Australian Government

Australian Transport Safety Bureau

VFR into IMC and in-flight break-up involving Van's Aircraft RV-7A, VH-XWI

90 km south of Charters Towers, Queensland, on 23 April 2021

ATSB Transport Safety Report

Aviation Occurrence Investigation (Short)

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Addendum

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Executive summary

What happened

On 23 April 2021, a Van's Aircraft RV-7A, registered VH-XWI, was being operated on a private flight under the visual flight rules (VFR) from Winton to Bowen, Queensland. The pilot, the sole occupant and the owner of the aircraft, had been on a multi-day tour in company with 3 other pilots, each operating their own aircraft.

About 2 hours after departing Winton, and about 90 km south of Charters Towers, the aircraft sustained an in-flight break-up. The pilot was fatally injured, and the aircraft was destroyed.

What the ATSB found

The ATSB found that the pilot departed Winton with a high risk of encountering adverse weather conditions along the planned route. About 100 km into the flight, overhead Catumnal Station, the pilot most likely entered instrument meteorological conditions (IMC) and lost control of the aircraft several times, recovering control within 50 ft of the ground. The pilot then turned back towards Winton.

About 11 km into the return leg, the pilot resumed track to Bowen, climbing to above 10,000 ft. The pilot flew at multiple altitudes between 10,000 ft and 500 ft above the ground, most likely to avoid weather along the track. The pilot again likely entered weather conditions before becoming spatially disorientated, resulting in loss of aircraft control. This led to the airspeed limitations of the aircraft being exceeded before rudder flutter structurally compromised the tail group, leading to a catastrophic airframe failure and in-flight break-up.

There were no operational reasons for the pilot to continue the flight to Bowen, and the pilot probably had a self-imposed motivation or pressure to continue the flight.

Safety message

VFR into IMC accidents usually result in a fatal outcome, and they are one of the most common types of fatal accidents in general aviation. Safety lessons to minimise the risk have been published in many sources, including the ATSB publication *Accidents involving Visual Flight Rules pilots in Instrument Meteorological Conditions*. Some of these lessons for VFR pilots include:

- Avoid deteriorating weather by conducting thorough pre-flight planning. Ensure you have alternate plans in case of an unexpected deterioration in the weather, and make timely decisions to turn back, divert or hold in an area of good weather.
- If you encounter deteriorating weather, turn back or divert before you are caught in cloud. For a non-instrument rated pilot, even with basic attitude instrument flying proficiency, maintaining control of an aircraft in IMC by reference to the primary flight instruments alone entails a very high workload that can result in narrowing of attention and loss of situational awareness.
- Recognise that weather often does not act as the forecast predicts. You must have alternatives available and be prepared to use them—even if it means returning to your departure point.
- Use a 'personal minimums' checklist to help control and manage flight risks by identifying risk factors that include marginal weather conditions and only fly in environments that do not exceed your capabilities. A personal minimums checklist is an individual pilot's own set of rules and criteria for deciding if and under what conditions to fly or to continue flying based on your knowledge, skills and experience. In other words, to be a competent pilot, you must know and fly within your own limitations.

The investigation

Decisions regarding the scope of an investigation are based on many factors, including the level of safety benefit likely to be obtained from an investigation and the associated resources required. 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

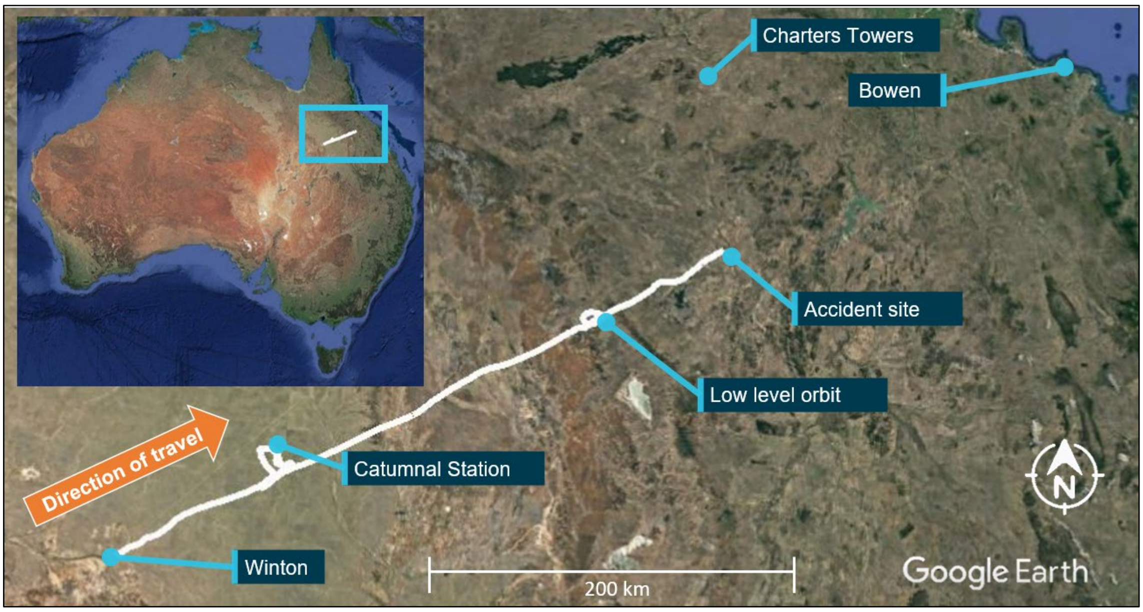
Events prior to departure

On 23 April 2021, a Van's Aircraft RV-7A, registered VH-XWI, was being operated on a private flight from Winton to Bowen, Queensland (Figure 1).

