pressure, captured through one or more static port(s), and a reference pressure. The reference conditions for the transducer are standard pressure and temperature (i.e. 1013.25 hPa and 15º Celsius). The static ports are located on the exterior of the aircraft, at locations chosen to detect the prevailing atmospheric pressure as accurately as possible i.e. without any disturbance from the passage of the aircraft.

On Metro 23 aircraft this sensor is connected to the copilot's static system. The raw recorded altitude data is converted to engineering units (i.e. altitude in feet) by a standard polynomial equation supplied by the FDR manufacturer.

34 Most significant word.

35 Least significant word.

Figure A-15: Comparison undamaged pneumatic printed circuit board

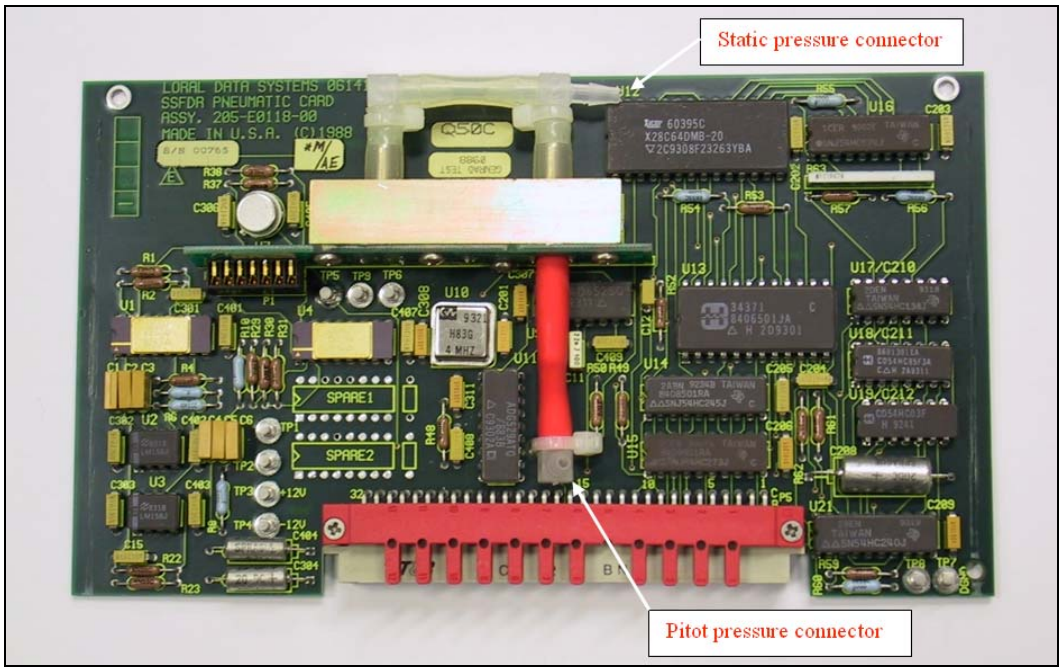
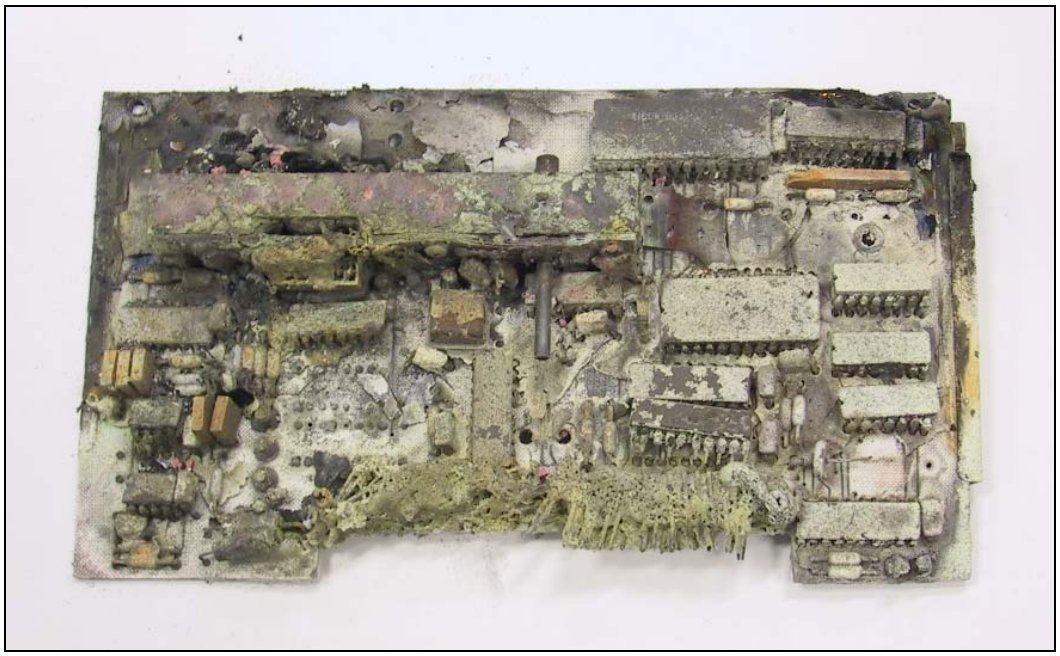


Figure A-16: Pneumatic printed circuit board from VH-TFU



The recorded altitude data was initially processed using the manufacturer's standard polynomial conversion equation. Examination of the results showed that the altitude values were unreasonable i.e. cruise levels did not agree with the cruise flight levels documented in the operator's trip records. The damage to the pneumatic PCB from VH-TFU precluded any direct testing/calibration so recorded radar data was used to calibrate the altitude data recorded by the FDR.

On the day of the accident VH-TFU flew the following sectors:

Cairns - Lockhart River - Bamaga - Lockhart River.

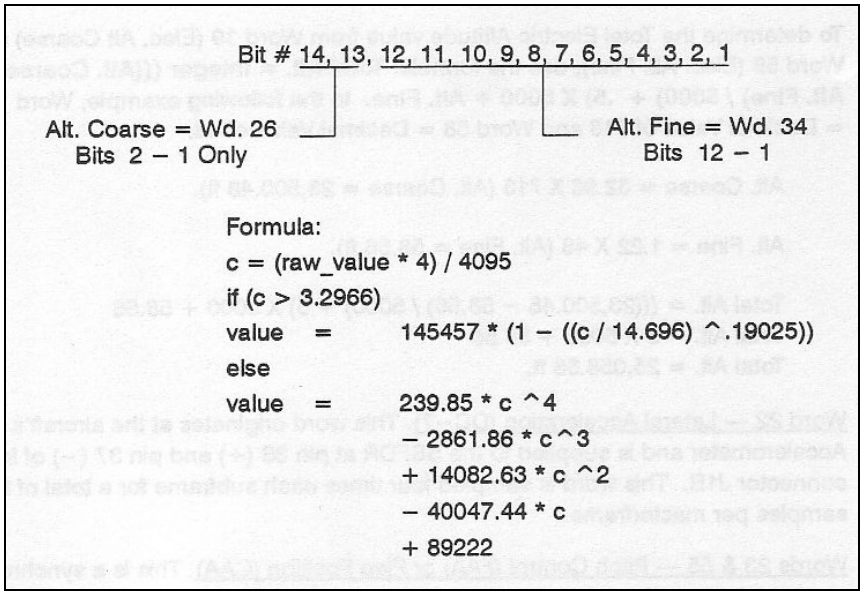
During climb and initial cruise after takeoff from Cairns the aircraft was under radar coverage from the secondary surveillance radar at Redden Creek (16º 51´ 38.7˝ South and 145º 44´ 38.7˝ East).

Recorded Mode C pressure altitude (referenced to 1013 hPa) was recorded by the radar system at intervals of 3.7 seconds while the aircraft was under radar coverage. The Mode C Pressure Altitude data accuracy was determined by the aircraft's encoding altimeter accuracy plus the transponder quantisation of 100 ft.

By comparing radar Mode C altitude with the recorded FDR altitude (Figure A-18) a calibration curve was derived (Figure A-19).

The standard pressure altitude engineering units were obtained using the equation listed in Figure A-17. Corrected altitude was then obtained by applying Equation 1.

Figure A-17: Manufacturer's standard pressure altitude conversion[36]



Equation 1:

Corrected altitude = value + correction

i.e. Corrected altitude = $value^3$ * 7.0E-11 + $value^2$ * 4.0E-6 + value * 0.9958 + 152.82

The accuracy of the corrected altitude values was:

Altitude	Accuracy
3,000 feet	± 100 feet
18,000 feet	± 300 feet
22,000 feet	± 400 feet

36 'Procedure for Crash Data Recovery for Flight Data Recorder Fairchild Model F1000 with Solid-State Memory'. Document FAR 0389 Revision 4, Figure 7-1, Page 2.

Figure A-18:

