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Australian Transport Safety Bureau

Navigation event involving a Fairchild SA227 aircraft, VH-UUO

Brisbane Airport, Queensland | 3 September 2014

Investigation

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Addendum

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Safety summary

What happened

On 3 September 2014, at about 0215 Eastern Standard Time (EST),[1] a Fairchild SA227 aircraft, registered VH-UUO, took off from Brisbane Airport, Queensland for a freight charter flight to Bankstown Airport, New South Wales, with one pilot on board. Following the take-off, when at about 200 ft above ground level, the pilot observed the horizontal situation indicator (HSI) indicating a right turn although the aircraft was still maintaining runway direction. The pilot reported that the attitude indicator (AI) displayed alternately a nose up and nose down attitude.

When at about 1,600 ft above ground level, the pilot advised air traffic control of a 'minor problem with heading' and was directed to conduct a right turn onto an easterly heading to avoid noise sensitive areas. The pilot turned the aircraft to the right, towards the Pacific Ocean, while referring to the HSI on the co-pilot's instrument panel, which was providing more accurate heading information. The pilot was aware that the captain's AI and HSI instruments were providing erroneous indications, but became disoriented by continuing to scan those instruments. The pilot looked out of the window in an attempt to gain a visual reference but could see only blackness.

The pilot continued a shallow right turn until the lights of runway 19 became visible. The aircraft landed back at Brisbane, on runway 19 about 150 kg above the aircraft's maximum landing weight.

What the ATSB found

The ATSB found that the cockpit was not configured correctly prior to taxi, nor was the incorrect heading reference detected or corrected during the taxi or line up. The left gyro slaving switch was selected to 'free' instead of 'slave' mode, resulting in the captain's HSI indicating about 50° left of actual heading throughout the flight.

The AI probably intermittently malfunctioned after take-off, and the pilot became distracted by the two erroneous instrument indications. These, combined with the dark night and flight over water without visual reference, contributed to the pilot's difficulty in maintaining orientation and achieving the planned departure track. The pilot therefore elected to return to land at Brisbane.

What has been done as a result

The aircraft operator developed a simulator exercise based on the incident, to ensure all company pilots demonstrated limited instrument panel skills – without reference to attitude indicator or direction indicator, and troubleshooting skills.

Safety message

This incident highlights the importance of completing pre-flight checks and ensuring the cockpit is correctly configured prior to taxiing. Particularly when operating at night or into instrument meteorological conditions, it is imperative to verify all reference instruments are indicating correctly. This incident also highlights the importance of communication, especially as emergencies arise. If a pilot is having difficulty controlling an aircraft and maintaining instrument or visual reference, then alerting air traffic control enables them to provide the necessary and appropriate assistance.

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[1] Eastern Standard Time (EST) was Coordinated Universal Time (UTC) + 10 hours.

Contents

The occurrence

On the night of 3 September 2014, the pilot of a Fairchild SA227 (or Metro III) aircraft, registered VH-UUO (UUO), prepared for a scheduled freight charter flight from Brisbane Airport, Queensland, to Bankstown Airport, New South Wales (Figure 1).

Figure 1: The occurrence aircraft, VH-UUO

Source: Aircraft operator

At about 0203 Eastern Standard Time, the pilot contacted air traffic control (ATC), obtained the required clearances and reported conducting all checks in accordance with normal operating procedures. The pilot reported having to reset the left generator three times before it became operational. During the taxi to runway 32, the pilot reported completing the taxi checks and was assigned a right turn onto a heading of 090° after take-off.

At about 0212, ATC cleared the aircraft to line up on runway 32. The pilot reported completing the line-up checks, setting the course bar of the horizontal situation indicator (HSI) course deviation indicator to the assigned heading of 090° and observing that all instruments appeared to read normally. During the initial climb, at about 200 ft, the pilot observed the HSI indicating a right turn although the aircraft was not turning. The pilot reported that the AI was 'bouncing', indicating alternately a nose up and nose down attitude.

Figure 2: Captain-side cockpit panel of VH-UUO

Source: Aircraft operator

When at about 1,600 ft above ground level, and one minute after take-off, the pilot advised the tower controller of a 'minor problem with heading'. The tower controller directed the pilot to contact the departures controller. The pilot then advised the departures controller of a heading issue and requested the aircraft's current heading. The pilot referred to the AI and HSI instruments on the co-pilot side of the cockpit display, which appeared to be providing valid information, and conducted a right turn in accordance with the clearance. The controller provided the aircraft's current heading and advised the pilot that the aircraft transponder was not providing a Mode C[2] readout. The pilot selected transponder 2, but ATC still did not receive altitude information. The pilot was aware the primary instruments were providing erroneous indications, but reported becoming disoriented as they continued to scan those instruments. The pilot looked out of the window in an attempt to gain a visual reference, or horizon, however the aircraft was heading over water on a dark night and the pilot could see only blackness.