The owner/pilot was the sole occupant and had been on a multi-day tour in company with 3 other pilots, each operating their own aircraft. The 4 aircraft were all travelling to the same event, being held near Bowen.

Prior to departing from Winton, the pilots discussed the forecast weather conditions for the planned flight, including their arrival at Bowen. Due to the likelihood of adverse weather towards the coast, the other pilots elected to operate to Bowen under the instrument flight rules[1] (IFR), while the pilot of VH-XWI, being restricted to operating in visual meteorological conditions[2] (VMC), departed under a daytime visual flight rules[3] (VFR) flight plan.

Figure 1: Flight track of VH-XWI from Winton to Bowen



Source: Google Earth with Aireon data, annotated by the ATSB

1 Instrument flight rules (IFR): a set of regulations that permit the pilot to operate an aircraft to operate in instrument meteorological conditions (IMC), which have much lower weather minimums than visual flight rules (VFR). Procedures and training are significantly more complex as a pilot must demonstrate competency in IMC conditions while controlling the aircraft solely by reference to instruments. IFR-capable aircraft have greater equipment and maintenance requirements.

2 Visual meteorological conditions (VMC): an aviation flight category in which visual flight rules (VFR) flight is permitted – that is, conditions in which pilots have sufficient visibility to fly the aircraft while maintaining visual separation from terrain and other aircraft.

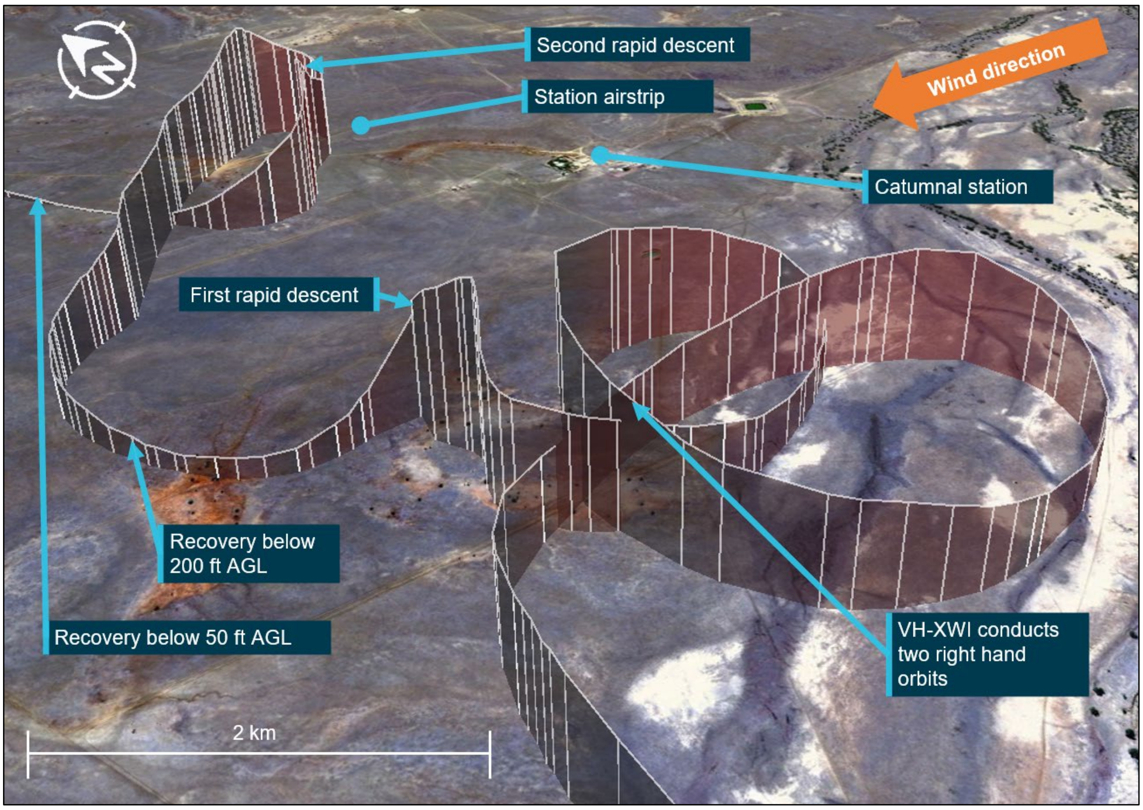
3 Visual flight rules (VFR): a set of regulations that permit a pilot to operate an aircraft only in VMC.

Accident flight

Witnesses stated that VH-XWI was last of the 4 aircraft to depart. Recorded data showed that the aircraft departed Winton at about 0751 local time and set a north-east course to track to Bowen, climbing to 7,500 ft above mean sea level (AMSL) for the 600-km flight.

At 0826, when the aircraft was near Catumnal Station, about 100 km north-east of Winton, the aircraft descended to about 500 ft above ground level (AGL) (Figure 2). The aircraft conducted 2 right orbits about 7 km to the south-west of Catumnal Station at indicated airspeeds as low as 25 kt, before rapidly descending to less than 200 ft AGL.