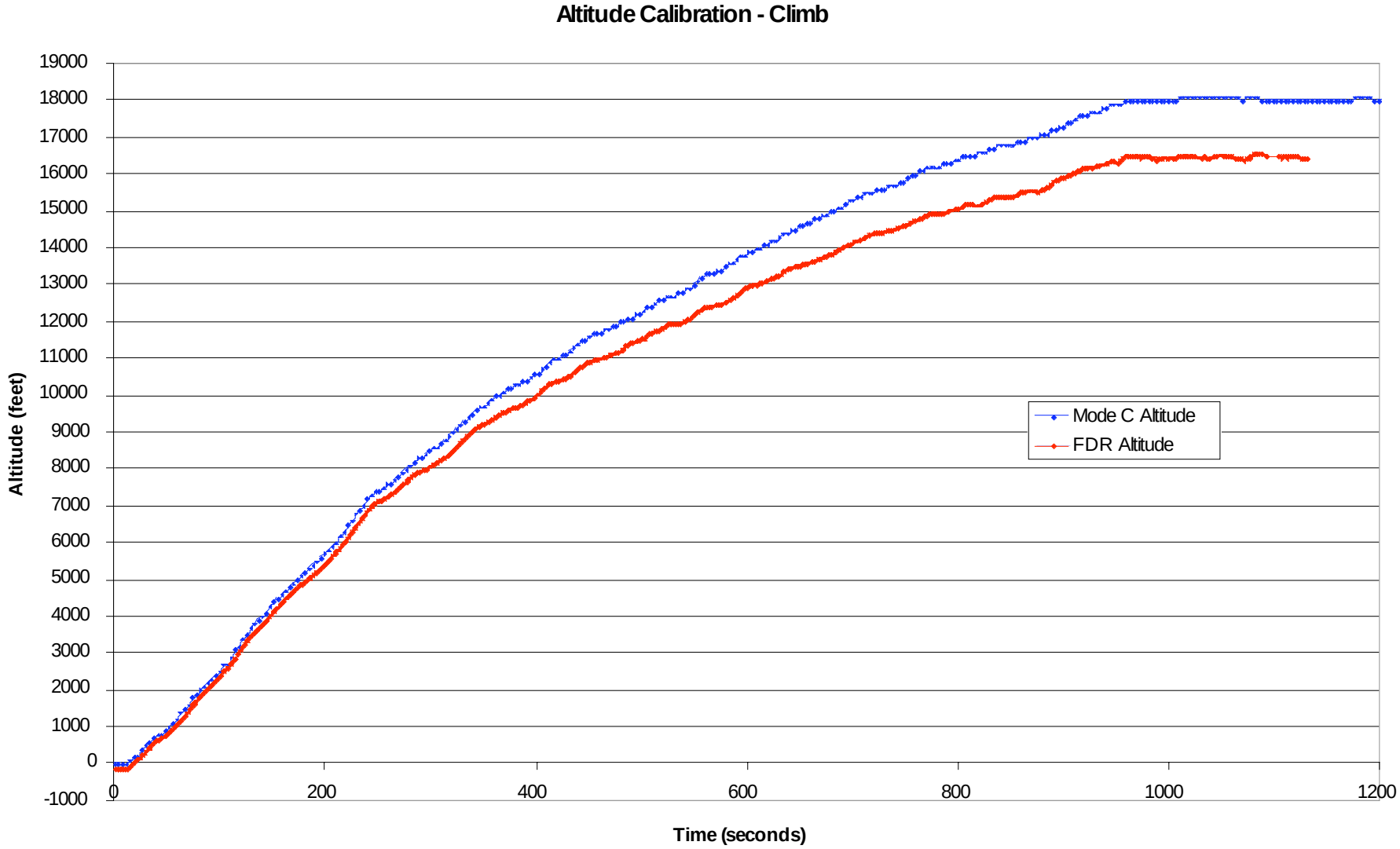
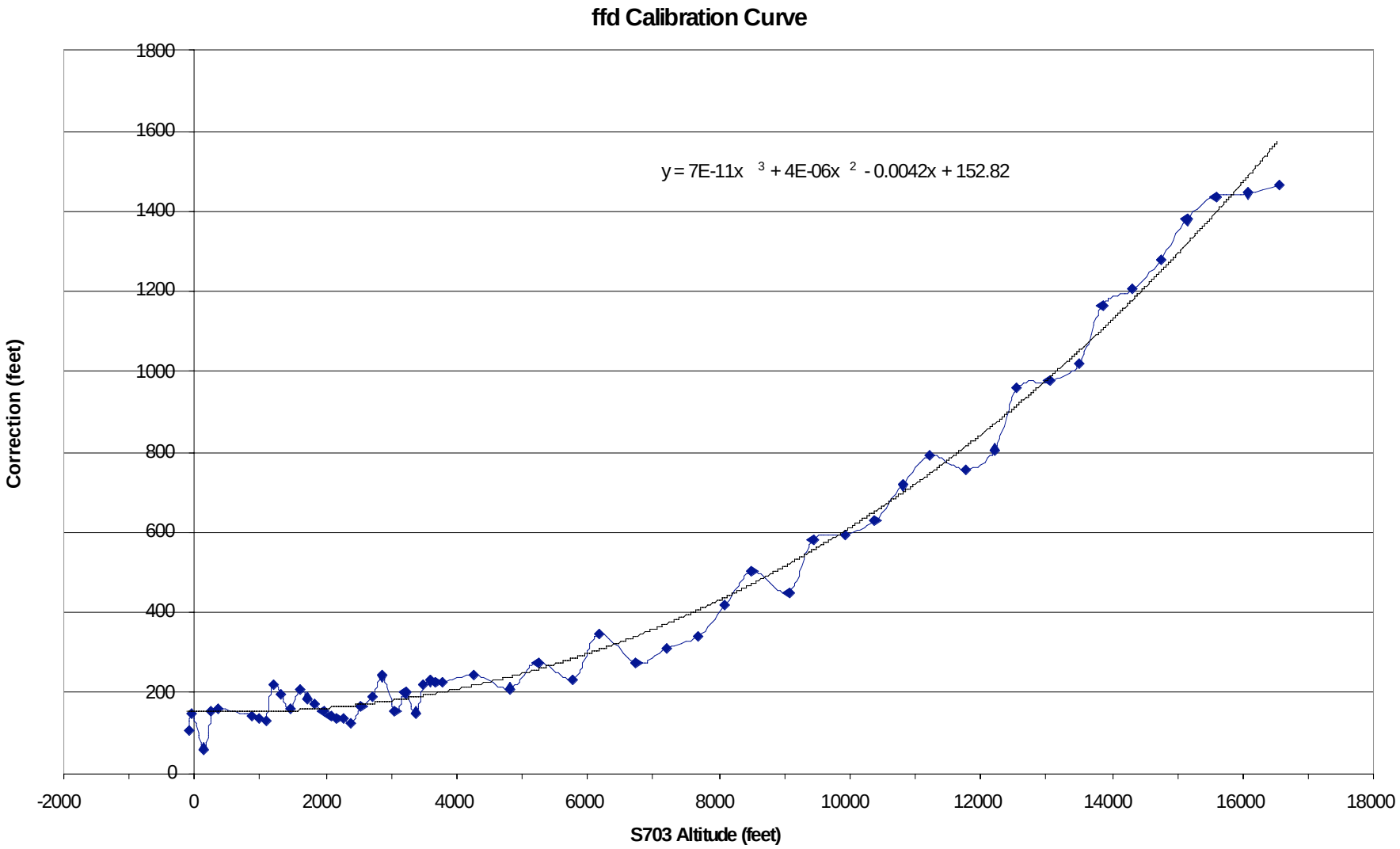

Altitude Calibration - Climb
19000
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
Altitude (feet)
0
200
400
600
800
1000
1200
Time (seconds)
Mode C Altitude
FDR Altitude

Figure A-19:


ffd Calibration Curve
y = 7E-11x 3 + 4E-06x 2 - 0.0042x + 152.82
Correction (feet)
S703 Altitude (feet)
1800
1600
1400
1200
1000
800
600
400
200
0
-2000
0
2000
4000
6000
8000
10000
12000
14000
16000
18000

Indicated airspeed

Signal Source:	**FDR pneumatic transducer**
Signal Type:	Pneumatic
Bits Used:	12
Word Location:	42
Resolution:	1 knot
Sampling Interval:	1 second

Pneumatic indicated airspeed (IAS) data is sensed by a transducer inside the FDR. The transducer measures the difference between static pressure, captured through one or more static port(s), and dynamic pressure captured through a pitot tube. The static ports are located on the exterior of the aircraft, at locations chosen to detect the prevailing atmospheric pressure as accurately as possible i.e. without any disturbance from the passage of the aircraft. The pitot tube accumulates 'ram air' i.e. air forced against the opening of the tube by the passage of the aircraft. Pitot tubes face forward in the direction of flight.

On Metro 23 aircraft, this sensor is connected to the copilot's pitot-static system. The raw recorded airspeed data is converted to engineering units (i.e. IAS in knots) by a standard polynomial equation supplied by the FDR manufacturer.

The recorded IAS data was initially processed using the manufacturer's standard polynomial conversion equation. Examination of the results showed that the IAS values were unreasonable i.e. cruise speeds did not agree with the cruise speeds documented in the operator's trip records. The damage to the pneumatic PCB from VH-TFU precluded any direct testing/calibration.

The same static pressure correction used for pressure altitude was also applied to IAS. To determine IAS the following steps were performed:

1. Determine the aircraft altitude

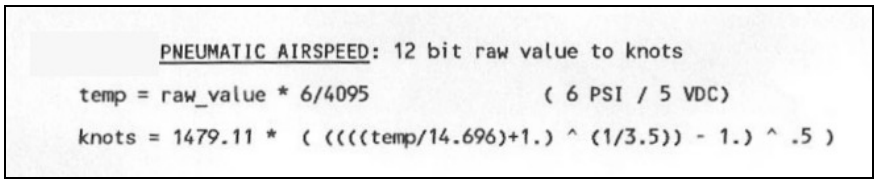
2. Determine the static pressure correction required

3. Convert this value to an equivalent voltage (i.e. multiply by 4095 and divide by 6)

4. Add this correction to the raw recorded IAS value

5. Apply the standard polynomial equation for IAS supplied by the FDR manufacturer.

Figure A-20: Manufacturer's standard airspeed polynomial[37]



The accuracy of the corrected IAS values was:

IAS	Accuracy
60 kts – 150 kts	± 10 kts
> 150kts	± 15 kts

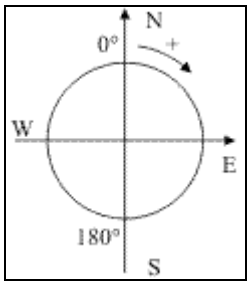
37 'Procedure for Crash Data Recovery for Flight Data Recorder Fairchild Model F1000 with Solid-State Memory'. Document FAR 0389, Revision 4, Figure 7-1, Page 2.

Magnetic heading

On Metro 23 aircraft, magnetic heading data is sensed from the pilot's gyrocompass.

Signal Source:	**Gyrocompass**
Signal Type:	Synchro
Bits Used:	12
Word Location:	9
Resolution:	0.09º
Sampling Interval:	1 second

Figure A-21: Sign convention



The standard scaling equation for magnetic heading was used and no corrections were applied. A reasonableness check was performed by examining recorded magnetic heading during takeoff and landing versus known magnetic heading of the runway obtained from the Airservices Australia publication 'En Route Supplement Australia'.

Location	**Runway Directions**	**Landing**	**Takeoff**
(7 May 2005)	(ºM)	(ºM)	(ºM)
Cairns	149/329	150.0	151.6
Lockhart River	119/299	119.9	120.8
Bamaga	131/311	129.2	133.3

The recorded headings were obtained at times when the IAS was between 80-100 kts.

The comparison showed that recorded magnetic heading agreed with documented magnetic heading within an accuracy of ± 5º.

Pitch attitude

Signal Source:	Attitude Direction Indicator
Signal Type:	Synchro[38]
Bits Used:	12
Word Locations:	13, 29, 45 & 53
Resolution:	0.09º
Sampling Interval:	0.25 second

The pitch attitude parameter was unserviceable.

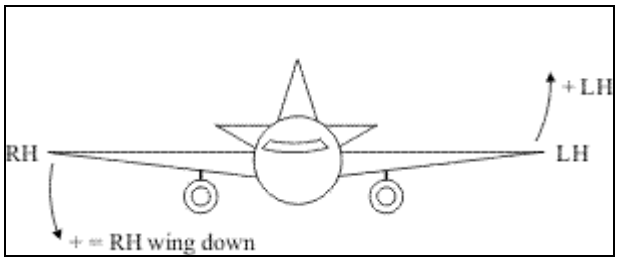
Examination of recorded pitch attitude data showed that unreasonable values had been recorded during takeoff, cruise and landing. These values were generally zero with occasional spikes. This was unrealistic behaviour as continuous variations in pitch attitude are expected during flight. This characteristic was evident in all the flights recorded by the FDR, not just the accident flight.

Roll attitude

Signal Source:	Attitude Direction Indicator
Signal Type:	Synchro
Bits Used:	12
Word Locations:	14 & 46
Resolution:	0.09º
Sampling Interval:	0.5 second

The sign convention for roll attitude is that positive values correspond to right wing low:

Figure A-22: Sign convention



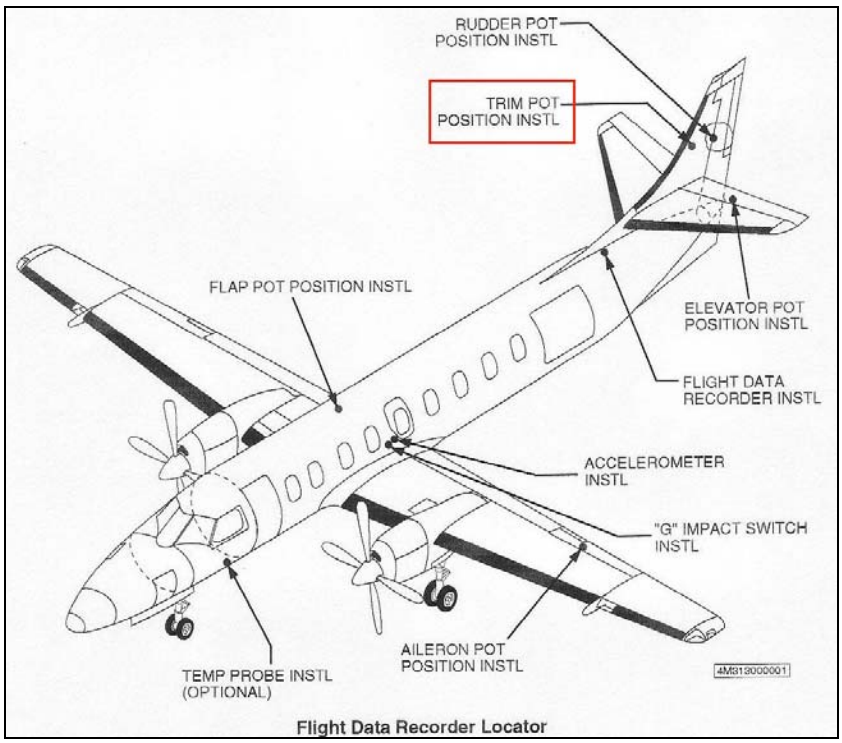
38 A synchro is an AC electrical position sensor.

The standard scaling equation for roll attitude was used and no corrections were applied.