The controller then directed the pilot to conduct a rate 1 turn[3] to the right to avoid noise sensitive areas. The pilot continued a shallower-than-rate 1 right turn, referring to the instruments on the co-pilot side of the cockpit display, until the lights of runway 19 became visible. The pilot requested a straight in approach, to return to land on runway 19, and the tower controller cleared the aircraft to land. At about 0223, the aircraft landed about 150 kg above the aircraft's maximum landing weight, as the aircraft had not burned off enough fuel during the short flight.

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2 An aircraft transponder signal that may contain barometric information from an encoding altimeter that enables altitude presentation on air traffic control radar screens.

3 A rate one turn is 180° in 1 minute, or 3° per second.

Context

Pilot information

The pilot held an Air Transport (Aeroplane) Pilot Licence issued in January 2011, a valid Class 1 Aviation Medical Certificate, and the appropriate ratings and endorsements for the Metro aircraft type. The pilot had 2,880 hours of aeronautical experience, and completed their most recent instrument renewal on 17 March 2014.

The pilot's Metro III endorsement was issued on 15 February 2014. The pilot had undergone 81.8 hours of line training in the Metro III aircraft, including 22.1 hours of remedial training. Training records from 5 May 2014, included comments stating that the pilot needed to ensure the cockpit was set up correctly for departure, during the pre-flight checks. The pilot was required to complete remedial training in that area prior to line and base checks. The pilot was checked to line operations on 27 May 2014.

The pilot's ability to control the aircraft using a limited instrument panel[4] was assessed in the pilot's check to line, which involved simulated failure of the primary AI. The pilot was assessed as competent in limited panel flight prior to the incident flight and assessed again as competent after the incident flight.

The pilot had been awake for about 8 hours prior to the incident and on duty for 5 hours, this followed having 8 hours of sleep. There was no condition identified that was likely to have affected the pilot's ability to control the aircraft.

Environmental conditions

From the ATC audio, the wind reported by Brisbane Tower was from 240° at 11 kt, at the time of landing.

The moon had set at 0023 EST and was below the horizon at the time of the incident, so there was no illumination by the moon during the flight.

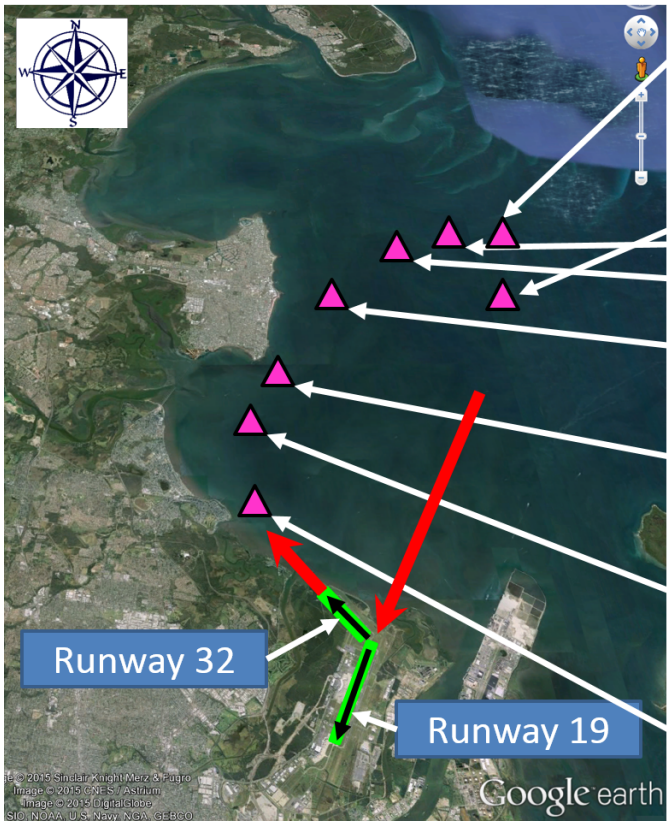
Radio communications

During the flight, the pilot conducted radio communications with Brisbane air traffic control (ATC) surface movement controller (SMC) for taxiing and airways clearance, aerodrome controller (ADC) for take-off and landing, and departures controller following take-off.

Figure 3 shows the location of the aircraft at the time of radio communications between the pilot of VH-UUO and Brisbane ATC.