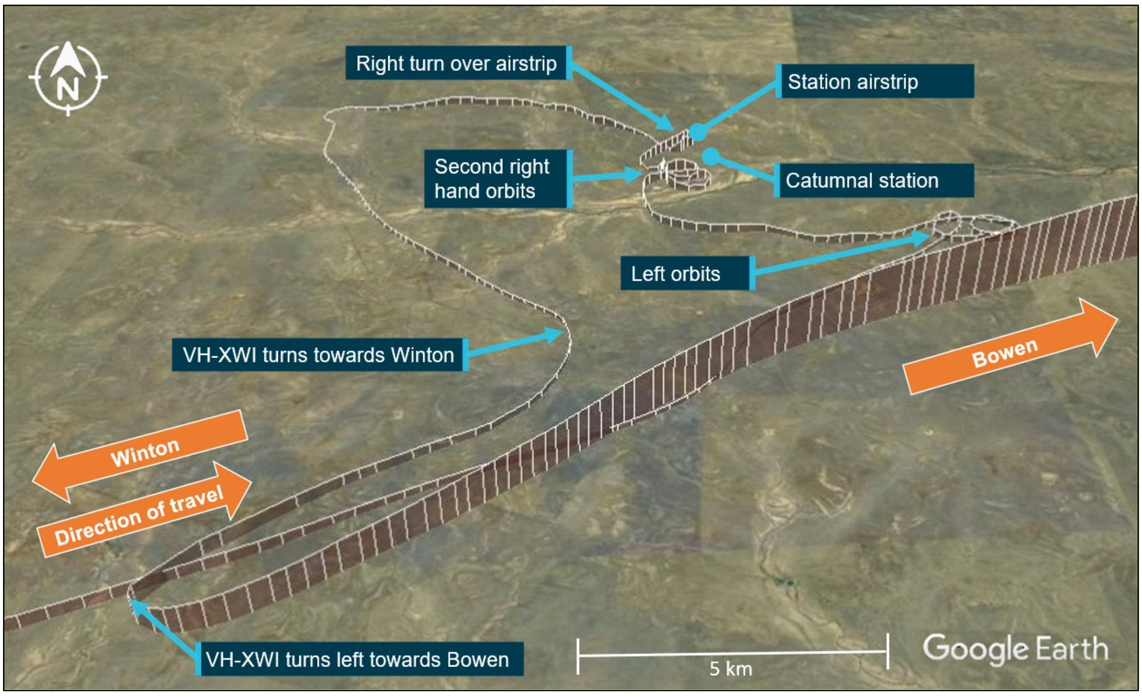
Figure 1: Flight path of VH-XWI over Catumnal Station



Source: Google Earth with Aireon data, annotated by the ATSB

The aircraft then climbed back up to about 1,000 ft AGL. At about 0829, when overhead the station airstrip, the aircraft's airspeed reduced to about 43 kt while the aircraft conducted a right turn. It then rapidly descended to less than 50 ft AGL before climbing away from the station, and turning back towards Winton (Figure 3).

Figure 2: Flight path of VH-XWI in the vicinity of Catumnal Station



Source: Google Earth with Aireon data, annotated by the ATSB

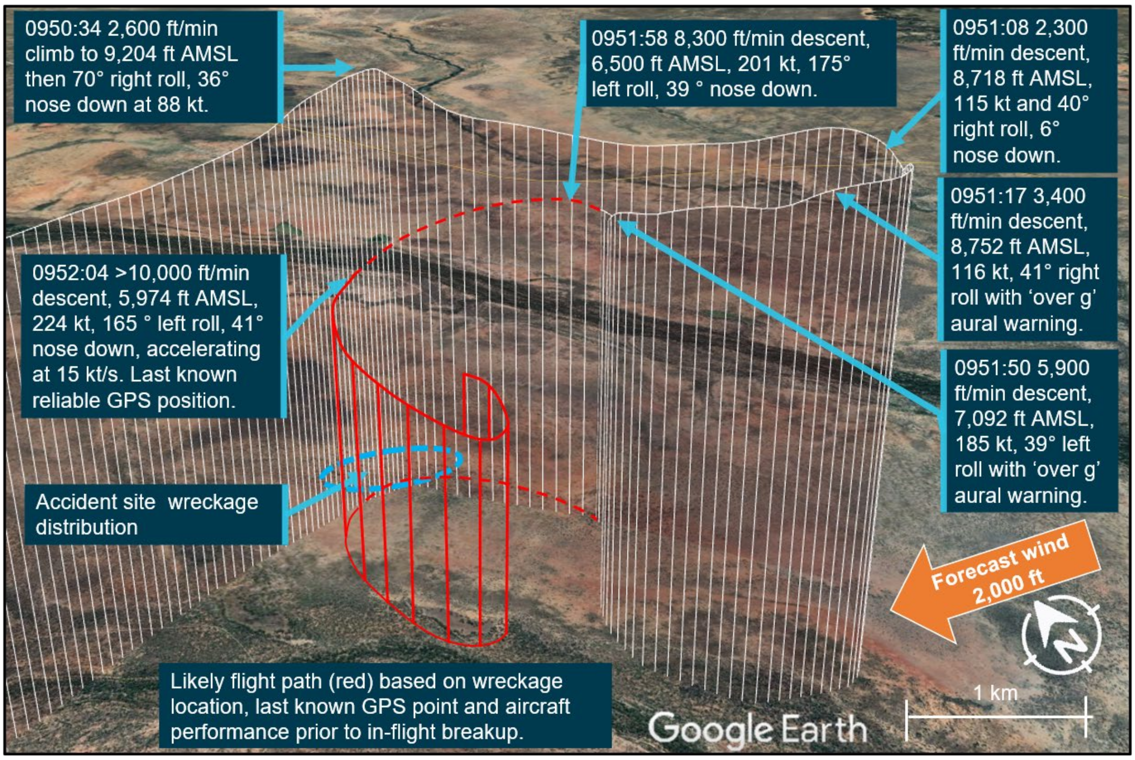
At 0838, about 11 km after turning towards Winton, the aircraft conducted a left climbing turn then commenced a track towards Bowen and climbed to about 10,500 ft AMSL.