Horizontal stabiliser position

Signal Source:	Potentiometer
Signal Type:	DC voltage
Bits Used:	12
Word Location:	18
Resolution:	0.04º
Sampling Interval:	1 second

Figure A-23: Trim potentiometer (pot) location



It has been observed in readouts from other Metro 23 aircraft, prior to the accident involving VH-TFU, that the standard scaling for horizontal stabiliser position resulted in unrealistic values and was incorrect. Neither the aircraft manufacturer nor the FDR manufacturer has been able to provide the correct scaling equation.

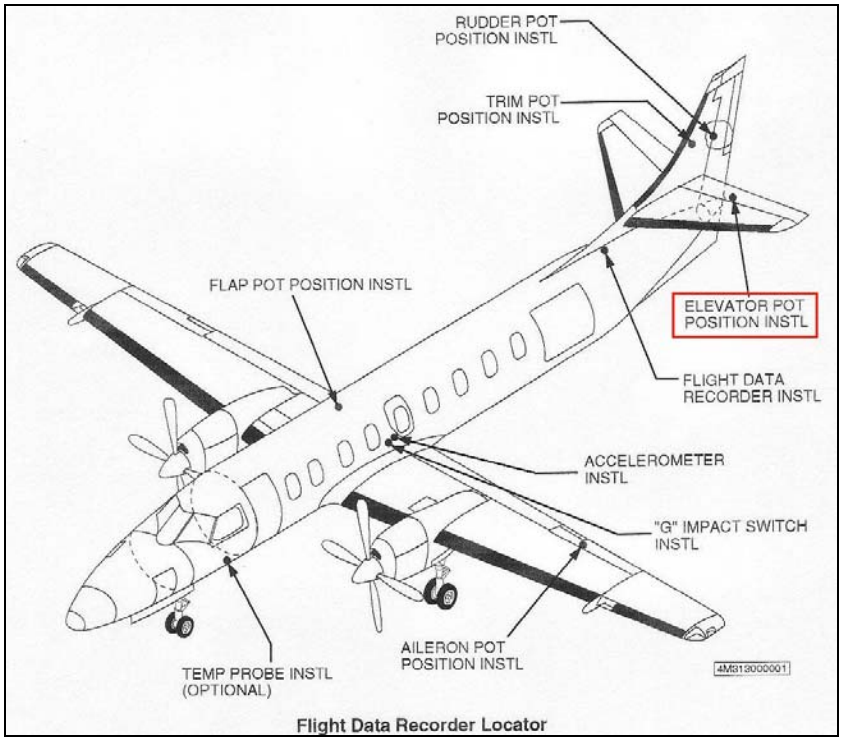
Examination of the raw horizontal stabiliser position data from VH-TFU showed that it behaved in a similar way to other Metro 23 aircraft. Data from VH-TFU and other Metro 23 aircraft were examined to determine the relationship between the raw decimal counts and horizontal stabiliser position.

Horizontal Stabiliser Position	Raw Decimal Counts
Full Nose Up (+7.8º) (Leading Edge Down)	2264
Full Nose Down (-2.4º) (Leading Edge Up)	2017

Elevator position

Signal Source:	Potentiometer
Signal Type:	DC voltage
Bits Used:	12
Word Location:	31
Resolution:	0.08º
Sampling Interval:	1 second

Figure A-24: Elevator potentiometer (pot) location



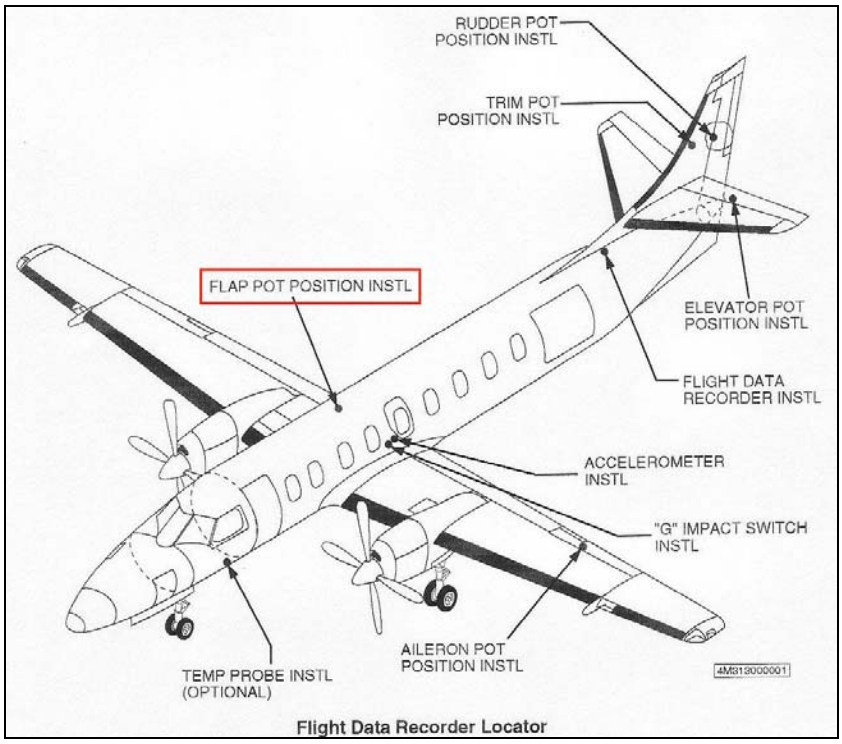
Elevator scaling was derived using Fairchild Aircraft drawing 27K82090 and Figure 1-25 from the L3 Communications component maintenance manual.

Elevator Position	Raw Decimal Counts
Neutral (0º)	1950
Full Up (+30º)	2434
Full Down (-15º)	1669

Flap position

Signal Source:	Potentiometer
Signal Type:	DC voltage
Bits Used:	12
Word Locations:	23 & 55
Resolution:	0.04º
Sampling Interval:	0.5 second

Figure A-25: Flap potentiometer (pot) location



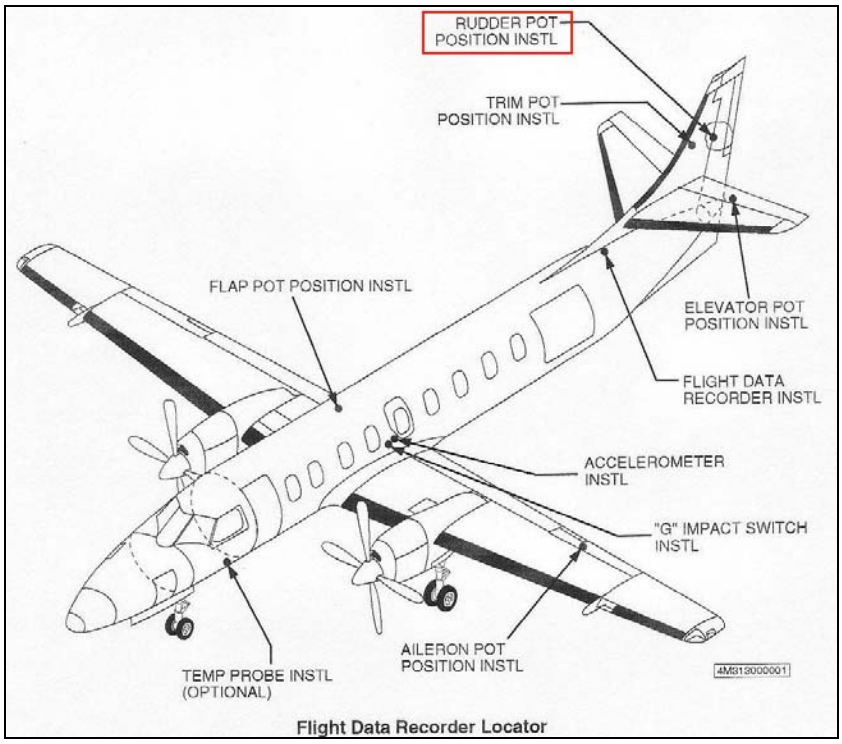
It was observed that the use of the standard scaling for flap position resulted in unrealistic values. The raw data was examined to determine the relationship between the raw decimal counts and flap position.

Flap Lever Detent Position	Flap Position	Raw Decimal Counts
Up	0º	2134 - 2140
¼	9º	1924 - 1944
½	18º	1714 - 1724
Down	36º	1282 - 1338

Rudder position

Signal Source:	Potentiometer
Signal Type:	DC voltage
Bits Used:	12
Word Location:	30
Resolution:	0.04º
Sampling Interval:	1 second

Figure A-26: Rudder potentiometer (pot) location



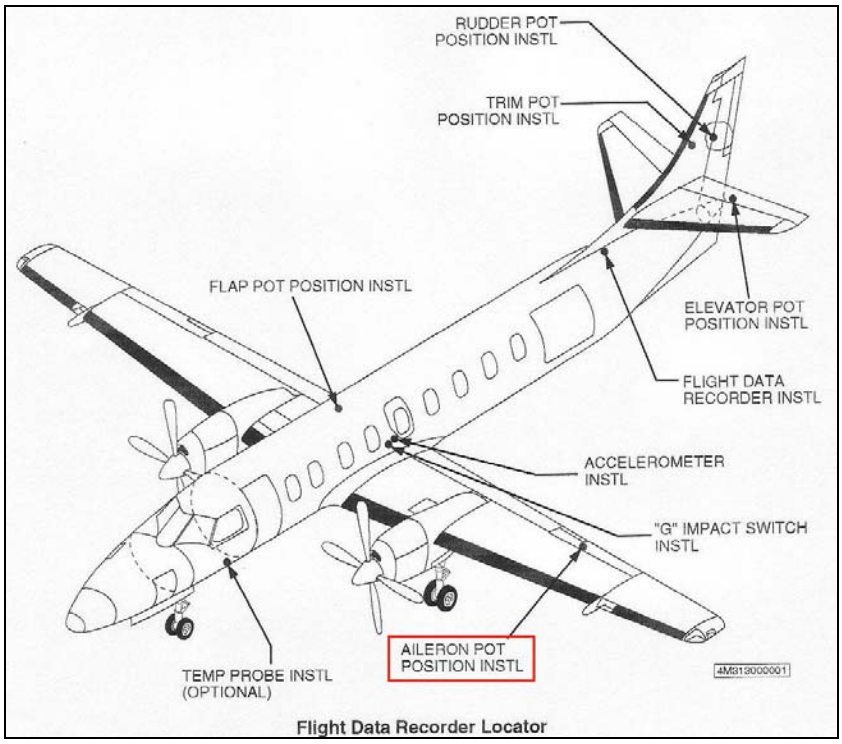
Rudder position scaling was derived using Fairchild Aircraft drawing 27K82090 and Figure 1-25 from the L3 Communications component maintenance manual.

Rudder Position	Raw Decimal Counts
Neutral (0º)	1950
Full Right (+25º)	2597
Full Left (-25º)	1365

Aileron position

Signal Source:	Potentiometer
Signal Type:	DC voltage
Bits Used:	12
Word Locations:	6, 22, 38 & 54
Resolution:	0.07º
Sampling Interval:	0.25 second

Figure A-27: Aileron potentiometer (pot) location



Aileron position scaling was derived using Fairchild Aircraft drawing 27K82090 and Figure 1-25 from the L3 Communications component maintenance manual.

Aileron Position	Raw Decimal Counts
Neutral (0º)	1950
Full Up (+18.5º)	2410
Full Down (-21.5º)	1482

Right engine propeller RPM

Signal Source:	**Tacho-generator**
Signal Type:	Frequency
Bits Used:	12
Word Location:	40
Resolution:	0.14%
Sampling Interval:	1 second

Right engine propeller RPM was transmitted to the FDR as a frequency signal. The standard scaling for propeller RPM was used and no corrections were applied.

Left engine propeller RPM

Signal Source:	**Tacho-generator**
Signal Type:	Frequency
Bits Used:	12
Word Location:	8
Resolution:	0.14%
Sampling Interval:	1 second

Left engine propeller RPM was transmitted to the FDR as a frequency signal. The standard scaling for propeller RPM was used and no corrections were applied.

Right engine torque

Signal Source:	**Torque transducer (strain-gauge)**
Signal Type:	DC voltage
Bits Used:	12
Word Location:	64
Resolution:	0.04%
Sampling Interval:	1 second

The standard scaling equation for torque was used and no corrections were applied.

