Australian Government
Australian Transport Safety Bureau

Unreliable airspeed indication involving Pilatus PC-12/47E, VH-OWI

on descent to Albany Airport, Western Australia on 22 June 2020

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Addendum

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Safety summary

What happened

On the evening of 22 June 2020, a Royal Flying Doctor Service, Pilatus Aircraft Ltd. PC-12/47E registered VH-OWI was conducting a positioning flight from Jandakot to Albany, Western Australia. Approximately four minutes into the descent to Albany Airport in instrument meteorological conditions the pilot observed an airspeed miscompare indication on the left primary flight display (PFD).

Having assessed that a blocked pitot tube was the likely cause of the issue, the pilot elected to climb the aircraft in an attempt to get clear of cloud. During this climb the pilot's indicated airspeed increased and exceeded the aircraft's maximum allowable speed. The pilot reported also receiving an overspeed alert at this time and consequently elected to discontinue the planned flight and return the aircraft to Jandakot.

When unable to obtain visual conditions, the pilot elected to descend the aircraft. During this descent the left indicated airspeed reduced to zero, however, no stall warning was activated. At 6,000 ft visual conditions were obtained, however, the turbulence at this level was severe. At this time the pilot observed a heading miscompare on both the left and right PFDs. Due to the severity of the turbulence at 6,000 ft the pilot climbed the aircraft first to 8,000 ft and then 10,000 ft on the return to Jandakot.

The pilot reported that on approach to Jandakot all indications had returned to normal and remained that way until short final when an altitude mismatch and low airspeed warning was identified on the PFDs.

What the ATSB found

The ATSB determined that during the flight, water entered the aircraft's pitot tube either as rain or an accumulation of moisture from flying through cloud. Due to a blockage in the pitot tube drain the water had been unable to escape. This in turn obstructed the flow of air to the aircraft's air data attitude heading reference system, resulting in an incorrect airspeed being displayed on the left PFD and triggering miscompare indications on both PFDs.

In addition, a heading miscompare was likely caused by the aircraft's movement through an area of moderate to severe turbulence during the return to Jandakot.

Finally, the ATSB found that recent training that the pilot had undertaken helped them to identify the erroneous airspeed data.

Safety message

Spurious instrument readings can create a more complex scenario for flight crew than an instrument failure.

In this case the pilot's recent training assisted in effectively assessing the situation, determining the likely failure mode and identifying the most accurate source of available data for a safe return to the departure airport.

The investigation

Decisions regarding whether to conduct an investigation, and the scope of an investigation, are based on many factors, including the level of safety benefit likely to be obtained from an investigation. For this occurrence, a limited-scope investigation was conducted in order to produce a short investigation report, and allow for greater industry awareness of findings that affect safety and potential learning opportunities.

The occurrence

At 2122 Western Standard Time[1] on 22 June 2020, a Royal Flying Doctor Service - Western Operations (RFDS), Pilatus Aircraft Ltd. PC-12/47E, registered VH-OWI (OWI), departed Jandakot Airport, Western Australia (WA) for Albany Airport WA, to collect a patient and transfer them back to Jandakot. The pilot, a doctor and a flight nurse were onboard.

At approximately 2150 the pilot commenced a descent to Albany from flight level[2] (FL) 210. About 4 minutes later, while in icing[3] conditions and passing through FL180, the pilot received an airspeed miscompare,[4] indicated by an amber colouration on the airspeed tape on the primary flight displays (PFD).

At this time the pilot reported that there was a light dusting of ice on the leading edge of the aircraft's wings and on the radome.[5] The pilot did not deem this level of icing to be a concern and did not observe any issues or receive any alerts from the aircraft's anti-icing systems.

While continuing the descent the pilot compared the airspeeds displayed on the two PFDs with the airspeed indication on the electronic secondary instrument system (ESIS) (Figure 1). Based on the speed readings from the PFDs and the ESIS the pilot determined that the left PFD was likely displaying incorrect information.