[4] Instrument flight without reference to attitude indicator or direction indicator.

Figure 3: Radar track of VH-UUO with aircraft position annotated at time of pertinent radio communications



Departures controller directed the pilot to contact the tower controller

Departures controller cleared the pilot to continue right turn, descend to 1,500 ft and for a visual approach to runway 19

Tower controller cleared the pilot to land on runway 19

Pilot requested return to runway 19

Departures controller directed the pilot to continue rate 1 right turn

Departures controller advised pilot of the aircraft's current heading and directed pilot to turn to the east for noise abatement. Also advised no Mode C

Pilot reported to the departures controller that the aircraft was passing 2,200 ft on climb to 4,000 ft, advised of a minor issue with heading control and requested current heading

Tower controller advised pilot to squawk altitude and contact the departures controller. Pilot responded that there was a minor problem with heading

Source: Google earth, Airservices Australia data, analysed and annotated by the ATSB

Flight data analysis

The flight data recorder (FDR) system specifications and maintenance details are contained in Appendix A.

Following the event, the flight data recorder was removed from the aircraft, and analysed by the ATSB.

Analysis of the FDR data showed the vertical acceleration parameter did not contain valid data. The operator found that the vertical accelerometer fitted to the aircraft was unserviceable, and subsequently replaced it.

The recorded magnetic heading parameter contained valid information. The aircraft's avionics drawings showed that the heading signal originated from the No. 1 magnetic compass gyroscope system and was sensed through connections to the left HSI.

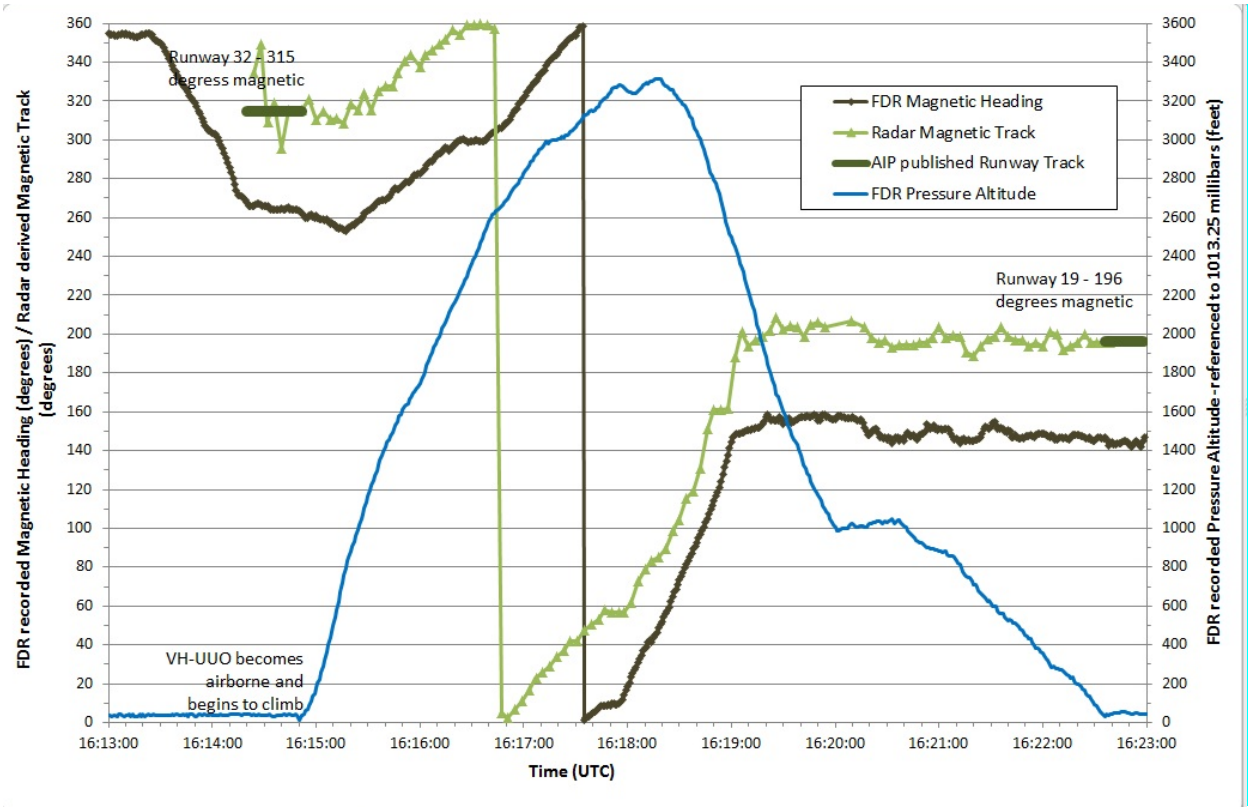
Figure 4 provides a comparison of the magnetic heading of the aircraft recorded by the FDR and the aircraft track derived from the radar data. A detailed examination of the aircraft heading and the derived track was made from the take-off and landing roll phases. The derived radar track was found to be consistent with the published runway heading, however the recorded FDR magnetic heading was offset by about 50°. The offset varied slightly from 49-53° throughout the flight. This variation was consistent with precession[5] of the gyro, due to the HSI selected in 'free' mode, and therefore not automatically slaved to the compass heading.