Left engine torque

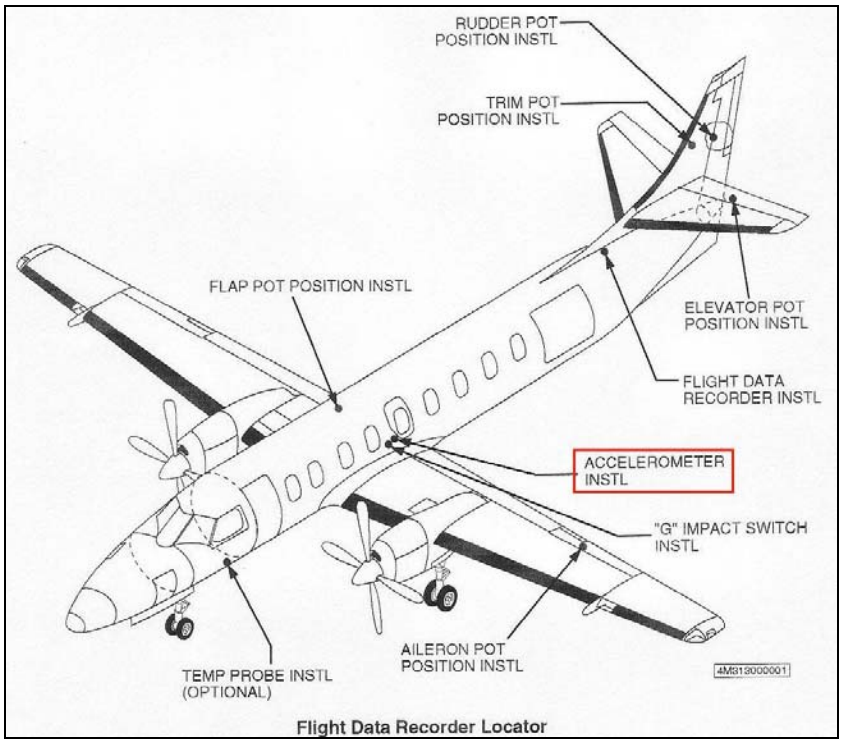
Signal Source:	**Torque transducer (strain-gauge)**
Signal Type:	DC voltage
Bits Used:	12
Word Location:	32
Resolution:	0.04%
Sampling Interval:	1 second

The standard scaling equation for torque was used and no corrections were applied.

Vertical acceleration

Signal Source:	DC accelerometer
Signal Type:	DC voltage
Bits Used:	12
Word Locations:	4, 12, 20, 28, 36, 44, 52 & 60
Resolution:	0.003 g
Sampling Interval:	0.125 second

Figure A-28: Accelerometer general location



A dual-axis DC accelerometer was fitted to VH-TFU. It provided acceleration information in the aircraft vertical (Z) and longitudinal (X) axes. The standard scaling equation for vertical acceleration was used and no corrections were applied. A reasonableness check was performed by examining recorded vertical acceleration values when the aircraft was on the ground and airborne. Values close to the expected 1 g were recorded on the ground with typical variations observed when the aircraft was airborne.

Figure A-29: Sign convention

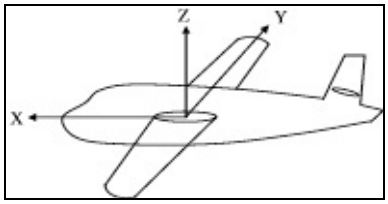
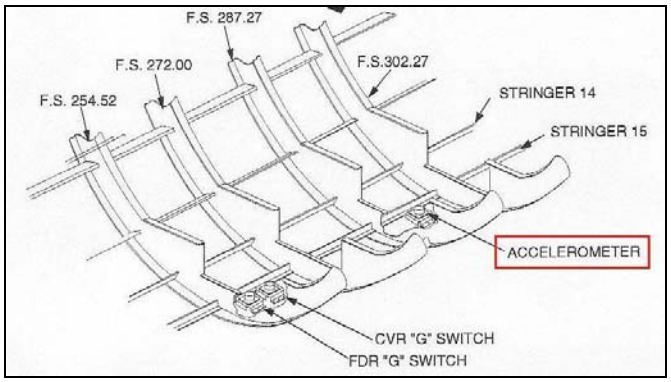


Figure A-30: Accelerometer detailed location



Longitudinal acceleration

Signal Source:	**DC accelerometer**
Signal Type:	DC voltage
Bits Used:	12
Word Locations:	5, 21, 37 & 53
Resolution:	0.0005 g
Sampling Interval:	0.25 second

The standard scaling equation for longitudinal acceleration was used and no corrections were applied. A reasonableness check was performed by examining recorded longitudinal acceleration values when the aircraft was on the ground and during the take-off roll. Values close to the expected 0 g were recorded on the ground and the typical increase in longitudinal acceleration was observed as the aircraft accelerated along the runway during takeoff.

Pilot microphone keying (COM 1)

Signal Source:	Pilot's transmitter
Signal Type:	DC voltage
Bits Used:	1
Word Location:	11 (bit 1)
Resolution:	N/A
Sampling Interval:	1 second

This parameter is used for recording the time that a radio transmission was made i.e. the time that a microphone was 'keyed'. It is used to synchronise a voice recording (either a cockpit voice recorder or a ground-based air traffic control audio recorder) with the flight data recorder.

No scaling equation is required for a discrete parameter. A 'zero' corresponds to 'keyed' and a 'one' corresponds to 'not keyed'.

Copilot microphone keying (COM 2)

Signal Source:	Copilot's transmitter
Signal Type:	DC voltage
Bits Used:	1
Word Location:	11 (bit 3)
Resolution:	N/A
Sampling Interval:	1 second

This parameter is used for recording the time that a radio transmission was made i.e. the time that a microphone was 'keyed'. It is used to synchronise a voice recording (either a cockpit voice recorder or a ground-based air traffic control audio recorder) with the flight data recorder.

No scaling equation is required for a discrete parameter. A 'zero' corresponds to 'keyed' and a 'one' corresponds to 'not keyed'.

End of recording

The FDR used solid-state technology (i.e. integrated circuits or memory chips) to store the flight data. The FDR memory board comprised 64 separate flash memory chips numbered 0 to 63. Each chip had a memory capacity of 1 megabit giving a total memory capacity of 64 megabits or 8 megabytes.

When the memory was downloaded for analysis, the resulting file (with file extension of *.fdt*) was an exact memory image of the contents of the flash memory chips. Time sequencing and decompression were performed on the *.fdt* file by proprietary software.

The flash memory chips were organized in pairs and data was ‘stitched’ between chips i.e. one frame (4 seconds or 4 subframes of data) was stored in one chip and the next frame was stored in its ‘buddy’ chip.

A memory analysis report was conducted and the results are shown in Figure A-31.

The break in sequence numbers (shown in the column titled SEQ#) in the memory analysis report shows that the most recent data was being recorded alternately in chips 10 and 11 (shown in the column titled PHY#).

Memory failure and error information was also stored in the flash chips. The memory analysis report showed that there were no memory failure or error indications recorded.

Manual examination of the data showed:

Chip:	Subframe:	FDR Elapsed Time Counter (seconds):
10	1	3020
10	2	3021
10	3	3022
10	4	3023
11	1	3024
11	2	3025
11	3	3026
11	4	3027
10	1	3028
10	2	3029
10	3	3030
10	4	3031
11	1	3032
The last valid parameter recorded was vertical acceleration in word 60 of subframe 1.		

The final data recorded by the FDR was consistent with power being removed from the FDR once only. During the initial accident impact with trees, the G switch[39] is likely to have operated removing power from the FDR. The FDR power supply circuit contains a large capacitor that can power the FDR for a short period in the absence of aircraft power. Once power is removed, the FDR is designed to enter a standby mode and later, if power is not restored, the FDR will shutdown. The standby and shutdown process takes approximately 1 second.

Input data to the FDR is not recorded instantaneously and must occur within 0.5 of a second[40]. In the case of the F1000, the delay (latency) between data being sampled and it being recorded is less than 0.1 of a second.

39 G switches are typically set to trigger in the range of 3 – 4 g and are orientated 45° to the aircraft's longitudinal axis.

40 EUROCAE document ED-55 page 27.

Figure A-31: Memory analysis report

MEMORY DEVICE STATUS

LOGICAL#	PHY#	SEQ#	BAD PAGES	CNTRDCTRY BAD_PGS	CORR'ED BIT_ERRS	UNCORR'ED BIT_ERRS	SUICIDE NOTE	VERSION
0	0	2	0	0	0	0	none	1.27
1	1	3	0	0	0	0	none	1.27
2	2	4	0	0	0	0	none	1.27
3	3	5	0	0	0	0	none	1.27
4	4	6	0	0	0	0	none	1.27
5	5	7	0	0	0	0	none	1.27
6	6	9	0	0	0	0	none	1.27
7	7	8	0	0	0	0	none	1.27
8	8	10	0	0	0	0	none	1.27
9	9	11	0	0	0	0	none	1.27
10	10	12	0	0	0	0	none	1.27
11	11	13	0	0	0	0	none	1.27
12	12	206	0	0	0	0	none	1.27
13	13	207	0	0	0	0	none	1.27
14	14	208	0	0	0	0	none	1.27
15	15	209	0	0	0	0	none	1.27
16	16	210	0	0	0	0	none	1.27
17	17	211	0	0	0	0	none	1.27
18	18	212	0	0	0	0	none	1.27
19	19	213	0	0	0	0	none	1.27
20	20	214	0	0	0	0	none	1.27
21	21	215	0	0	0	0	none	1.27
22	22	216	0	0	0	0	none	1.27
23	23	217	0	0	0	0	none	1.27
24	24	218	0	0	0	0	none	1.27
25	25	219	0	0	0	0	none	1.27
26	26	220	0	0	0	0	none	1.27
27	27	221	0	0	0	0	none	1.27
28	28	223	0	0	0	0	none	1.27
29	29	222	0	0	0	0	none	1.27
30	30	224	0	0	0	0	none	1.27
31	31	225	0	0	0	0	none	1.27
32	32	226	0	0	0	0	none	1.27
33	33	227	0	0	0	0	none	1.27
34	34	228	0	0	0	0	none	1.27
35	35	229	0	0	0	0	none	1.27
36	36	230	0	0	0	0	none	1.27
37	37	231	0	0	0	0	none	1.27
38	38	233	0	0	0	0	none	1.27
39	39	232	0	0	0	0	none	1.27
40	40	234	0	0	0	0	none	1.27
41	41	235	0	0	0	0	none	1.27
42	42	236	0	0	0	0	none	1.27
43	43	237	0	0	0	0	none	1.27
44	44	238	0	0	0	0	none	1.27
45	45	239	0	0	0	0	none	1.27
46	46	240	0	0	0	0	none	1.27
47	47	241	0	0	0	0	none	1.27
48	48	242	0	0	0	0	none	1.27
49	49	243	0	0	0	0	none	1.27
50	50	244	0	0	0	0	none	1.27
51	51	245	0	0	0	0	none	1.27
52	52	246	0	0	0	0	none	1.27
53	53	247	0	0	0	0	none	1.27
54	54	248	0	0	0	0	none	1.27
55	55	249	0	0	0	0	none	1.27
56	56	251	0	0	0	0	none	1.27
57	57	250	0	0	0	0	none	1.27
58	58	252	0	0	0	0	none	1.27
59	59	253	0	0	0	0	none	1.27
60	60	254	0	0	0	0	none	1.27
61	61	255	0	0	0	0	none	1.27
62	62	0	0	0	0	0	none	1.27
63	63	1	0	0	0	0	none	1.27
64 DEVICES TOTALS			0	0	0	0	0	

Timing correlation

UTC was not recorded by the FDR, however the FDR did record an elapsed time counter which began when power was applied to the recorder and was incremented once per second. When power was removed and later re-applied, this counter was reset to zero and began incrementing again.

UTC was matched with the recorded FDR elapsed time by correlating the microphone keying discrete parameter with the UTC time stamp from the ATC air/ground voice recording. Using this technique the radio transmission from VH-TFU ('*Brisbane centre tango foxtrot uniform*'), that was recorded on the ground at 0114:28 UTC, was correlated with the FDR microphone keying parameter at an elapsed time of 1281 seconds. This correlation was accurate to ± 1 second.

Flights landing at Lockhart River

The F1000 model FDR compresses the flight data before it is recorded and as a result the recording duration exceeds the minimum requirement of retaining the most recent 25 hours. In this case 100 hours, 2 minutes and 16 seconds of data was recorded covering the accident flight and 59 previous flights. The oldest data recorded was from the cruise and descent portion of the Lockhart River to Cairns flight on 13 April 2005.