As the descent continued, the pilot observed the airspeed on the left PFD continuing to decrease. The pilot reported to air traffic control (ATC) that a blocked pitot tube was the likely cause of the issue and requested clearance for a climb to FL 230. The pilot believed that this altitude would allow them to establish the aircraft clear of cloud and therefore avoid the worst of the icing conditions.

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1 Western Standard Time (WST): Universal Coordinated Time (UTC) +8 hours.

2 Flight level: at altitudes above 10,000 ft in Australia, an aircraft's height above mean sea level is referred to as a flight level (FL). FL 180 equates to 18,000 ft above mean sea level, not the ground level.

3 Icing conditions are atmospheric conditions that can lead to the formation of ice on an aircraft.

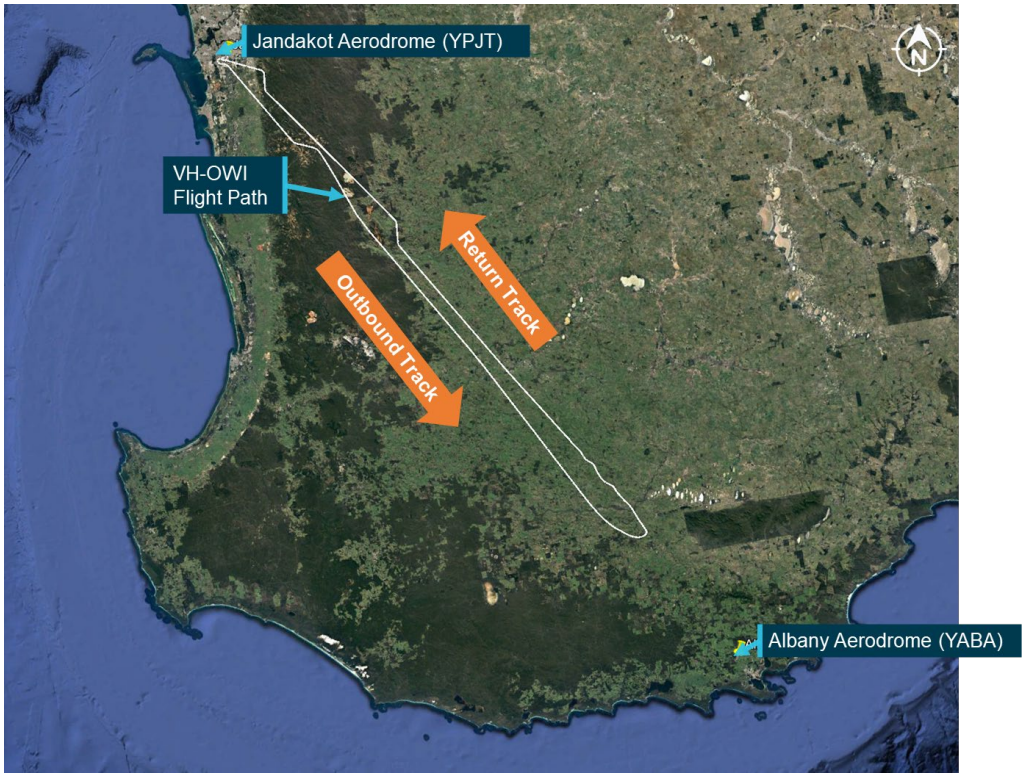
4 An airspeed miscompare is displayed when the aircraft's monitor warning system detects a difference in the airspeed between the left and right primary flight displays of more than 10 knots.

5 A protective covering for an aircraft's radar or other aerials located at the most forward part of an aircraft's fuselage.

Figure 1: PC-12/47E exemplar cockpit layout

Source: Pilatus, annotated by the ATSB

Figure 2: ADS-B[6] track of the incident flight



Source: FlightRadar24 and Google Earth, annotated by ATSB

6 ADS-B: Automatic Dependent Surveillance–Broadcast is a surveillance technology in which an aircraft periodically broadcasts it position based on satellite navigation information.

During the climb, the pilot observed the airspeed displayed on the left PFD increasing. This continued throughout the climb with the pilot observing V_{mo}[7] and M_{mo}[8] exceedances on the left PFD and receiving audible overspeed alerts from the aircraft's avionics. Noting that due to this indicated exceedance the aircraft would need to be grounded for inspection, they elected to discontinue the planned flight and return the aircraft to Jandakot (Figure 2).