[5] Precession is a change in the orientation of the rotational axis of a rotating body.

Related occurrences

There have been a number of previous occurrences in Metro aircraft investigated by the ATSB where there were issues with inoperative parameters in the flight data recording systems. A listing of those occurrences is contained in Table 1 of Appendix A.

Figure 4: Comparison of radar and FDR information



Source: Aircraft operator and Airservices Australia data, analysed and annotated by the ATSB

Aircraft information

The Fairchild Industries Incorporated SA227-AC, or Metro III, aircraft, serial number AC 530, had 38,929.9 hours total time in service (TTIS) at the time of the incident. The aircraft was manufactured in 1982 and first registered in Australia on 1 May 1996.

The operator had a fleet of six Metro III and two Metro 23 aircraft, with non-standardised cockpit instrumentation across the fleet. The location of switches and functions for instruments such as the transponder and the HSI differed between each aircraft. Due to these differences in instrumentation configuration, greater knowledge and care was required by company pilots to ensure the cockpit setup was completed correctly. However, the operator stated that completion of the operator's standard flows and checks correctly, should ensure the cockpit is set up appropriately prior to flight.

Aircraft maintenance

On the day of the occurrence, maintainers conducted a 150-hourly Phase 3A/C maintenance inspection on the aircraft. Some instruments were removed for access during this inspection, including the left horizontal-situation indicator (HSI) and attitude indicator (AI) instruments. A review of the maintenance documents indicated that the AI had been fitted and tested in accordance with the maintenance manual, but the manual did not contain installation or testing procedures.

Following the refit of the instruments, the maintainers had selected the left gyro system (and therefore left HSI) to FREE mode, the VOR to the test frequency of 108.00, and the transponder altitude to OFF.

The aircraft had not been flown following the inspection prior to the incident flight. There were no requirements for a check flight to occur, following the maintenance that had been carried out.

Following the maintenance, the engineer had incorrectly added 1,000 hours instead of 160 hours until the next inspection was due on the maintenance release.

After commencing the pre-flight checks, the pilot observed that, according to the maintenance release,[6] engineers had recently completed the 150-hourly maintenance inspection on the aircraft, and that this would be the first flight subsequent to the inspection. The maintenance release stated that some instruments, including the AI and HSI instruments had been removed and refitted during the inspection (Figure 2). There were no outstanding items on the maintenance release, but the hours remaining to the next service had been recorded incorrectly. The pilot contacted a company engineer and about 20 minutes later, they arrived and corrected the maintenance release.

Aircraft weight and balance

The aircraft was refuelled with aviation turbine fuel at Brisbane Airport such that the total fuel on board at the time of taxi was 1,421 L (2,500 lb), or 1,136 kg. The freight weight was 1,438 kg. The aircraft took off at an all up weight of 6,644 kg. The trim sheet completed for the flight showed that the aircraft was loaded within the allowable weight and centre of gravity limitations. It landed about 150 kg above the maximum landing weight of 6,350 kg.

The freight was offloaded after the aircraft returned to Brisbane. A reconciliation of actual loading versus trim sheet was not conducted at the time of the offloading. There was no evidence that the aircraft was loaded other than according to the trim sheet, or that the load had shifted during the flight.

The aircraft loading was not considered to be a factor in the incident, or to have caused any pitch changes that may have appeared as ‘bouncing’ on the AI.

Aircraft electrical system

After landing, the pilot noted the left ammeter was indicating zero. This was because there was no power being provided by the left generator due to the open circuit current limiter. No loss of instrumentation occurred as a result of the failure, due to redundancy in the electrical bus systems.

Transponder equipment

Examination of the air traffic control ground station secondary surveillance radar (SSR) data found that both Mode A response, which provides the aircraft’s position relative to a ground station, and Mode C response, which also provides the aircraft’s altitude, had been transmitted. However, the Mode C response did not contain any altitude information. That corresponded to the transponder being switched on, but the altitude switch selected to off.