Flights that landed at Lockhart River (LHR) are tabulated below:

VH-TFU Flight Sequence: **(before accident flight)**	**Sector:**	**Date:**	**Landing Runway:**
2	CS-LHR	7 May	12
9	CS-LHR	4 May	12
17	BAM-LHR	30 April	12
19	CS-LHR	30 April	12
28	BAM-LHR	27 April	12
30	CS-LHR	27 April	12
34	CS-LHR	25 April	12
36	BAM-LHR	23 April	12
50	CS-LHR	20 April	12

Sequence of events

The accident flight was examined in detail and relevant parameters plotted (refer to Figure A-32 to Figure A-37).

Table A-1: Sequence of events

UTC	Replay	Pressure	Mag.	Indicated	Elapsed	Elapsed	Event
(from ATC recordings)	Time	Altitude	Heading	Airspeed	Time	Time	
	Counter					Counter	
		(feet)	(degrees)	(knots)	(hh:mm:ss)	(seconds)	
00:53:07	355926	N/A	N/A	N/A	00:00:00	0	FDR power-up. Aircraft was stationary at Bamaga.
01:07:32	356791	N/A	N/A	N/A	00:14:25	865	Right engine start.
01:09:15	356894	N/A	N/A	N/A	00:16:08	968	Left engine start.
01:09:42	356921	N/A	N/A	N/A	00:16:35	995	Takeoff flap selected.
01:10:14	356953	83	107.5	N/A	00:17:07	1027	Microphone keyed - Pilot. Aircraft began to taxi.
01:10:45	356984		25	N/A	00:17:38	1058	Control checks: aileron and elevator.
01:11:09	357008	118	343.3	N/A	00:18:02	1082	Microphone keyed - Pilot.
01:11:54	357053	80	147.4	N/A	00:18:47	1127	Power applied for takeoff on runway 13 at Bamaga.
01:12:19	357078	107	134.3	119	00:19:12	1152	Lift off.
01:12:39	357098	381	131	149	00:19:32	1172	Torque reduced on both engines after takeoff.
01:13:01	357120	866	124.6	147	00:19:54	1194	Microphone keyed - Pilot.
01:13:14	357133	1248	121.4	154	00:20:07	1207	Microphone keyed - Copilot.
01:13:31	357150	1773	120.4	146	00:20:24	1224	Flap selected up.
01:14:28	357207	3360	145.8	153	00:21:21	1281	Microphone keyed - Copilot.
01:14:33	357212	3438	149.2	155	00:21:26	1286	Microphone keyed - Copilot.
01:14:49	357228	3667	151	165	00:21:42	1302	Microphone keyed - Copilot.

UTC	Replay	Pressure	Mag.	Indicated	Elapsed	Elapsed	Event
(from ATC recordings)	Time	Altitude	Heading	Airspeed	Time	Time	
	Counter					Counter	
		(feet)	(degrees)	(knots)	(hh:mm:ss)	(seconds)	
01:14:58	357237	3924	149.7	163	00:21:51	1311	Microphone keyed - Copilot.
01:24:36	357815	14281	142.8	165	00:31:29	1889	Microphone keyed - Copilot.
01:28:32	358051	16977	153.1	169	00:35:25	2125	Top of climb (FL170).
01:32:26	358285	17124	143.3	201	00:39:19	2359	Top of descent.
01:33:06	358325	16130	147.9	226	00:39:59	2399	Microphone keyed - Copilot.
01:33:28	358347	15412	150.5	239	00:40:21	2421	Microphone keyed - Copilot.
01:33:37	358356	15127	150.9	246	00:40:30	2430	Torque reduced on both engines.
01:33:54	358373	14531	153.7	252	00:40:47	2447	Further reduction in torque on both engines.
01:34:31	358410	13067	157.1	248	00:41:24	2484	Microphone keyed - Copilot.
01:35:24	358463	11202	150.7	247	00:42:17	2537	Microphone keyed - Copilot.
01:35:42	358481	10583	147.3	249	00:42:35	2555	Microphone keyed - Copilot.
01:35:48	358487	10376	146.9	250	00:42:41	2561	Microphone keyed - Copilot.
01:36:18	358517	9369	147.6	250	00:43:11	2591	Microphone keyed - Copilot.
01:36:49	358548	8364	149.4	253	00:43:42	2622	Microphone keyed - Copilot.
01:38:44	358663	4305	145.3	243	00:45:37	2737	Torque increased on both engines.
01:39:30	358709	3505	146.8	229	00:46:23	2783	Aircraft reached 3,500 feet and began to climb.
01:39:50	358729	3992	144.6	195	00:46:43	2803	Aircraft levelled at 4,000 feet.
01:39:56	358735	3992	157.1	192	00:46:49	2809	Aircraft began to descend. Microphone keyed - Copilot.

UTC	Replay	Pressure	Mag.	Indicated	Elapsed	Elapsed	Event
(from ATC recordings)	Time	Altitude	Heading	Airspeed	Time	Time	
	Counter					Counter	
		(feet)	(degrees)	(knots)	(hh:mm:ss)	(seconds)	
01:40:19	358758	3316	177.7	204	00:47:12	2832	Altitude 3,300 feet.
01:40:26	358765	3457	175.7	197	00:47:19	2839	Microphone keyed - Copilot.
01:40:28	358767	3513	175.7	197	00:47:21	2841	First stage of flap selected.
01:40:33	358772	3600	177	190	00:47:26	2846	Aircraft levelled at 3,600 feet. Microphone keyed - Copilot.
01:40:46	358785	3596	183.6	181	00:47:39	2859	Torque increased on both engines.
01:41:11	358810	3588	139.4	179	00:48:04	2884	Aircraft left 3,600 feet.
01:41:52	358851	2998	134.8	188	00:48:45	2925	Aircraft levelled at 3,000 feet.
01:42:19	358878	3039	127	180	00:49:12	2952	Second stage of flap selected.
01:42:29	358888	3043	126.9	174	00:49:22	2962	Aircraft left 3,000 feet on descent.
01:43:39	358958	1365	136	157	00:50:32	3032	End of recorded data.