Climbing through FL 210, on the return to Jandakot, the pilot reported icing conditions and poor visibility and decided to discontinue the climb. In a further attempt to exit the icing conditions and obtain visual reference, the pilot requested a descent to 8,000 ft. The pilot was advised by ATC, who had been in contact with the Bureau of Meteorology (BOM), that this was the approximate lower limit of cloud. On descent the indicated airspeed on the left PFD reduced to zero, however, the pilot did not observe or hear a stall warning. At 8,000 ft, the pilot indicated to the controller that they had not obtained visual conditions and were encountering moderate turbulence. The pilot requested, and was granted, a further descent to 6,000 ft. During this descent the turbulence increased to severe, and consequently the pilot elected to climb the aircraft back to 8,000 ft.

Throughout the descent to 8,000 ft and then 6,000 ft the pilot noted a difference in the heading data as displayed on the left and right PFDs. The pilot observed that this led to a heading miscompare[9] indication on the left PFD, with the letters 'HDG' appearing in a yellow box at the top of the compass display. The miscompare continued to increase until there was reported 50-60° of indicated heading difference between the two PFDs. Further, the pilot also reported that during this sequence the left PFD displayed an incorrect attitude, indicating that the aircraft was level when the nose was approximately 3° below the horizon. This was less than the 5° difference required to trigger a pitch miscompare.

The pilot continued to track to Jandakot, at 8,000 ft with a further climb to 10,000 ft. Approaching Jandakot, the pilot reported that all indications for airspeed, heading and attitude had returned to normal and continued that way until the aircraft was on final approach. During the final approach, the pilot reported a 60 ft mismatch in altitude between the left PFD and the ESIS and a low airspeed warning on the left PFD.

The aircraft was landed and taxied back to the RFDS apron without further incident. The pilot then completed the incident log due to the indicated V_{mo} and M_{mo} exceedances.

Context

Aircraft information

The PC-12/47E is a single-engine, turboprop, pressurised aircraft, designed and built by Pilatus Aircraft Ltd in Switzerland. OWI was manufactured as serial number 1232 in 2010 and registered in Australia in January 2011. At the time of the occurrence the aircraft had over 12,600 hours in service and 11,100 flight cycles.

The PC-12/47E pitot tubes[10] are fitted with an electric anti-ice system that uses heating elements to prevent ice build-up. The aircraft is also fitted with an alerting system that activates when the temperature is less than 10 °C and there is visible moisture in the air. In addition, if either system is non-operational a warning will be displayed on the crew alerting system. The pilot did not report

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7 V_{mo} is the aircraft's maximum operating speed, expressed in knots, that may not be exceeded at any time.

8 M_{mo} is the aircraft's maximum operating limit speed, expressed as a Mach number, that may not be exceeded in normal flight operations.

9 Heading miscompare is received when the aircraft's monitoring and warning system detects a difference in the heading between the pilot and co-pilot primary flight displays of more than 6°.

10 A pitot tube is an open ended tube facing into the airflow used to measure dynamic air pressure as tan aircraft moves through the air.

receiving any alerts related to the anti-icing system and no errors were recorded in the aircraft data provided to the ATSB.

Post-flight maintenance

Due to the overspeed reported by the pilot the aircraft was grounded for inspection on its return to Jandakot. RFDS personnel examined the aircraft and reviewed the recorded data.

The initial aircraft examination revealed that a small amount of foreign material was blocking the left pitot tube drain. Following removal of the pitot tube, this material, and a small amount of water, was expelled using compressed air. The composition and source of the material could not be determined as it was not retained for further analysis.

The pitot static and anti-ice systems were inspected, and relevant checks were conducted in accordance with the aircraft's maintenance manual requirements. No further defects were identified, and the aircraft was returned to service.