At 0936, when about 290 km north-east of Winton, the aircraft descended to about 1,000 ft AGL. It then conducted a large left orbit before turning back towards Bowen and climbing to about 9,000 ft AMSL.

At 0950, when about 370 km north-east of Winton (and about 90 km to the south of Charters Towers), the aircraft conducted an abrupt 90° right turn, followed by a series of further turns, with airspeed and altitude fluctuations. Soon after, the aircraft was in a right descending turn. It then rolled to the left and continued until almost inverted, and then pitched towards the ground.

At the last recorded GPS position (0952:04), the aircraft was at a recorded altitude of about 6,000 ft, where it had rolled 165° to the left and pitched down 41°. It was descending at more than 10,000 ft/min at an indicated airspeed of 224 kt and was accelerating at 15 kt/s (Figure 4). This recorded airspeed was more than 20% over the never exceed speed (V_{NE}) for the RV-7A.

Figure 3: VH-XWI accident sequence



Source: Google Earth with Dynon data, annotated by the ATSB

Based on the wreckage distribution and the nature of the wreckage, it was evident that VH-XWI sustained an in-flight break-up before the wreckage collided with terrain. The pilot was fatally injured, and the aircraft was destroyed.

Other information

In-flight radio contact between the pilot of VH-XWI and the 3 other pilots in company was made intermittently. These pilots recalled that, during the flight, the pilot of VH-XWI indicated that they would descend from 7,500 ft to 3,500 ft due to cloud. The pilot of VH-XWI then advised the group that they were unable to 'get through' and decided to descend below the cloud to continue the flight to Bowen. Sometime later the pilot of VH-XWI advised that they were 'going to turn back'.

On landing at Bowen, the other pilots checked on the progress of VH-XWI using web-based aircraft tracking software and saw that VH-XWI's track had stopped. They then alerted the Joint Rescue Coordination Centre.

Context

Pilot information

Qualifications and experience

The pilot held a valid private pilot licence (aeroplane), initially issued in August 1975, and was qualified to fly by day under the visual flight rules (VFR). Their licence was reissued as a Civil Aviation Safety Regulation (CASR) Part 61 licence on 3 May 2021, for single-engine aeroplanes, with endorsements for manual propeller pitch change and retractable undercarriage. The pilot had a total flying experience of 276.8 hours prior to the accident flight.

After receiving their private licence in 1975, the pilot flew several times a month until about 1981 before taking a break from flying for about 3 years. In 1984 they conducted a flight review and continued flying 3-4 times a year until January 1990. Most of their total flight time (216.1 hours) was conducted prior to January 1990. The remaining 60.7 hours was conducted in VH-XWI from July 2020 to March 2021.

In July 2020, the pilot accompanied a test pilot in 17 hours of initial flight testing of VH-XWI (in a non-flying capacity). When phase 1 flight testing of VH-XWI was finalised, the pilot began to undertake flight training in the aircraft with a flying school in September 2020. The pilot flew with a number of instructors and completed 9.4 hours of dual training. Flying school records indicated that there were a number of areas that remained inconsistent when not coached by instructors and therefore the chief flying instructor believed that the pilot was not yet of a standard to be considered ready for a flight review.

In February 2021, the pilot conducted a further 3.9 hours of flight time in VH-XWI with another flying school before passing a flight review on 18 February 2021. The instructor noted that the pilot seemed careful and made good decisions, however spent considerable time focussed on instrumentation inside the cockpit to the detriment of heading and altitude. The instructor further remarked that this was not uncommon for pilots presenting for flight reviews in aircraft such as the RV-7A that were equipped with glass cockpits.[4] The instructor added that the pilot was experimenting with the glass cockpit and demonstrated the use of the autopilot during one leg of the navigation exercise.

The instructor recalled that, during initial stalling exercises, the pilot overly pitched the aircraft forward during the recovery, however subsequent stalls were conducted to an acceptable standard. During advanced stalling, with full flaps selected, the aircraft had a wing drop that the pilot recovered with aileron. After discussion and a number of other recoveries with rudder, the instructor was satisfied that the pilot had met an acceptable standard.

During the flight review, the pilot was given an engine failure and conducted a practice forced landing to an acceptable standard. Navigation diversions and instrument flying scenarios were not conducted during the flight review. The instructor stated that these were optional during a day VFR flight review.

After completing their flight review, the pilot operated VH-XWI on numerous local and cross-country flights, leading up to the planned multi-day tour with the 3 other pilots.

Medical information and recent history

The pilot was 74 years old and held a valid basic class 2 medical certificate, with the last examination conducted on 1 February 2021. This type of certificate is based on the standard required for a commercial motor vehicle driver’s licence declaration, verified by a general practitioner.

A post-mortem examination and toxicological screen were performed, with no evidence of incapacitation or effects of alcohol or other drugs.

Due to the pilot being away from home for the days preceding the accident, a detailed recent history could not be obtained. However, from the limited information available, there were no fatigue-related concerns identified.