Figure A-32: Plot of flight parameters

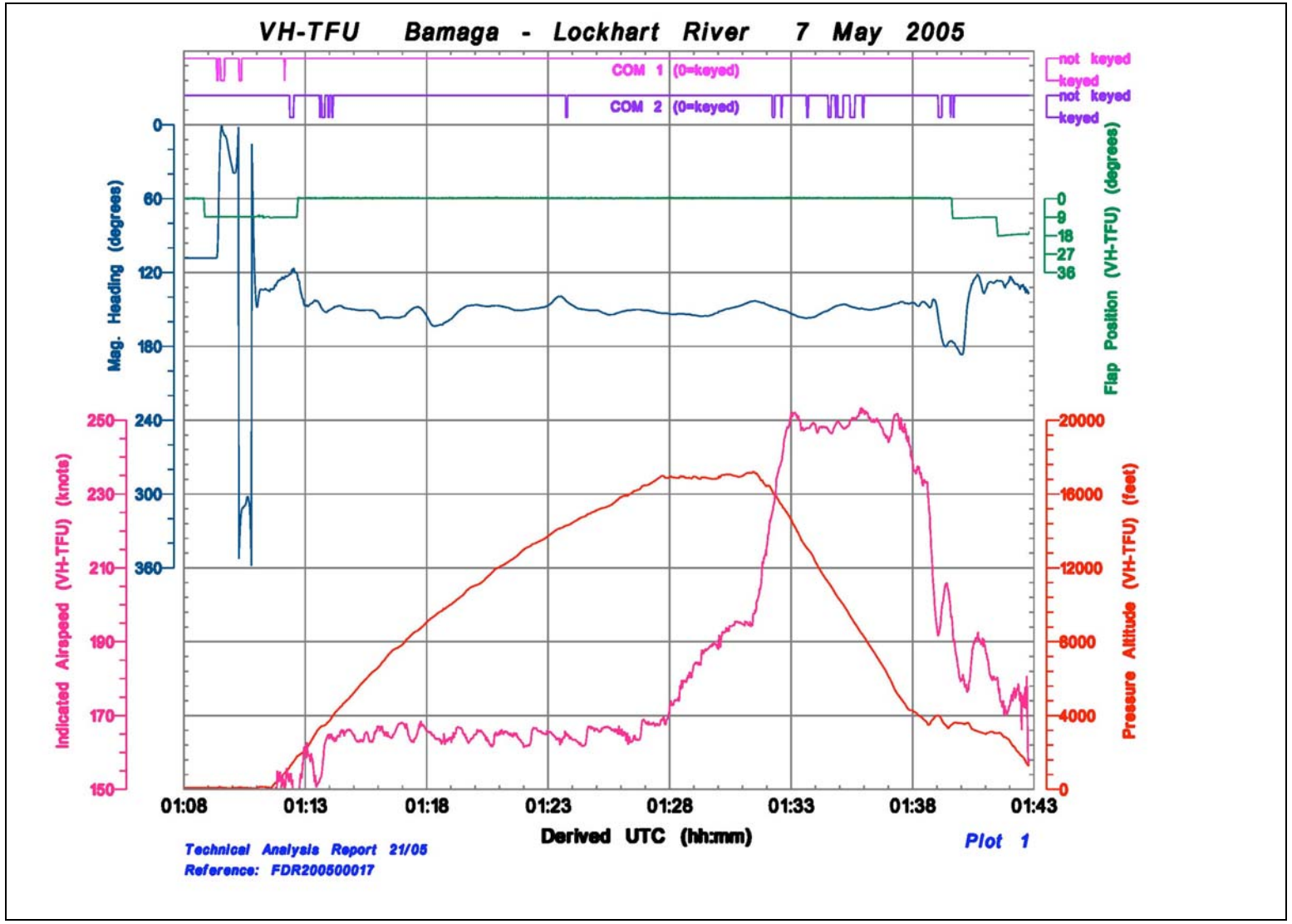


Figure A-33: Plot of engine parameters

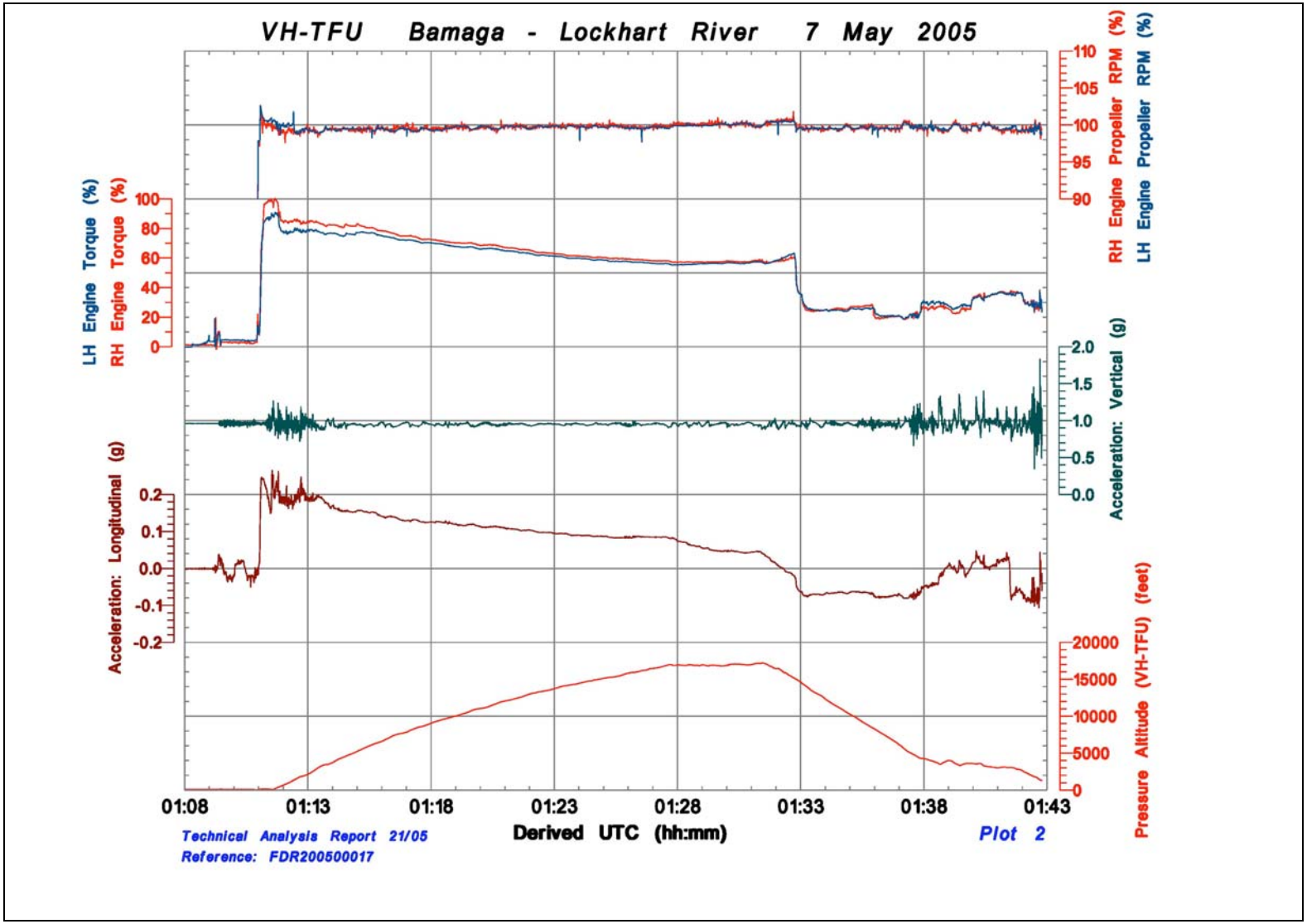


Figure A-34: Plot of control parameters

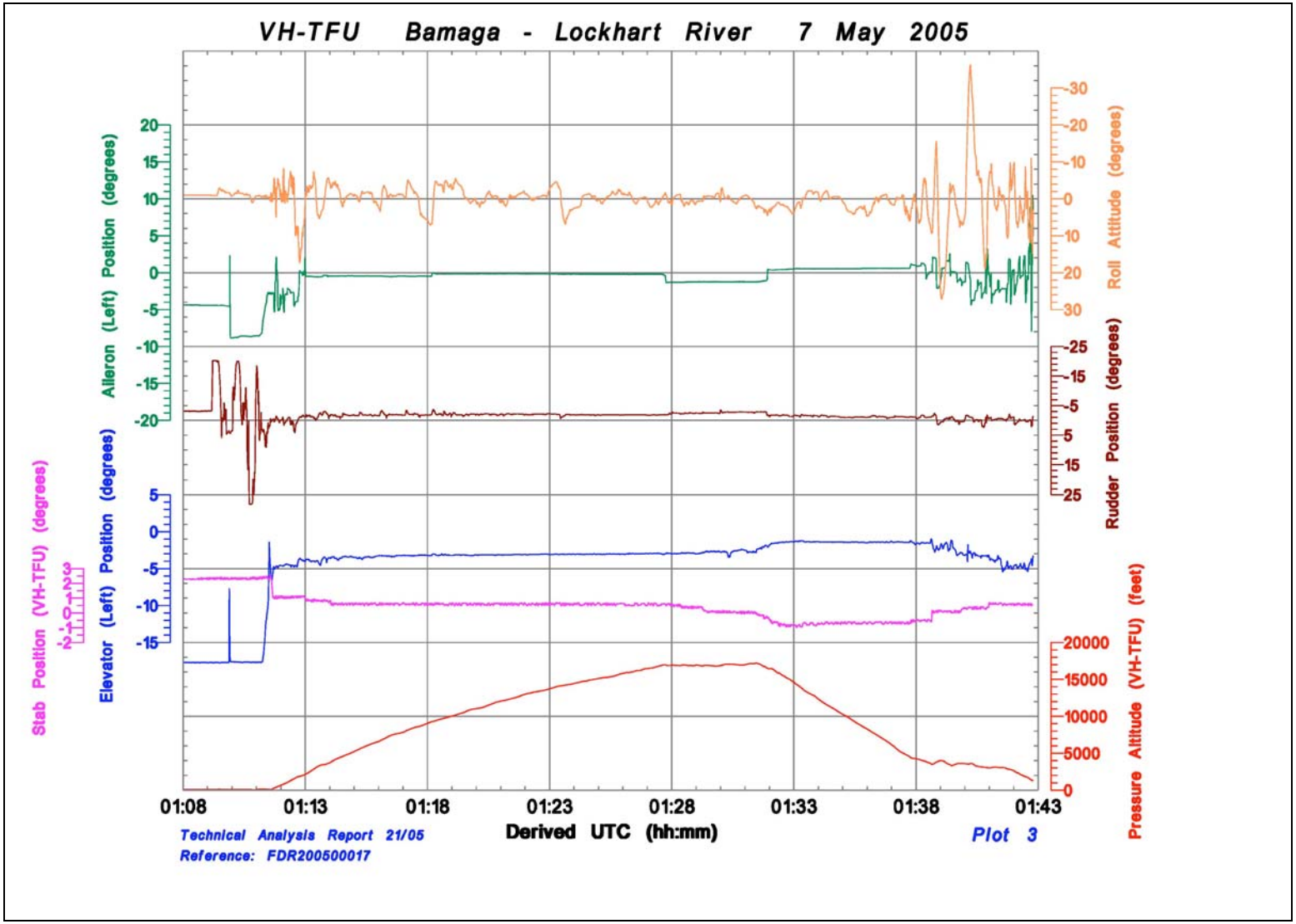


Figure A-35: Plot of flight parameters (last 5 minutes)

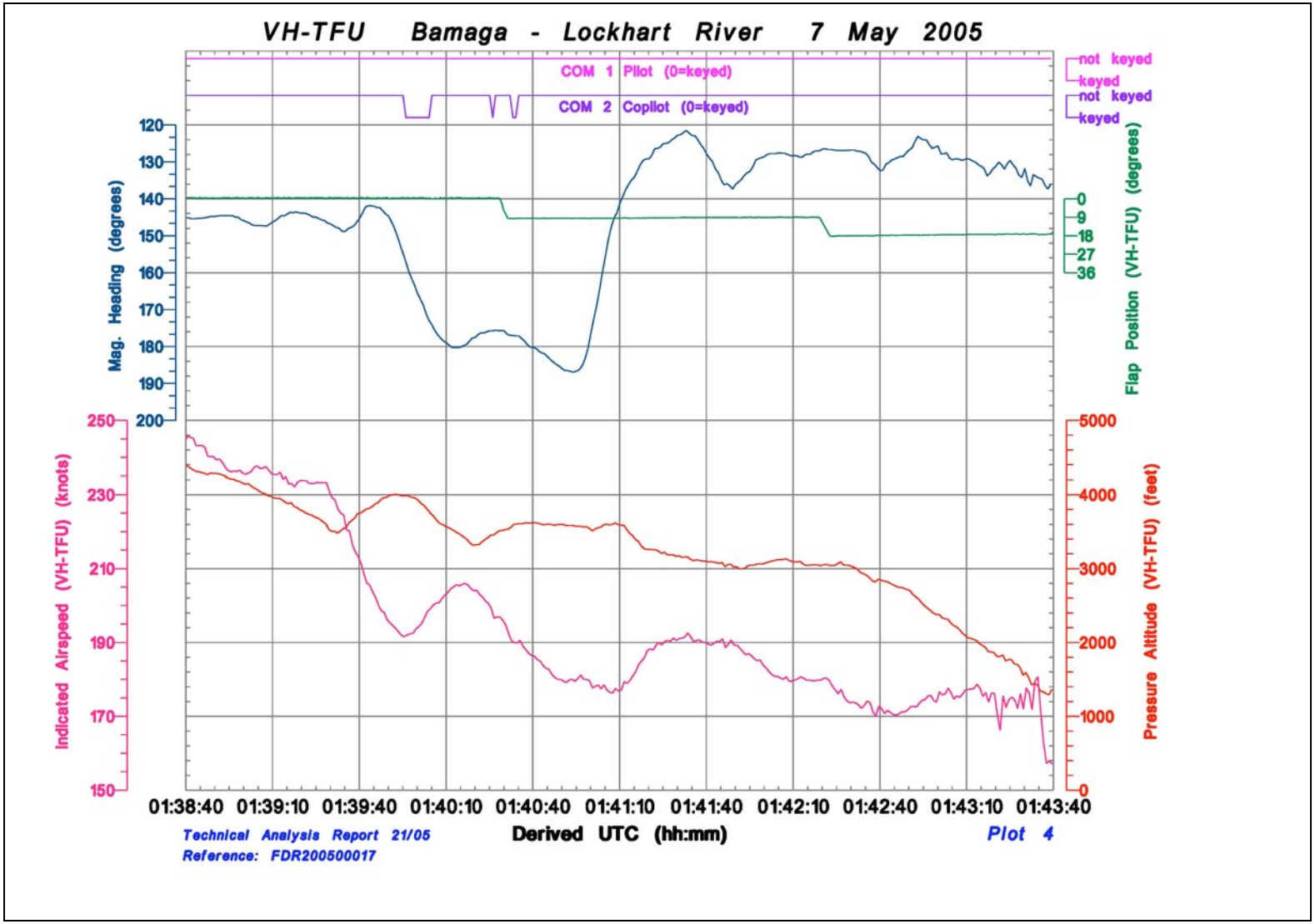


Figure A-36: Plot of engine parameters (last 5 minutes)