The data review performed by RFDS maintenance personnel determined that the overspeed was an instrumentation issue and the aircraft had not actually exceeded its V_{mo} or M_{mo} limits. However, several data anomalies were identified. The aircraft was returned to service and RFDS maintenance personnel sent relevant data to the avionics manufacturer for further assessment. The manufacturer identified a number of instances of miscompare in the data. They recommended that the air data attitude heading reference system (ADAHRS) unit be replaced and returned for more detailed examination (see the section titled *ADAHRS examination*).

Pre-flight inspection procedure

The PC-12/47E standard pre-flight checks required a check of the pitot probes. The requirement was for the pitot cover to be removed and for the pitot tube to be 'Checked'. There was no stated requirement for the pitot drain to be checked for obstruction.

The operator advised that they had no additional specific requirements relating to the pitot inspection. They advised that the pitot drain hole is visible during the pre-flight inspection, however, a blockage would not be easily identified unless it was external to or protruding from the drain.

Meteorological information

At 1843 on the evening of the incident the Bureau of Meteorology (BOM) issued a SIGMET[11] for severe icing conditions between 1900 and 2300 over a large portion of south-west WA, for altitudes between 8,000 ft and FL190 (Figure 3). The conditions were predicted to move to the east at approximately 30 kt throughout the forecast window.

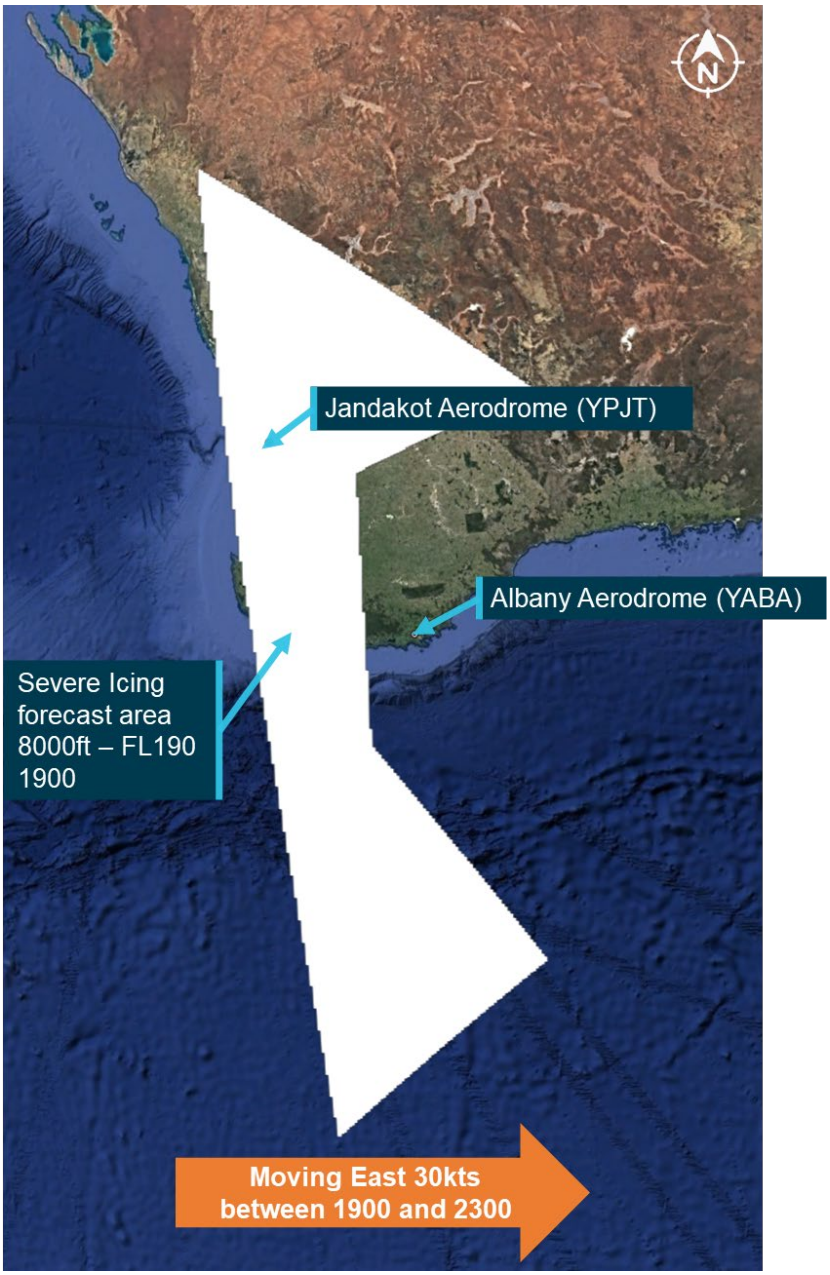
A grid point wind and temperature forecast was issued by BOM at 1417 on the day of the incident. The forecast indicated that from 2000, temperatures between Jandakot and Albany would drop to or below 0° C between 7,000 and 10,000 ft.