Heading reference system

The aircraft was fitted with two heading reference systems, each of which displayed the aircraft’s heading on a horizontal situation indicator (HSI) and a radio magnetic indicator (RMI).

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[6] The maintenance release is an official document, issued by an authorised person, that is required to be carried on an aircraft as an ongoing record of its time in service (TIS) and airworthiness status. Subject to conditions, a maintenance release is valid for a set period, in this aircraft, 160 hours TIS or 6 months, whichever occurs first.

When operated in ‘slaved’ mode, the gyroscope aligned with magnetic north. Otherwise, in ‘free’ mode, the direction indicator (DI) was not aligned with magnetic north, and the indicated heading was incorrect.

For the incident flight, the left gyro slaving switch had been selected to FREE. The right compass system was slaved and indicating the correct heading. The captain’s side HSI was showing about 50° left of the aircraft’s actual heading, and the co-pilot’s side HSI was showing the aircraft’s correct heading.

Attitude indicator (AI)

The left AI was a Castleberry 500 ECFC Horizon Reference Indicator, referred to as an ‘AIM 500’, with serial number 538. The operator report into the incident stated that the specification sheet for the part recommended a mean time between overhaul of 1,200 hours. At the time of the incident, the part had a service time of 1,783 hours.

On 24 December 2014, subsequent to this incident, the AI was removed from the aircraft due to the AI flag remaining in view despite power being applied to the inverter. A statement from the manufacturer following repair of the AI indicated that the ‘gyro motor had quit or been running much slower than normal, which was typical for the hours of usage of the part’.

The AIM 500 AI was replaced with an AIM 510, which does not have a recommended mean time between overhaul.

Post-incident engineering inspection

After the incident, an engineering inspection found the following:

- The left AI was serviceable.
- The left gyro slaving switch was selected to FREE. When selected to SLAVE, the left HSI slaved to the correct heading and found to be serviceable.
- The transponder ALT/OFF selector switch was in the OFF position. The switch was then selected to ALT and the system was found to be serviceable.
- The left ammeter was reading zero due to an unserviceable 325 ampere current limiter. No loss of flight and navigation instrumentation should have occurred due to this fault.
- The VHF omni-directional radio range (VOR) was set to a test frequency (not the Brisbane VOR ground).
- No defects were found during the subsequent overweight landing inspection.

Safety analysis

Introduction

On 3 September 2014, following a dark night take-off from runway 32 at Brisbane Airport, Queensland, the pilot of UUO had difficulty maintaining orientation of the aircraft due to erroneous instrument indications. When at about 200 ft AGL, the pilot observed the left horizontal situation indicator (HSI) indicating a right turn although the aircraft was still aligned with runway heading, and reported that the attitude indicator (AI) was alternating between indicating a pitch up and pitch down attitude. After advising ATC of a minor heading issue, the pilot requested a clearance and returned to land at the airport on runway 19. ATC had advised the pilot that the aircraft transponder displayed a zero altitude on the air situation (radar) display during the flight.

A subsequent engineering inspection found the HSI selected to FREE rather than SLAVE mode, the transponder altitude selected to OFF, and the left ammeter was reading zero due to a blown current limiter.

The ATSB analysed the flight data from the aircraft's FDR. The vertical acceleration parameter contained invalid data due to an unserviceable accelerometer.

This analysis examines the incorrect setup of the cockpit, and the taxi and line up checks that may have detected the incorrect heading information. It also examines the effect of the instrument indications, combined with the over-water operation and dark night, on the pilot's ability to manage the aircraft.

Cockpit setup and checks

The pilot had operated a different Metro aircraft from Bankstown to Brisbane, arriving about 1 hour before the pilot was scheduled depart Brisbane for Bankstown in UUO. The pilot had left the cockpit of the inbound aircraft set up in the positions normally set by pilots, namely the transponder set to transmit altitude, the heading reference systems slaved, and the VOR selected to the Brisbane frequency.

UUO had undergone maintenance early that day. During the maintenance, the aircraft maintenance engineers had set the transponder altitude to off, the heading reference systems in free mode, and the VOR dialled up to a test frequency. The flight crew operating manual (FCOM) included instrument setup in the responsibilities of the pilot in command.

After completing the external inspection of UUO, the pilot commenced the pre-flight checks. The cockpit setup was conducted using a series of flows, followed by checklists to ensure the setup had been completed correctly. On reviewing the maintenance release, the pilot noted an error, and phoned an engineer to attend and correct the error. The pilot had commenced pre-flight checks, but stopped while waiting for the engineer. The final set up of the avionics needed the airways clearance from ATC, but the pilot could not request the clearance until the engineer had corrected the maintenance release. This interruption in normal setup procedures, may have led to the pilot's omission of some checks.