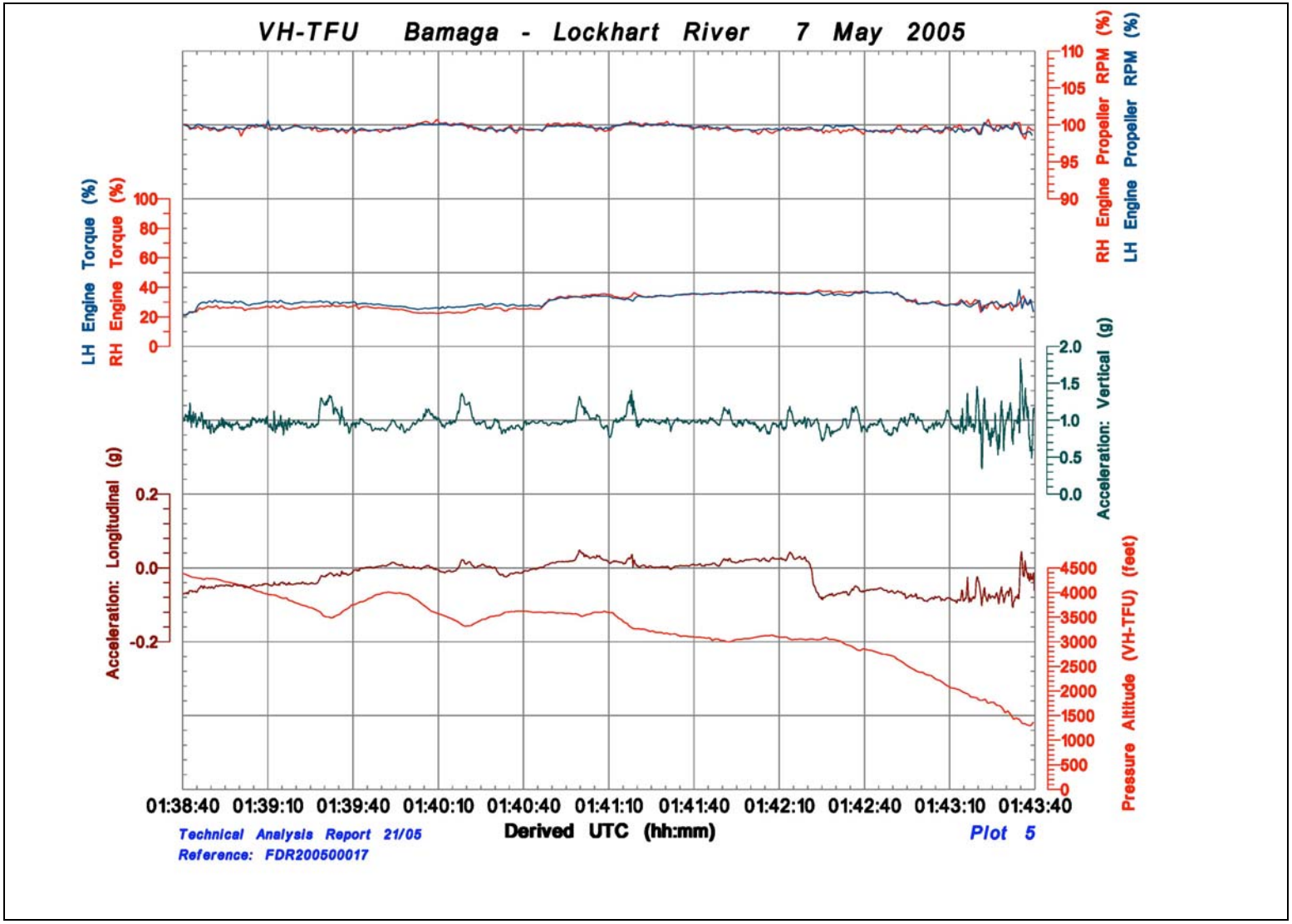
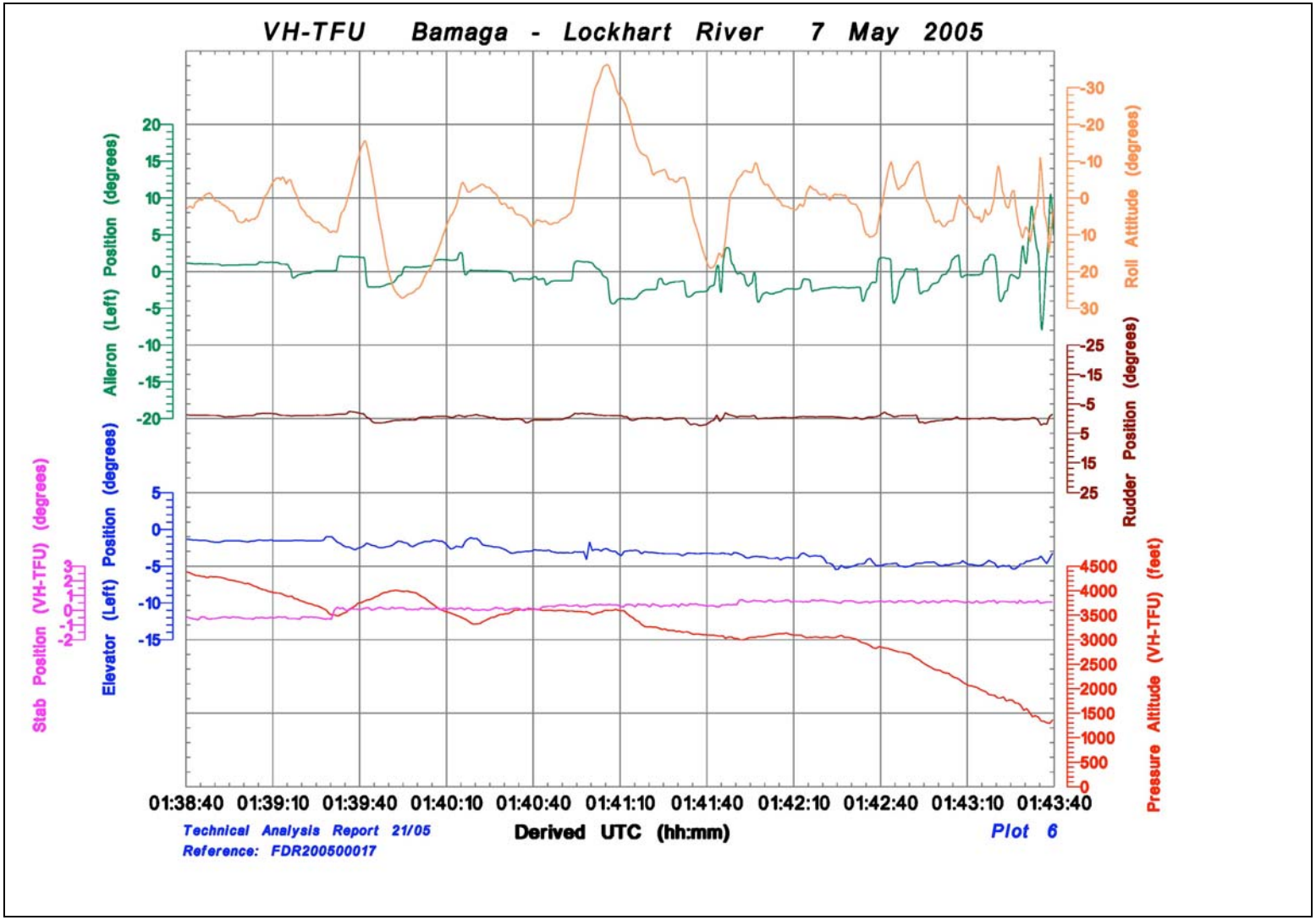


Figure A-37: Plot of control parameters (last 5 minutes)



Findings

The FDR was recovered from the accident site and transported to the ATSB laboratories in Canberra. The FDR was visually inspected and disassembled to obtain the FDR memory board. Under ATSB control, data from the memory board was successfully downloaded at an authorised repair agency in Melbourne.

Examination of the recovered data showed that the accident flight and 59 previous flights had been recorded by the FDR. The total duration of recorded data was 100 hours, 2 minutes and 16 seconds.

Parameter serviceability

Examination of the data showed that the following parameters were serviceable during the accident flight:

Pressure Altitude[41]

Indicated Airspeed

Magnetic Heading

Roll Attitude

Horizontal Stabiliser Position

Flap Position

Elevator Position

Rudder Position

Aileron Position

Right Engine Propeller RPM

Left Engine Propeller RPM

Right Engine Torque

Left Engine Torque

Vertical Acceleration

Longitudinal Acceleration

Microphone Keying - Pilot

Microphone Keying - Copilot

---

41 The pneumatic printed circuit board, inside the FDR, that was used to provide pressure altitude and indicated airspeed data was out of calibration. Calibration equations were developed which corrected for this problem.

The pitch attitude parameter was unserviceable during the accident flight and all the previous flights recorded by the FDR.

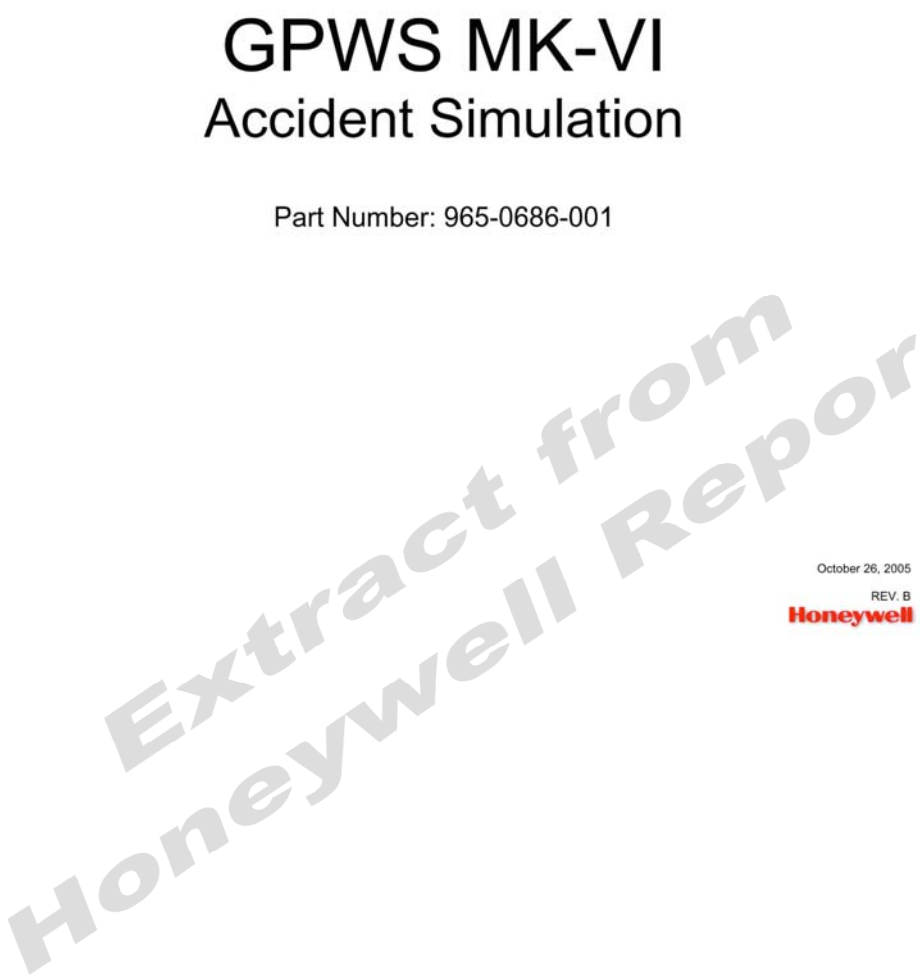
Abbreviations

Acronyms may be used in upper case or lower case.

AC	Alternating Current
AD	Aerodrome
ADI	Attitude Director Indicator
ALT	Altitude
ATC	Air Traffic Control
BAM	Bamaga
BOM	Bureau of Meteorology
C	Celsius
CNS	Cairns
CVR	Cockpit Voice Recorder
DC	Direct Current
ELEV	Elevation
FAF	Final Approach Fix (eg. LHRWF)
FDR	Flight Data Recorder
FFD	Frame Format Descriptor
FS	Fuselage Station
G	Gravitational Constant
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HDOP	Horizontal Dilution of Precision
hPa	Hectopascals
HZ	Hertz (cycles per second)
IAF	Initial Approach Fix
IAS	Indicated Airspeed
IF	Intermediate Fix (eg. LHRWI)
ILS	Instrument Landing System
LHR	Lockhart River
LSW	Least Significant Word
MHz	Mega Hertz (frequency)
MSL	Mean Sea Level

MSW	Most Significant Word
NDB	Non-Directional Beacon
NM	Nautical Mile
NPA	Non-Precision Approach
PCB	Printed Circuit Board
P/N	Part Number
QNH	Mean Sea Level Atmospheric Pressure
RMS	Root Mean Square
RNAV	Area Navigation
RPM	Revolutions Per Minute
RWY	Runway
S/N	Serial Number
ºT	Degrees True
TAS	True Airspeed
UTC	Coordinated Universal Time
VAC	Volts AC
VDC	Volts DC
VSI	Vertical Speed Indicator
WPT	Waypoint

Appendix B: Honeywell GPWS Mk-VI Simulation



The following simulation of the classic MKVI GPWS computer relies heavily on an estimated radio altitude value. The actual radio altitude value was not recorded on the flight recorder. The estimated radio altitude value is derived by using the estimated 3D flight path of the aircraft and the best available digital elevation model (DEM). Because of this the results must be used with caution as the actual radio altitude values as seen by the GPWS computer could be quite different.

The simulation assumes that the flaps were not in landing configuration and that the landing gear was down. Also the simulation assumes that the cockpit GPWS DESENS or Flap Override switch was not activated. If the GPWS DESENS or Flap Override switch was activated NO GPWS alerts would be issued.

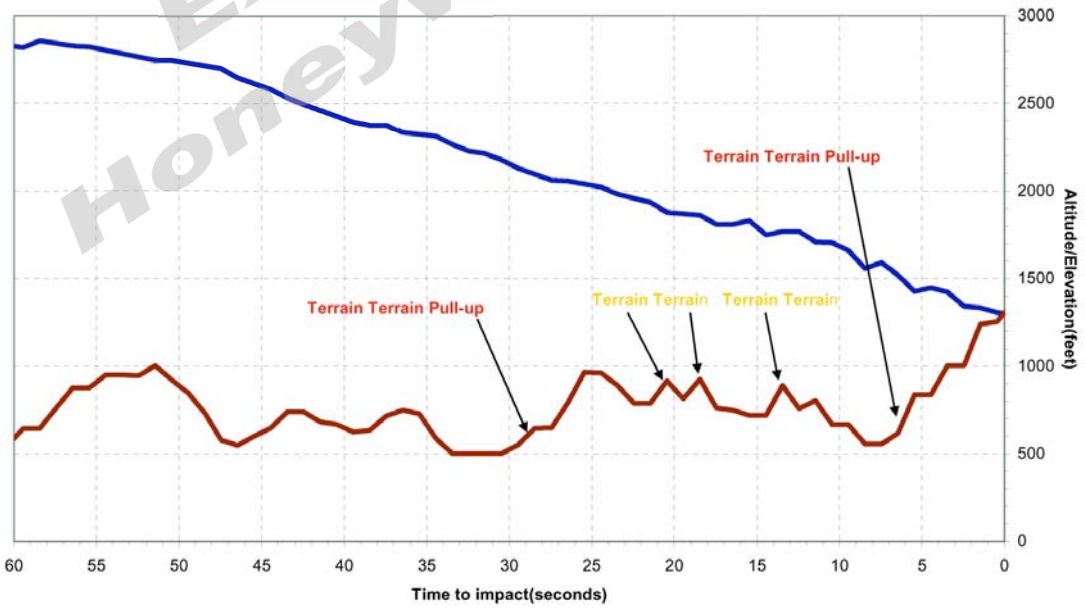
The following table shows the results of the GPWS simulation.