The relevant graphical area forecasts (GAF) indicated the potential for showers of rain and moderate turbulence. In addition, isolated thunderstorms were forecast with associated severe turbulence and icing.

The terminal area forecasts (TAF) indicated the likely presence of severe turbulence below 5,000 ft at both Jandakot and Albany from the start of the flight reducing to moderate at Jandakot by 2200.

[11] Significant meteorological information (SIGMET): a weather advisory service that provides the location, extent, expected movement and change in intensity of potentially hazardous (significant) or extreme meteorological conditions that are dangerous to most aircraft, such as thunderstorms or severe turbulence.

Figure 3: Overlay of SIGMET identified icing area



Source: Bureau of Meteorology and Google Earth, annotated by the ATSB.

Recorded data

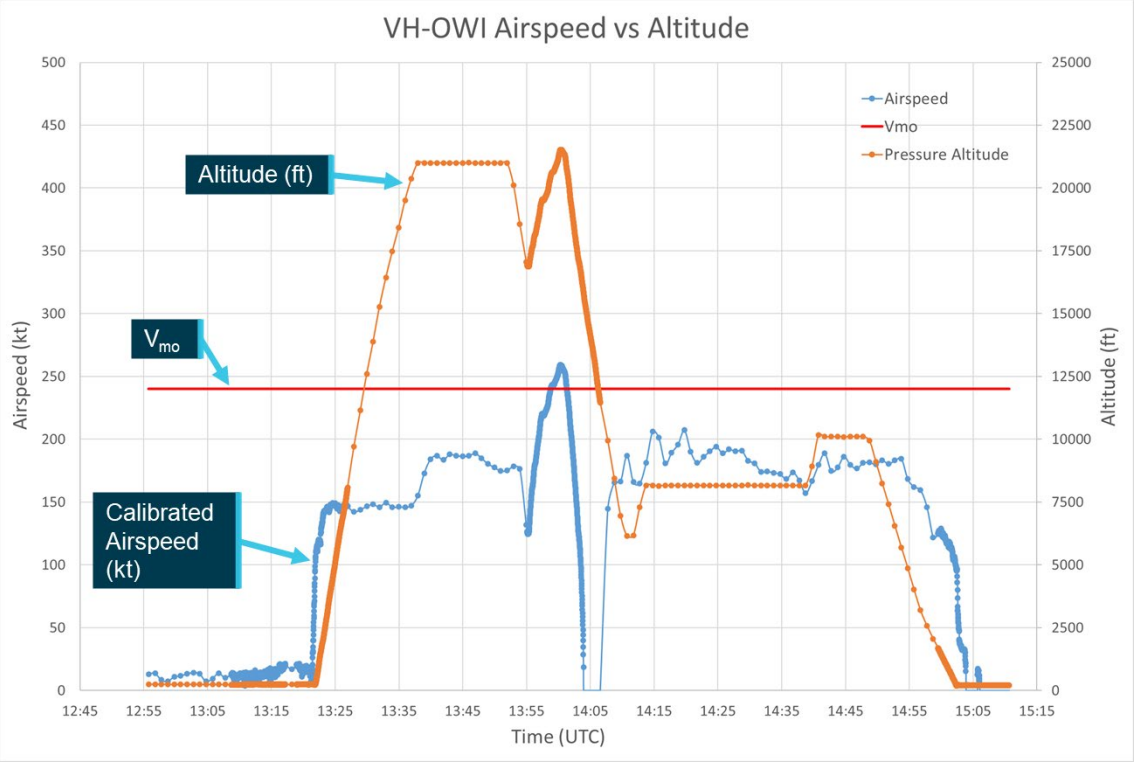
The ATSB was provided with aircraft maintenance files (ACMF) data which recorded a range of aircraft parameters for multiple flights, including the incident flight. Only the data feed to the left PFD was recorded. Figure 4 shows the aircraft's calibrated airspeed[12] and altitude for the incident flight. Also shown on the plot is a red line indicating the V_{mo} speed of the aircraft.