According to the flight data, a period of about 8 minutes elapsed between engine start and commencement of taxiing. The operator considered this period normal and providing sufficient time for the pilot to complete all checks and for the gyro equipment to be fully functioning.

With the left heading reference system set to FREE, when the left (captain's side) HSI erected, it would have appeared serviceable, but not aligned to the earth's magnetic field. Consequently, the direction indicator (DI) reading on the HSI would not have correctly indicated the aircraft's heading. Flight data showed it indicated about 50° left of the actual heading. The left radio magnetic indicator (RMI), located below the HSI, was slaved. It would have been showing the correct heading information, but not matching the HSI.

Taxi and line-up checks

As the aircraft taxied to the holding point for runway 32, the pilot reported conducting the published taxi checks. In addition to the published taxi checks,[7] the pilot was required to check all primary, secondary and emergency turn indicators.

The taxi from the parking bay to the runway included sufficient turns and distance to check all turn indications were serviceable and turning in the correct sense. While the HSI would have been turning in the correct direction, completion of these checks should have alerted the pilot that the HSI was displaying the incorrect heading.

The final check that the heading reference information was set correctly, normally occurs as the aircraft lines up on the runway. The pilot then confirms that the aircraft's compass, HSI and RMI all indicate the runway heading. At this stage, the heading bug was also required to be set to the runway heading. Based on the flight and air traffic control data, ATC cleared the pilot for a rolling take-off, and the aircraft did not come to a stop when lined up on the runway centreline.

The pilot reported feeling rushed due to the combination of the delay waiting for the engineer, and the tight scheduling by the operator. This may have led to the pilot omitting the line-up heading checks. The single-pilot aircraft operation did not provide the opportunity for a second, monitoring pilot, to detect the omission of the checks prior to take-off. However, the ATSB has not recorded a significant number of similar events involving single-pilot operations.

Erroneous instrument indications

Once the aircraft became airborne, the pilot quickly found that the HSI heading information did not make sense. This was because the HSI indicated a right turn, while the aircraft was still aligned with the runway. With the VOR selected on, but set to a test frequency, the VOR information also displayed on the HSI may have added to the nonsensical information presenting to the pilot. The pilot reported intending to set the VOR to Brisbane frequency during the climb out, although the taxi checklist included tuning this instrument to the correct frequency. At about the same time, the AI appeared to be bouncing, indicating alternately pitch up and down. The AI did not display a red flag, so was not unserviceable, but the aircraft was not pitching up and down. There was no evidence that the freight had shifted on take-off to cause the aircraft to pitch. The bouncing indicated on the AI was probably due to partial (and intermittent) failure of the AI, due to its excessive time in service.

The pilot was then starting to believe that there was some form of electrical issue. During the engine start-up procedure, the left generator had needed to be reset three times before it supplied power to the electrical system. The pilot reported that was not uncommon for the Metro aircraft, but was now concerned it had been indicative of a problem. When the departures controller then advised the pilot that the transponder was not giving a Mode C readout, this added further weight to the pilot's assessment of an issue with the aircraft's electrical system. The pilot's relatively low number of hours on the aircraft type, combined with the autopilot off, increased the pilot's workload, which reduced the pilot's ability to troubleshoot while maintaining control of the aircraft.

[7] Flight crew operating manual (FCOM), quick reference handbook (QRH), and the airplane flight manual (AFM).

Findings

From the evidence available, the following findings are made with respect to the navigation event involving a Fairchild SA227, registered VH-UUO, at Brisbane Airport, Queensland on 3 September 2014. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

Safety issues, or system problems, are highlighted in bold to emphasise their importance. A safety issue is an event or condition that increases safety risk and (a) can reasonably be regarded as having the potential to adversely affect the safety of future operations, and (b) is a characteristic of an organisation or a system, rather than a characteristic of a specific individual, or characteristic of an operating environment at a specific point in time..

Contributing factors

- The pilot did not correctly configure some of the cockpit instruments and systems prior to taxiing, or detect or correct the problem with the primary heading reference prior to take-off. This led to erroneous heading information being presented to the pilot.
- The primary attitude indicator probably malfunctioned intermittently after take-off, leading to the pilot being presented with erroneous attitude information.