Aircraft information

General

The Van’s Aircraft RV-7A is a low-wing, all-metal, high-performance, amateur-built aeroplane. It has a 2-seat, side-by-side configuration. It is supplied in kit form and is designed to be constructed for the education and recreation of the owner. The RV-7A has a fixed, tricycle

[4] A glass cockpit is a cockpit where flight data is shown on electronic flight displays (EFDs) rather than separate gauges for each instrument.

landing gear and is suitable for cross-country flying, with speed ranges from 56–200 kt, and can be operated between +6 g and -3 g,[5] making it suitable for flying aerobatic manoeuvres.

VH-XWI was registered in the experimental category. Pilots and passengers of experimental aircraft in Australia accept the risk that the aircraft may not meet the same airworthiness safety standards as certified aircraft, and therefore operate on the basis of informed participation.[6]

Airworthiness

The Special Certificate of Airworthiness issued to VH-XWI on 26 August 2020 indicated in the annexure, among other requirements, that the aircraft be operated ‘by day and under VFR only’.

The airframe hours prior to the accident flight were unable to be established as the maintenance release was not located at the accident site. The most recent entries in the aircraft and engine maintenance logs were on 10 April 2021, about 13 days prior to the accident. They showed that the aircraft had accumulated 84.8 hours total time in service. Prior to that, the aircraft had received an oil change and a new oil filter at 25.2 hours on 10 August 2020, with no evidence of contaminants found in the filter.

Operating limitations

Aircraft operating limitations were contained within the aircraft pilot’s operating handbook (POH), and the relevant airspeed limitations are detailed in Table 1.

Table 1: Airspeed limitations

Speed	Knots indicated airspeed (KIAS)	Remarks
V_{NE} – never exceed	200	Do not exceed this speed in any operations.
V_{NO} – maximum structural cruising speed	168	Do not exceed this speed except in smooth air.
V_{MA}	123	Do not make full control movements above this speed. Full elevator deflection will result in a 6g load at this speed.
Stall speed (no flaps)	56	
Stall speed (landing configuration)	50	

Never exceed speed

The aircraft structure was designed to support aerobatic operations with a never exceed speed (V_{NE}) of 200 kt. The calculation of this speed is driven by structural or aerodynamic limitations; however, control system flutter is typically one limitation that factors heavily into the calculation of V_{NE}.

Flutter is an oscillatory motion of a wing or flight control. Aerodynamic vibration starts when aerodynamic forces cause a structure to deflect in a way that alters the aerodynamic force being generated, resulting in a feedback loop. This oscillation may be damped, stable (non-divergent) or unstable (divergent). Undamped forms of vibration are known as flutter. Small changes to conditions can change the mode of oscillation rapidly. The onset of flutter in aircraft is usually instantaneous and normally leads to catastrophic failure.

Factors that can contribute to flutter include high speed, a reduction in structural or system stiffness, or an incorrect or a change in control surface mass distribution. The flutter speed is

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5 G load: the nominal value for acceleration. In flight, g load represents the combined effects of flight manoeuvring loads and turbulence and can have a positive or negative value.

6 Informed participation relies on the premise that before the participant takes part, or pays for an activity, they are fully aware of the potential risks and consequences.

dependent on many individual aspects of the aircraft and the way the aircraft is being flown at any time.

The RV-7A has an open-circuit rudder control system, and cable tension in a control circuit affects the flutter speed for that circuit. Flutter speed variation can be affected by the pressure on the rudder pedals, the centre of mass of the control surface or free play in a trim tab. Therefore, a V_{NE} of 200 kt does not mean the aircraft will flutter immediately above this speed.

Fuel

The aircraft operated on aviation gasoline (avgas) and had a usable capacity of 159 L in 2 (80 L) wing tanks. The aircraft was refuelled prior to departure from Winton, with records indicating that about 75 L was uplifted.

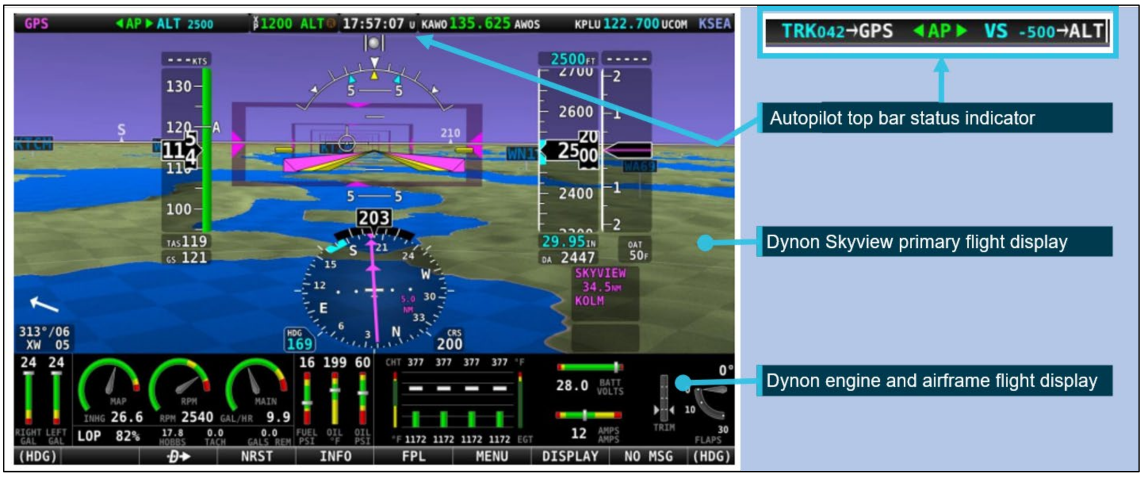
Recorded data provided by the aircraft instrumentation indicated an average fuel burn across the entire flight of about 29 L/hour, with straight and level cruise sectors at about 75–80% power settings using about 35 L/hour. The data also indicated that the fuel pressure remained uniform throughout the flight and, at the time of the accident, the aircraft had about 51 L in the left tank and about 43 L in the right.