The indicated airspeed, displayed to the pilot, is calculated by comparing the dynamic air pressure, sensed through the pitot tube, on the aircraft's wing, with the static air pressure sensed at the static ports on the aircraft's tail. A blockage of the pitot tube will cause the pressure in the

[12] Calibrated Airspeed: Indicated airspeed accounting for system errors and subsequent corrections in the airspeed indicator.

tube (dynamic air pressure) to remain constant while static pressure changes with altitude. This will cause the indicated airspeed to over read during a climb and under read during a descent.

Figure 4: Recorded aircraft altitude and airspeed



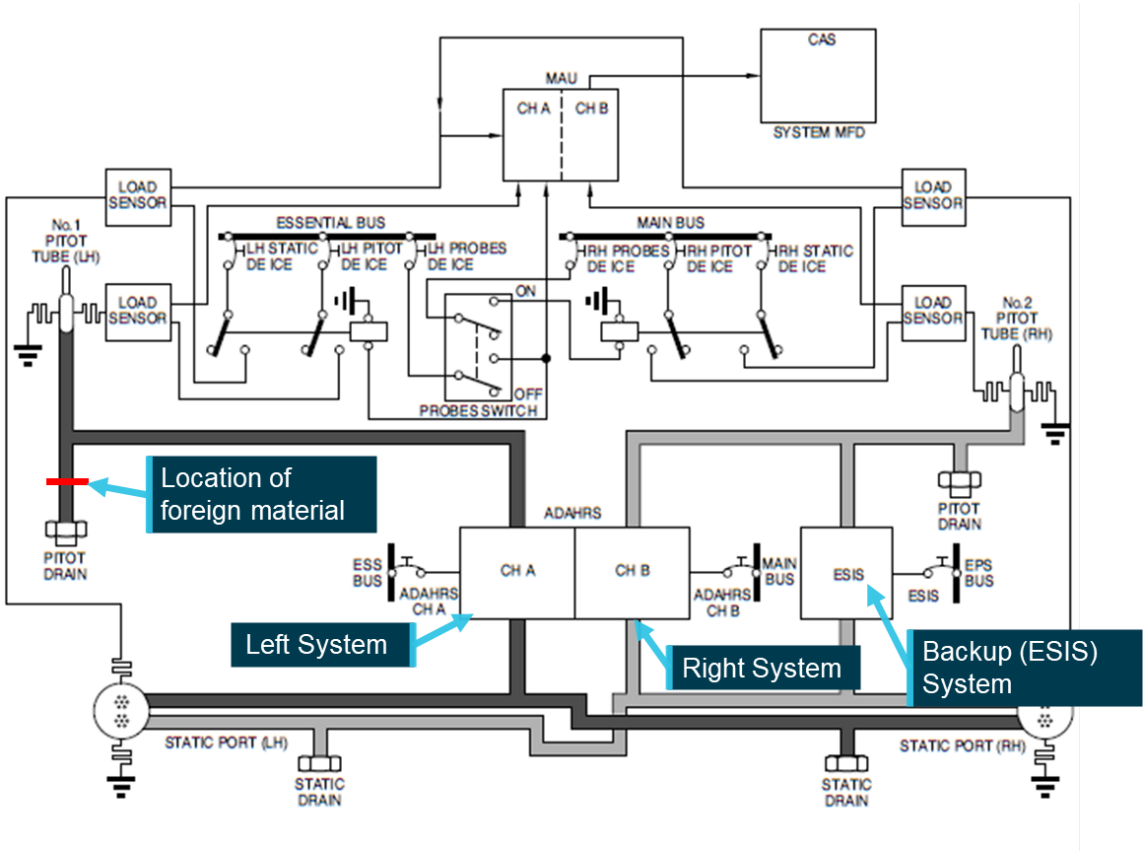
Source: ATSB

Air data attitude heading reference system

OWI was fitted with a Honeywell KSG7200 air data attitude heading reference system (ADAHRS). The ADAHRS unit reads data from a range of sensors and inputs throughout the aircraft including aircraft attitude, GPS, magnetometer, air pressure and temperature.

The processed data is then displayed on the relevant PFD. The system consists of two separate units, channel A taking inputs from the sensors on the left of the aircraft for display on the left PFD and channel B, which receives inputs from sensors on the right of the aircraft for display PFD (Figure 5).

Figure 5: ADAHRS unit system schematic



Source: Pilatus, annotated by the ATSB.

The unit has two systems detecting anomalies between channel A and B data. The first system monitors and reviews the input data from the two sources. It identifies differences that fall outside of a certain threshold, flagging these in the maintenance fault log as miscompares for later action by maintenance personnel. This information is not visible to the flight crew.

The second system monitors and reviews the data being displayed on the PFDs. It identifies differences that fall outside of a certain threshold and flags these visibly on the PFD's for the flight crew. In the case of an identified difference, if the crew identify which data source is incorrect (channel A or B), both PFDs can be selected to the same valid data source.

ADAHRS examination

The ADAHRS unit examination at the manufacturer's facility did not identify any faults with channel A. Three parameters were identified within the fault log as having miscompared in the manufacturers review, these were pitot pressure, heading and total air temperature (TAT). The pitot pressure miscompare was identified as corresponding with the pilot's report. The recorded heading miscompare, while significantly smaller than that reported by the pilot, aligned with the timing reported by the pilot. The TAT miscompare that was identified was not deemed to be an issue as TAT data is not used in any calculations within the ADAHRS unit and is not displayed on either PFD.