Other factors that increased risk

- The attitude indicator had been in service for 1,783 hours, which exceeded its recommended time in service of 1,200 hours.
- The pilot did not declare an emergency or communicate the magnitude of the problem to ATC, but only advised of a minor heading issue. ATC issued a right turn due to noise abatement (and away from the city lights), and two frequency changes in accordance with normal ATC service provision. Had the pilot communicated the issue to ATC, they could have provided assistance.

Other findings

- The flight data recorder did not have any valid recorded data for vertical acceleration.

Safety issues and actions

Additional safety action

Whether or not the ATSB identifies safety issues in the course of an investigation, relevant organisations may proactively initiate safety action in order to reduce their safety risk. The ATSB has been advised of the following safety actions in response to this occurrence.

Operator of VH-UUO

The operator of VH-UUO created a simulator exercise based on the incident. The training managers are working towards a cyclic pattern for the company flight crew base checks to ensure systematic coverage of test scenarios.

Following the incident, the operator's Quick Reference Handbook (QRH) reference for inverter failure was amended to become a 'memory item'. Thus if an inverter fails, particularly at a critical phase of flight, the pilot can take the necessary steps to swap inverters without referencing the QRH.

The operator has subsequently removed the AIM 500 AI from the captain's instrument panel and fitted an AIM 510, which carried the appropriate authorisation. The operator replaced the vertical accelerometer to provide valid FDR data. The engineering order (EO) was amended to label the accelerometer as a single vertical axis accelerometer. The test procedure for the accelerometer was amended to check for vertical acceleration data only.

General details

Occurrence details

Date and time:	3 September 2014 – 0216 EST	
Occurrence category:	Serious incident	
Primary occurrence type:	Navigation event	
Location:	Brisbane Airport, Queensland	
	Latitude: 27° 23.05' S	Latitude: 153º 7.05' E

Pilot details

Licence details:	Australian Transport Pilot (Aeroplane) Licence, issued 28 January 2011
Endorsements:	Manual Propeller Pitch Control; Retractable Undercarriage; C208, J41, PA31, BE-76, PN68, Metro
Ratings:	Multi engine Command Instrument Rating; Night VFR Aeroplane; Private IFR Multi Engine
Medical certificate:	Class 1, valid to 28 October 2014
Aeronautical experience:	2,880 hours
Last flight review:	27 May 2014

Aircraft details

Manufacturer and model:	Fairchild Industries SA227-AC	
Year of manufacture:	1982	
Registration:	VH-UUO	
Operator:	AC530	
Serial number:	38,929.9 hours	
Total Time In Service	Charter – Freight	
Type of operation:	Fairchild Industries SA227-AC	
Persons on board:	Crew – 1	Passengers – Nil
Injuries:	Crew – Nil	Passengers – Nil
Damage:	Nil	

Sources and submissions

Sources of information

The sources of information during the investigation included:

- the pilot in command of VH-UUO
- the aircraft operator
- the aircraft flight data recorder
- Airservices Australia
- the Bureau of Meteorology.

References

Wickens, C.D., and Hollands, J.G. (2000). *Engineering psychology and human performance*, 3rd edition. New Jersey: Prentice Hall.

Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003* (the Act), the Australian Transport Safety Bureau (ATSB) may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the pilot of VH-UUO, the aircraft operator, and Airservices Australia.

Submissions were received from the aircraft operator and Airservices Australia. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

Appendices

Appendix A – Flight data recorder

Recorder requirements

As required by Civil Aviation Order (CAO) 20.18, VH-UUO was fitted with a cockpit voice recorder (CVR) and a flight data recorder (FDR) (SSFDR, part number S703-1000-00, serial number 00690). The flight recorder equipment standards for the CVR were specified in CAO 103.20 and for the FDR in CAO 103.19. The flight data recorder was an L-3 Communications Aviation Recorders (L-3AR) model F-1000 solid state flight data recorder (SSFDR). The model F1000 stored a minimum of 25 hours of aircraft operation. The SSFDR was installed, as an upgrade of the FDR system, in accordance with an engineering order (EO), AVE-EO-10813-UUO. The engineering order stated that the FDR system, as required by CAO 103.19, was capable of recording the parameters relating to:

- time
- altitude
- airspeed
- vertical acceleration
- heading
- press to talk (PTT) for each transceiver.

Recorder installation

The aircraft FDR system was upgraded in August 2012. The previous FDR was an L-3AR model F800 digital flight data recorder (DFDR) which utilised magnetic tape as the recording medium. The model F800 was replaced with a model F1000 solid state flight data recorder (SSFDR), which utilised solid state memory devices as the recording medium and was designed to higher reliability and crashworthiness standards.