The recorded data provided detailed fuel quantity readings that were consistent throughout the flight, leaving a high degree of certainty that 94 L of fuel remained on board the aircraft at the time of the accident. This equated to a further 2 hours flight time, which was sufficient to divert to another landing area or continue to Bowen.

Instrumentation and systems

VH-XWI was fitted with a Dynon Skyview HDX primary flight display (Figure 5). The Skyview system incorporated various communication and GPS navigation systems.

Figure 4: Dynon SkyView HDX primary flight display



Source: Dynon Avionics, annotated by the ATSB

The aircraft was fitted with a 2-axis Dynon Skyview autopilot which had multiple modes of operation, including a level mode. When selected, the autopilot's level mode will immediately attempt to reach zero vertical speed and zero roll angle. It will not attempt to fly the aircraft to any previous pilot-selected altitude, track or other selected inputs. When activated, level mode will cause the autopilot to engage if it was not already engaged. Level mode is engaged by pushing the LEVEL button on the autopilot panel.

The Dynon Skyview HDX included a stall warning system that incorporated an angle of attack (AoA)[7] indicator to measure and provide an audio alert if the AoA increased significantly. The Dynon Skyview HDX pilot user guide stated:

> AOA Alerts: When AOA audio alerting is enabled, it enables a progressive tone that increases in intensity as AOA increases. It is similar in nature to a conventional reed-type aircraft stall warning sound, although it is much more predictable in its progression. It can be set to start its progressive tones at either the border of the yellow/green marks on the AOA bars, the middle of the yellow, or at the yellow/red border. The tones start at the level selected and get progressively quicker and closer together until a solid tone is played at critical AOA (in the red).

The test pilot confirmed the correct operation of the AoA alert system during VH-XWI's flight testing.

Meteorological information

Bureau of Meteorology forecasts indicated there was significant cloud, reduced visibility and adverse weather predicted for the intended duration of the flight from Winton to Bowen. Although generally better weather conditions existed inland of the east coast of Queensland, these were forecast to deteriorate from greater than 10 km visibility down to about 1,000 m in isolated thunderstorms with showers, rain and broken cloud from 800 ft to above 10,000 ft. Severe icing and turbulence were expected within the proximity of isolated thunderstorms and cumulonimbus.

A witness at Catumnal Station, about 100 km north-east of Winton, heard an aircraft overhead the station for a period of time, consistent with the recorded data from VH-XWI; however, they were unable to visually identify the aircraft due to the presence of fog.

A witness at Pajingo Station, about 17 km to the north-west of the accident site, recalled hearing an aircraft operating in the vicinity at about 1000. They did not see the aircraft in flight but indicated that the weather at the station was heavily overcast and raining on and off most of the morning.

The night before the flight to Bowen, the pilot contacted the test pilot, who had conducted the initial test flying of the aircraft. In general conversation about the trip, the weather forecast for the next day's flight was discussed. The test pilot recalled that, despite the forecast, the pilot expressed a strong desire to remain with the group, even though predicted weather may not have been conducive to visual flight.

One of the pilots travelling in company with the pilot of VH-XWI indicated that all the pilots discussed the weather for the planned flight prior to departure from Winton as a point of concern. They recalled that the weather at Winton was clear with no fog or cloud, however significant weather was expected closer to the coast. Prior to departure, an offer was made to the pilot of VH-XWI that, should the weather be too bad for VFR flight, one of the group would return to pick them up and take them to Bowen.

Another pilot travelling in company with the pilot of VH-XWI recalled the weather as initially good at 7,000 ft with little cloud. However, as the flight progressed, the weather deteriorated into instrument meteorological conditions (IMC)[8] with cloud and rain for the last 30–40 minutes of their flight to Bowen. They recalled becoming visual on the approach to Bowen below 2,000 ft with significant wind.

The pilots of the 3 aircraft travelling in company with VH-XWI, who were conducting IFR flights, tracked about 30 km to the south of VH-XWI's accident location.

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7 Angle of attack: angle between the wings cord line and the relative airflow.

8 Instrument meteorological conditions (IMC): weather conditions that require pilots to fly primarily by reference to instruments, and therefore under IFR, rather than by outside visual reference. Typically, this means flying in cloud or limited visibility.

Recorded data

The pilot utilised a tablet with a flight planning software program. Some limited GPS data was able to be extracted for the first 5 minutes of flight, before no longer recording.

VH-XWI was fitted with an Automatic Dependant Surveillance – Broadcast (ADS-B) system, which provided ground-based aircraft tracking by digital data link on average once every 6 seconds. Airservices Australia described ADS-B on its website as:

> The system involves an aircraft with ADS-B determining its position using GPS. A suitable transmitter then broadcasts that position at rapid intervals, along with identity, altitude, velocity and other data. Dedicated ADS-B ground stations receive the broadcasts and relay the information to air traffic control for precise tracking of the aircraft.

The last few parameters of ADS-B data from VH-XWI were erratic, most likely due to line-of-sight limitations with the associated antennas during the in-flight break-up sequence.