Crew comment

The pilot advised the ATSB that one of the key things that assisted them in working through the incident was training they had undertaken as part of an operational proficiency check (OPC). As part of the OPC, carried out about a month before the incident, the pilot, under the guidance of a check and training pilot, observed the aircraft's performance at various engine power setting and aircraft attitude combinations. Their assessment was that this check flight had given them more

confidence in the assessment that it was likely a pitot tube blockage and that the right PFD and ESIS were showing the correct information.

Analysis

Pitot tube blockage

Foreign material identified after the occurrence in the left pitot tube drain likely prevented water draining effectively. Consequently, water that entered the pitot tube during flight either as the aircraft was flying through rain, or as water vapour condensing in the tube as it flew through cloud, probably accumulated and blocked the pitot tube.

Both the weather forecasts and the pilot's report indicate that the aircraft was operating in icing conditions at the time the miscompares and spurious warnings were received. However, as the pitot tubes were fitted with an anti-icing system and the aircraft data indicated that the system was operational anytime the aircraft was operating below 10 °C with visible moisture, it was unlikely that icing contributed to the blockage.

The result of this blockage was that air was unable to flow freely through the pitot tube artificially changing the dynamic pressure recorded by channel A of the ADAHRS unit.

Airspeed miscompare

The incorrect air pressure being fed into the ADAHRS unit from the blocked pitot tube resulted in the airspeed displayed on the left PFD being incorrect. The airspeed over read during climb and under read during descent. The miscompare monitoring functionality of the ADAHRS unit identified the difference between the two displayed airspeeds, triggering miscompare indications on the PFDs.

The manufacturer's inspection and analysis of the ADAHRS ruled out any technical issues with channel A of the unit causing the erroneous data.

Heading miscompare

Following the airspeed miscompare indication, the pilot detected, and the aircraft's fault log showed, a heading miscompare. Based on the review of the data and the results of the ADAHRS unit examination no technical reason for the miscompare could be determined.