Time to impact	Voice message - event
29.4	"TERRAIN-TERRAIN PULL UP"
27.4	"PULL UP"
25.4	"PULL UP"
24.0	Voice off. GPWS alert lamp remains on
20.65	"TERRAIN-TERRAIN"
18.4	"TERRAIN-TERRAIN"
13.9	"TERRAIN-TERRAIN"
6.35	"TERRAIN-TERRAIN PULL UP"

Extract from Honeywell Report

October 26, 2005
REV. B
Honeywell

Lockhart River, QLD, Australia (YLHR)
Accident: May 07, 2005
Metroliner



October 26, 2005
REV. B
Honeywell

Appendix C: Estimated aircraft weight and balance

Regulatory requirements regarding load sheets

Civil Aviation Order (CAO) 20.16.1 required that both the operator and the pilot in command were to ensure that a load sheet was carried in the aircraft and, for those aircraft engaged in regular public transport services, that a copy of the load sheet was retained on the ground at the aerodrome of departure.

A copy of the load sheet for the flight from Bamaga to Lockhart River for VH-TFU on 7 May 2005 was not located at Bamaga and a copy was not found at the accident site. Current and former employees of the operator reported that it was not routine practice for load sheets to be left at Bamaga.

Aircraft weight limitations

The following weight limitations applied to VH-TFU:

Maximum take-off weight	7,484 kg
Maximum landing weight	7,110 kg
Maximum zero fuel weight	6,577 kg

Aircraft empty weight

The aircraft's *Weight and Balance Record*, dated 10 March 2005, listed the empty weight of VH-TFU as being 4,388.7 kg. Empty weight was the mass of the aircraft in the 19 passenger-seat configuration and included full oils and unusable fuel.

Passenger and carry-on baggage weight

The operator's operations manual indicated that standard passenger weights could be used to calculate the load on company aircraft. It indicated that for seating capacities of between 10-19 seats that a standard weight of 85 kg for a male occupant and 69 kg for a female occupant could be used. These weights were to include a carry on baggage allowance of 6 kg. There were no standard weights listed in the operations manual for aircraft with a seating capacity of more than 20 seats. There were no standard weights listed for checked baggage. The manual stated that the pilot in command was to ensure that all checked baggage was weighed prior to loading on the aircraft.

Civil Aviation Advisory Publication (CAAP) 235-1(1) *Standard Passenger and Baggage Weights* was a publication produced by the Civil Aviation Safety Authority (CASA) to assist operators in complying with Civil Aviation Regulations 1988 (CAR), r. 235. CAR 235 dealt with the loading of aircraft during the take-off phase of flight and required that an aircraft not be loaded above its maximum take-off weight or its performance limited weight.

CAAP 235-1(1) indicated that standard passenger weights could be used when compiling a load sheet for certain aircraft. Section 15 of the CAAP indicated that for an aircraft with a maximum seating capacity of between 20-39 seats (including crew seats) the standard passenger weights were 84 kg for a male occupant and 69

kg for a female occupant. This weight did not include an allowance for cabin baggage. The CAAP also indicated that for the purposes of baggage, no standard weight was given in the publication and it was up to each operator to decide whether to weigh all baggage or carry out their own survey to calculate standard weights for baggage and carry on baggage.

Three female and 10 male passengers boarded the aircraft at Bamaga for the flight to Lockhart River. The investigation estimated the total weight of the two male crew and 13 passengers as 1,305 kg. This figure was based on the CAAP standard passenger weights, which were more conservative than the operations manual, and assumed that each flight crew member and passenger had 6 kg of carry-on baggage.

Checked baggage weight

A passenger/cargo manifest document was subsequently provided to the investigation and indicated that only one piece of baggage, weighing 15 kg, was checked in by a passenger at Bamaga for the flight to Cairns. There was no record of other passenger baggage being checked-in at Bamaga. However, there were several suitcases found at the accident site. The estimation of the total baggage checked in at Bamaga was 255 kg, which assumed that the other 12 passengers each checked in a 20 kg bag, which was a standard airline allowance.

Fuel weight

The following fuel figures calculated by the investigation used information from the aircraft's *Flight/Maintenance Log*, fuel invoices and release notes, and estimated fuel burn figures that were derived from a fuel flight plan, which used the forecast wind velocities at the flight levels flown by the crew. The fuel burn figures also included an allowance for the actual time intervals as determined from the air traffic control and common traffic advisory frequency automated voice recordings.

The operator's flight crews recorded fuel burn and remaining fuel on board in the aircraft's *Flight/Maintenance Log* in pounds, as the aircraft fuel gauges and fuel totaliser were calibrated in that unit of measurement. The following estimation used a specific gravity of 0.79[42] for the aviation turbine fuel carried on the aircraft.

---

42 Specific gravity is the density of a material expressed as a decimal fraction of the density of water at 4 degrees C. The specific gravity of aviation turbine fuel is typically 0.80 kg/l at 15 degrees C. As the temperature of the fuel increases, the specific gravity decreases. A specific gravity of 0.79 kg/l was used to estimate the fuel weight as the aircraft was refuelled in a tropical area.

	Pounds	Litres	Kg
Fuel on board at Cairns Completion of previous day's operations	700		318
Add Fuel loaded at Cairns		800	632
Fuel on board – departure from Cairns			*950*
Less Estimated fuel burn off Cairns – Lockhart River – Bamaga	-1,342		-609
Estimated fuel on board – arrival at Bamaga			*341*
Add Fuel loaded at Bamaga		800	632
Estimated fuel on board – departure from Bamaga			*973*
Less Estimated fuel burn off Bamaga – Lockhart River	-491		-223
Estimated fuel on board – time of accident			*750*

Estimated aircraft weight

The following table summarises the estimated weight of the aircraft at the time of the accident, using the figures discussed above.

	kg
Aircraft basic weight	4,389
Estimated weight of crew, passengers and carry-on baggage	1,305
Estimated weight of checked baggage	255
Estimated zero fuel weight	*5,949*
Estimated weight of fuel on board at time of accident	750
Estimated weight of aircraft at time of accident	*6,699*

At this estimated weight, the aircraft was below the maximum take-off and landing weights specified in the aircraft's *Approved Airplane Flight Manual*.

Centre of gravity range

Type certificate data sheet A18SW, which was issued by the US Federal Aviation Administration and covered the SA227-DC aircraft (including VH-TFU), indicated that the centre of gravity range was between 262.8 inches (6,675 mm) and 277 inches (7,036 mm) behind the datum at 16,500 lbs (7,484 kg). The range at 11,000 lbs (4,990 kg) and below was 257 inches (6,528 mm) and 277 inches (7,036 mm). There was straight-line variation between the points.

Passenger loading

The passengers on the flight from Cairns to Bamaga had been assigned seats by the ground agent in Cairns prior to departure. This seat assignment was completed using a seat allocation chart provided by the operator. Interviews with the

passengers revealed that when they boarded the aircraft they could sit wherever they desired and the crew did not enforce the assigned seating allocation as determined by the agent.

The actual seating of the passengers for the flight from Bamaga to Lockhart River could not be ascertained as the disruption of the aircraft during the impact sequence did not allow the determination of the seating positions of occupants.

Baggage loading

The aircraft's seat allocation chart indicated that the maximum load in the front baggage compartment was 150 kg. The chart also indicated that the rear baggage compartment was divided into two zones with the maximum allowable load in forward zone was 216 kg and the rear zone was 148 kg.

Loading scenarios

The aircraft's centre of gravity remained in the specified range in the following two loading scenarios:

- the passengers were seated in accordance with the aircraft's seat allocation chart and 100 kg of the checked baggage was loaded in the front baggage compartment with the remaining 155 kg in the rear baggage compartment. The centre of gravity remained in the range if all the checked baggage was loaded in the rear compartment
- the passengers all elected to sit at the front of the aircraft, with the male passengers all seated forward of the female occupants, and 100 kg of the checked baggage was loaded into the front baggage compartment with the remaining baggage in the rear.

The aircraft's centre of gravity moved outside the specified range in the following scenarios:

- the passengers all elected to sit at the front of the aircraft, with the male passengers all seated forward of the female occupants, and 150 kg of the checked baggage was loaded into the front baggage compartment with the remaining baggage in the rear
- the passengers elected to sit at the rear of the aircraft with the male passengers located behind the female occupants and all the checked baggage was loaded into the rear baggage compartment.

The investigation considered that it was unlikely that all the passengers would have all been seated at either the front or the rear of the aircraft and there would have been some empty seats throughout the aircraft cabin. It also considered that the checked baggage would have been divided between the front and rear baggage compartments.

For all loading scenarios, the weight of VH-TFU was below the maximum take-off and landing weights for the aircraft. However, due to the fact that the load sheet relating to the accident flight was not located, the investigation could not conclusively determine the position of the aircraft's centre of gravity.

Australian Government
Australian Transport Safety Bureau

Media Release

2006/29

31 August 2006

ATSB Interim Factual Report: Metro 23 fatal accident near Lockhart River

The ATSB has released a further Interim Factual Investigation Report into the Lockhart River accident on 7 May 2005 in which both pilots and all 13 passengers perished and says that it expects to complete its draft final report by the end of November.

This is the third factual report issued by the Australian Transport Safety Bureau since the tragic accident and, in accordance with international convention, it contains no analysis. The ATSB has previously issued a number of safety recommendations arising from the accident and others will be considered ahead of the final report if or as needed.

The ATSB is today also issuing research papers providing data on fatal accidents in Far North Queensland compared with other regions and on surveyed pilot perceptions of difficulties with the type of approach made in the bad weather of the accident flight.

This Interim Factual report also includes additional information relating to wreckage and the aircraft, the flight data recorder factual report, and a summary of survey and other research dealing with area navigation global satellite positioning system (RNAV (GNSS)) approaches.

The investigation is continuing and in addition to drafting of the final report - which will contain detailed analysis - will include further work on: the operator's management processes, standard operating procedures, flight crew training and checking, and document control; regulatory oversight of the operator's activities, including approvals and surveillance undertaken; the design and chart presentation of RNAV (GNSS) approaches; and desired action to enhance future safety.

The ATSB expects to complete a draft final report by the end of November 2006. To ensure factual accuracy and natural justice, directly involved parties in Australia and internationally will have 60 days to comment on this confidential draft. Contingent on the extent and timing of comments received, the ATSB plans to release its final report to the public in March 2007 after advance notice is given to the families of the deceased.

While the long time taken for the investigation is regretted, the Bureau seeks understanding on this because it is Australia's worst civil aviation accident since 1968 and, in addition to the destruction of the aircraft, the investigation team does not have the benefit of a cockpit voice recording, survivors, or witnesses. For the sake of those who lost their lives and their friends and loved ones, and in the interest of future safety, the ATSB wishes to undertake as thorough an investigation as possible in the circumstances.

Copies of the latest *Interim factual Aviation Safety Investigation Report 200501977* can be downloaded from the website, or obtained from the ATSB by telephoning (02) 6274 6425 or 1800 020 616

Media contact: George Nadal business hours & after hours duty officer 1800 020 616

15 Mort Street, Canberra City ACT 2601 • PO Box 967, Civic Square ACT 2608 Australia
Telephone: 02 6274 6440 • Facsimile: 02 6274 6474
24 hours: 1800 621 372 • www.atsb.gov.au
ABN 86 267 354 017