The Dynon Skyview HDX was capable of internally recording various types of data through numerous sensors and inputs, such as the GPS position, accelerometers, pressure transducers and magnetometers. This enabled recording of many aircraft and in-flight parameters, some of which included:

- flight path direction, airspeed, groundspeed and altitude
- engine data: pressures, temperatures, RPM, voltage
- fuel quantity, usage and quantity remaining
- autopilot activation
- angle of attack (AoA).

The data was recorded at up to 16 times per second. The data was buffered for a short time, before being transferred the Dynon's internal storage. Captured data over 10 minutes old was down sampled to a data point every second.

Onboard data recovered from the Dynon consisted of 1 second data from the start of the flight up until 11 minutes before the end of the flight, and then 16 times per second up until 1 minute before the end of the flight. The last minute or so was not recorded.

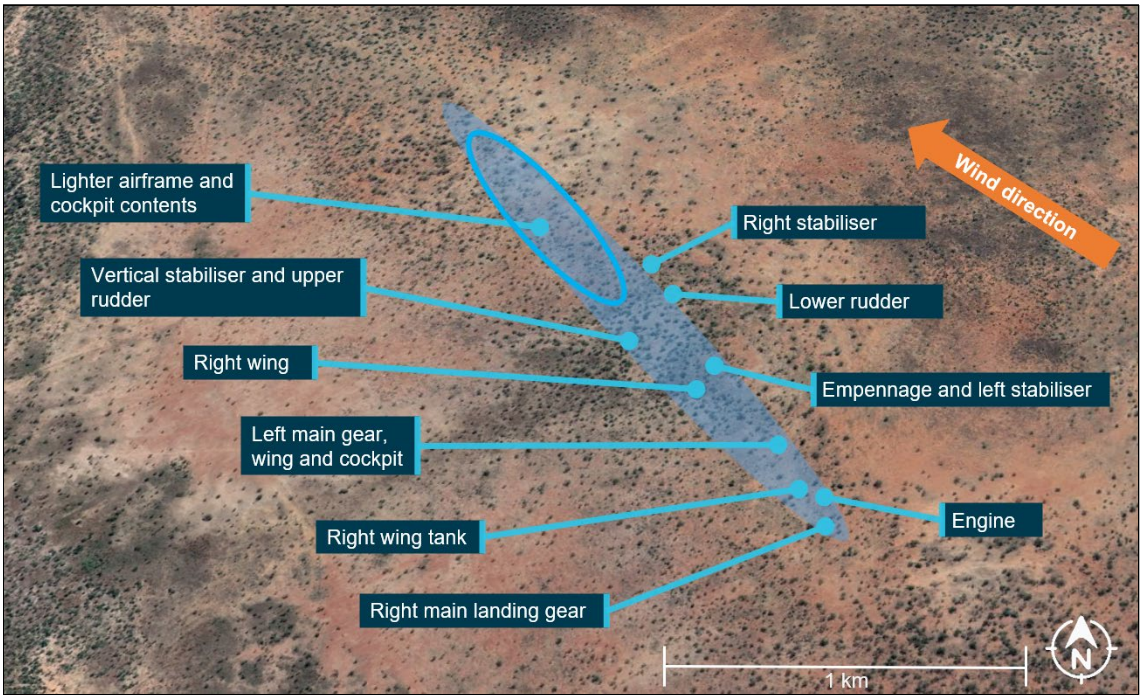
Combined data from the ADS-B and Dynon instrumentation provided detail relating to VH-XWI's airspeed and altitude before the data stopped recording. Relevant data during the flight is presented in Figure 4. In addition:

- at 0950:19, about 2 minutes before the in-flight break-up while climbing slowly through 8,700 ft at 120 kt indicated airspeed, the aircraft entered into an abrupt climb to 9,660 ft and reduced speed to 56 kt before turning right and tracking southwards in a descent with speeds increasing to 145 kt
- at 0951:04, about 1 minute before the in-flight break-up, the aircraft had descended to 8,579 ft and stabilised airspeed at about 145 kt
- at 0950:34, about 30 seconds before the in-flight break-up, the aircraft had climbed to 9,204 ft and slowed to 88 kt before entering a right descending turn with an increasing descent rate and airspeed
- at 0951:58, about 6 seconds before the in-flight break-up, the aircraft had increased speed above V_{NE} limitation of the aircraft and continued to accelerate
- airspeed increased to 224 kt with an increasing trend before the data stopped being recorded.

Wreckage information

The accident site was located almost directly below the last known reliable recorded data point, on partially-vegetated, open bushland with the ground significantly softened by recent rainfall. The wreckage was distributed over a distance of about 1.5 km, with the larger and heavier aircraft sections located closer to each other, and lighter, smaller sections of wreckage found to the north-west of the main wreckage, consistent with the forecast wind direction (Figure 6). All major aircraft components were accounted for, and there was no evidence of pre-impact defects.

Figure 5: Accident site scatter pattern



Source: Google Earth, annotated by the ATSB

The propeller, engine, and associated structure was located separately to the rest of the wings, cockpit, and rear tail sections.

The left wing and centre section/cockpit floor with part of the right-wing spar remained attached to the fuselage and was deformed downwards. The right wing was found nearby and showed transfer marks on its lower surface from the right main landing gear tyre.

The vertical stabiliser and the upper rudder section had separated as an assembly from the main fuselage. The rivet line at the training edge of the rudder had burst open, and the aerodynamic mass balance (normally located on the top of the rudder) was not found at the accident site (Figure 7). The lower section of the rudder had torn away immediately below its centre hinge point and was located some distance away from the vertical stabiliser and rudder assembly.