The miscompare occurred during the aircraft's descent into increasing turbulence. Based on advice from the avionics manufacturer it is likely that the motion of the aircraft in turbulence caused the unit to miscompare. When the aircraft climbed from 6,000 ft, and exited the worst of the turbulence, the pilot reported that the heading data returned to normal.

Findings

ATSB investigation report findings focus on safety factors (that is, events and conditions that increase risk). Safety factors include 'contributing factors' and 'other factors that increased risk' (that is, factors that did not meet the definition of a contributing factor for this occurrence but were still considered important to include in the report for the purpose of increasing awareness and enhancing safety). In addition 'other findings' may be included to provide important information about topics other than safety factors.

These findings should not be read as apportioning blame or liability to any particular organisation or individual.

From the evidence available, the following findings are made with respect to the unreliable airspeed indication involving Pilatus PC-12/47E, VH-OWI which occurred on descent to Albany Airport, Western Australia on 22 June 2020.

Contributing factors

- Water trapped in the left (pilot's) side pitot system by a blocked pitot drain likely obstructed the airflow through the pitot lines during the flight. This resulted in inaccurate dynamic air pressure information being received by channel A of the air data attitude heading reference system.
- Incorrect air pressure data received by channel A of the air data attitude heading reference system resulted in the calculation and display of false airspeed data on the left primary flight display. This triggered an airspeed miscompare, erroneous alerts and resulted in the pilot returning to Jandakot.

Other findings

- The heading miscompare detected by the pilot was likely a result of the movement of the aircraft through moderate to severe turbulence.

Sources and submissions

Sources of information

The sources of information during the investigation included the:

- pilot of VH-OWI
- Bureau of Meteorology
- aircraft operator/maintainer and avionics manufacturer.

Submissions

Under section 26 of the *Transport Safety Investigation Act 2003*, the ATSB may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. That section 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 following directly involved parties:

- pilot of VH-OWI
- Bureau of Meteorology
- aircraft operator/maintainer and avionics manufacturer.

Submissions were received from:

- Bureau of Meteorology
- avionics manufacturer.

The submissions were reviewed and, where considered appropriate, the text of the report was amended accordingly.

General details

Occurrence details

Date and time:	22 June 2020 – 2155 WST	
Occurrence category:	Incident	
Primary occurrence type:	Avionics / Flight Instruments	
Location:	78 km north-west of Albany Airport, Western Australia	
	Latitude: 34° 14.7858' S	Longitude: 117° 16.0718' E

Aircraft details

Manufacturer and model:	Pilatus Aircraft Ltd PC-12/47E	
Registration:	VH-OWI	
Operator:	Royal Flying Doctor Service of Australia (Western Operations)	
Serial number:	1232	
Type of operation:	Aerial Work - other	
Departure:	Jandakot, Western Australia	
Destination:	Albany, Western Australia	
Actual Landing:	Jandakot, Western Australia	
Persons on board:	Crew – 3 (1 flight crew, 2 medical staff)	Passengers – Nil
Injuries:	Crew – Nil	Passengers – Nil
Aircraft damage:	None	

Australian Transport Safety Bureau

About the ATSB

The ATSB is an independent Commonwealth Government statutory agency. It is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers.

The ATSB's purpose is to improve the safety of, and public confidence in, aviation, rail and marine transport through:

- 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, as well as participating in overseas investigations involving Australian-registered aircraft and ships. It prioritises investigations that have the potential to deliver the greatest public benefit through improvements to transport safety.

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

Purpose of safety investigations

The objective of a safety investigation is to enhance transport safety. This is done through:

- identifying safety issues and facilitating safety action to address those issues
- providing information about occurrences and their associated safety factors to facilitate learning within the transport industry.

It is not a function of the ATSB to apportion blame or provide a means for determining 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. The ATSB does not investigate for the purpose of taking administrative, regulatory or criminal action.

Terminology

An explanation of terminology used in ATSB investigation reports is available on the ATSB website. This includes terms such as occurrence, contributing factor, other factor that increased risk, and safety issue.