Table 1 of the engineering order indicated that the post upgrade FDR system recorded the following parameters;

- altitude
- airspeed
- heading
- press to talk (PTT) for COM 1 and COM 2
- vertical acceleration
- lateral acceleration
- longitudinal acceleration.

Table 1 included details of a post installation FDR readout which indicated all parameters except lateral acceleration were recorded, however the heading and longitudinal acceleration parameters did not appear to have an input signal.

Section 3.1 of the engineering order indicated an accelerometer part number 5690-1 was to be fitted and described as a tri-axial accelerometer that would detect longitudinal, vertical and lateral acceleration forces. The part was actually a single axis accelerometer, sensing vertical acceleration only. The EO has now been amended. The test procedures were also amended to check vertical acceleration only, and to record N/A for the lateral and longitudinal parameters.

Recorder maintenance

Section 4.2 of the engineering order included direction for continued airworthiness instructions. These instructions indicated the F1000 did not require scheduled maintenance and instructed that the installed equipment was maintained in accordance with the manufacturer's recommendations and/or servicing instructions.

The maintenance program for VH-UUO included the FDR unit being removed from the aircraft and forwarded to a service provider for testing.

The FDR unit had been tested annually in accordance with the maintenance schedule. That testing did not include analysis to determine whether the recorded data was valid, and therefore whether all components of the FDR system were functioning correctly.

A replacement FDR was fitted to VH-UUO following the event. It was an F1000, part number S703-1000-00, serial number 02171. This FDR had been removed from a different aircraft and bench tested on 9 July 2014 by the service provider. Examination of the FDR download file showed the recording contained part of the bench test protocol and 54 sectors of aircraft operation. The heading parameter contained valid information. However, the vertical acceleration parameter did not record valid information.

At the time of the incident, Civil Aviation Advisory Publication (CAAP) 42L-4(0), *Flight data recorder maintenance*, was current. The CAAP stated:

> 1.3 CAR [Civil Aviation Regulation] 42L prescribes matters to be included in a system of maintenance and specifically requires that the system contains a schedule that sets out the procedures to be followed in carrying out inspections and tests for the aircraft systems or equipment. This includes a maintenance program covering the Flight Data Recorder System, its ancillaries and the aircraft installation to assure the integrity and functionality of the system is preserved.

The Civil Aviation Order relevant and in force at the time (CAO 20.18) did not specify explicit time periods to verify system functionality. The ICAO Annex 6, which an operator could elect to use, included conduct of a system functional check each 8,000 hours' time in service, or 5 years, whichever occurs first.

In May 2015, subsequent to this incident, CASA released Advisory Circular AC 21-24, *Flight recorder and underwater locating device maintenance*. The AC specified that a FDR maintenance program must be included in the approved maintenance program of system of maintenance.

In the course of the FDR analysis, several issues were identified in common with previous ATSB investigations (see Table 1):

- The operator had been testing the FDR unit but not the FDR system.
- The FDR system documentation did not match aircraft installation.
- A lack of information to assist the investigation due to recorder system unserviceability.

Table 1: Flight recorder system issues identified during ATSB investigations

AO-2014-147 SA227-AC VH-UUO	• FDR system accelerometer unserviceable which prevented analysis of reported pitch issue, trip and date encoder not utilised
AT-2013-086 SA227-DC VH-OYN	• FDR data interpretation, recording of torque parameter design issue
AO-2012-024 SA227-AT VH-UZA	• FDR no data due to possible 'g' switch activation, examination of recorded data showed unserviceable accelerometer
AO-2008-085 SA227-AC VH-OZA	• FDR system did not record accident flight • CVR did not record accident flight • The FDR and CVR recorded previous flight recorded with valid information
20051977 SA227-DC VH-TFU	• FDR system corrections had to be calculated for both airspeed and altitude parameters, pitch attitude parameter was unserviceable • CVR system was malfunctioning and did not record the accident flight, two of three sister ships CVRs were discovered unserviceable when tested
199503057 SA227-AC VH-NEJ	• FDR system airspeed and altitude parameters were unserviceable, aircraft performance was derived from accelerometer information

Australian Transport Safety Bureau

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The ATSB is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; fostering safety awareness, knowledge and action.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to operations involving the travelling public.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

Purpose of safety investigations

The object of a safety investigation is to identify and reduce safety-related risk. ATSB investigations determine and communicate the factors related to the transport safety matter being investigated.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes it appropriate. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

Australian Transport Safety Bureau

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Investigation

ATSB Transport Safety Report
Aviation Occurrence Investigation

Navigation event involving a Fairchild SA227 aircraft, VH-UUO Brisbane Airport, Queensland, on 3 September 2014

AO-2014-147
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