Figure 6: Rudder and vertical stabiliser

Source: ATSB

The elevators remained with the rear fuselage, attached by the elevator control horns and pushrod. Sections of the right horizontal stabiliser main spar had been torn from the horizontal stabiliser and were attached to the elevator at its hinge points. The horizontal stabilisers had separated in flight and were located some distance away from the rear fuselage in the debris field.

Appendix A provides details of 2 previous in-flight break-up accidents involving RV-7 aircraft. The damage to the rudder and vertical stabiliser exhibited similar damage and failure modes to that of VH-XWI. In both of those previous accidents, the aircraft's speed had significantly exceeded V_{NE}.

Visual flight rules requirements

Civil Aviation Regulation (CAR) 172 (Flight visibility and distance from cloud) outlined that a flight under the VFR could only be conducted in VMC.[9] The Australian Aeronautical Publication (AIP) ENR 1.2-4 contained the requirements for VMC. For flight in class G (uncontrolled) airspace below 10,000 ft above mean sea level (AMSL), these were stated as:

- a flight visibility of 5,000 m
- a minimum vertical distance of 1,000 ft and horizontal distance of 1,500 m from cloud.

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9 CAR 172 was in force at time of accident, CASR 91.270 now replaces the former regulation.

In the case of aeroplane operations in Class G airspace at or below 3,000 ft AMSL or 1,000 ft above ground level (AGL) (whichever was higher), the following minimum conditions were stipulated:

- a flight visibility of 5,000 m
- the aeroplane be maintained clear of cloud and in sight of the ground or water.

In addition to minimum visibility and distance from cloud, a pilot was also required to maintain a minimum height above the ground.

CAR 157 (Low flying)[10] detailed that a pilot in command must not fly the aircraft over:

- any city, town, or populous area at a height lower than 1,000 ft; or
- any other area at a height lower than 500 ft.

This did not apply if, through stress of weather or any other unavoidable cause, when essential that a lower height be maintained.

Risks of flying in areas of reduced visual cues

When VFR pilots enter IMC (or similar environments) and lose sufficient external visual cues, this can result in various types of accidents, including a loss of control leading to a collision with terrain (most common), a loss of control leading to an in-flight break-up, or a controlled flight into terrain.

The loss of control is usually associated with spatial disorientation, which occurs when a pilot does not correctly sense the position, motion and attitude of an aircraft relative to the surface of the Earth. VFR pilots can rapidly become spatially disoriented when they cannot see the horizon and other external cues. The brain receives conflicting or ambiguous information from the sensory systems, resulting in a state of confusion that can rapidly lead to incorrect control inputs and resultant loss of aircraft control.

Spatial disorientation can either be unrecognised by the pilot (type I) or recognised (type II). When type II disorientation accidents occur, they generally involve erratic flight paths resulting from the pilot having difficulty maintaining control of the aircraft's flight path (consistent with what was seen in this case).

The safety risk of VFR into IMC accidents are well documented. As noted by Wiggins and others (2012):

> …pilots who are not authorized to operate outside [VMC] lose control of their aircraft within a relatively short period of time following entry into [IMC]… This loss of control tends to be associated with a high rate of descent and a collision with terrain, the outcome of which is typically not survivable…

For example, in the United States, there were 226 VFR into IMC accidents involving small non-commercial fixed-wing aircraft during 2010–2019, of which 194 (86%) were fatal accidents.[11] Detwiler and others (2008) found that VFR into IMC accidents were 4 times more likely to result in fatalities when compared to all other types of general aviation accidents.

In Australia, in the 11 years from 2011 to 2021, there were 14 fatal accidents involving VFR into IMC (with 29 fatalities).[12] In comparison, there were 26 fatal VFR into IMC accidents in 1991–2000 (58 fatalities) and 10 such accidents in 2001–2010 (18 fatalities).

Of the 14 VFR into IMC fatal accidents during 2011–2021, 13 involved private flights (including 2 community service flights) and 1 involved a charter operation. The list of these accidents is provided in Appendix B. Overall, they accounted for 11% of all fatal accidents and 18% of fatal accidents involving private flights. During 2011-2021, there were also 3 other fatal accidents (with

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[10] CAR 157 was in force at time of accident, CASR 91.267 now replaces the former regulation.

[11] This was based on a review of data provided by the United States Aircraft Owners and Pilots Association (AOPA) annual review of general aviation accidents (known as the Nall Report)

[12] Only civil registered (VH- or equivalent) aeroplanes and helicopters were considered in these statistics.

6 fatalities) involving VFR into other adverse weather conditions (such as storms) as well as several accidents involving VFR flights into dark night conditions.

Some characteristics of VFR into IMC accidents

A significant number of studies have examined VFR into IMC accidents, and a range of factors are involved, with no one factor being involved in all accidents. These include pilots incorrectly assessing weather conditions, pilots underestimating the risk of the conditions, pilots overestimating their ability (or the ability of their aircraft) to handle the situation, and motivational (personal and social) factors (NTSB 2005, Goh and Wiegmann 2001, Detwiler and others 2008, Harris and others 2022).

Weather-related decision making is best characterised as a dynamic, ongoing process (Batt and O'Hare 2005). Wiggins and O'Hare (1995) noted that weather-related decision making in some cases can be highly complex and therefore more prone to errors:

> Because of the variable nature of operations in the aviation environment, weather-related decision making is often considered a skill that cannot be prescribed during training. Rather it is expected to develop gradually through practical experience. However, in developing this type of experience, relatively inexperienced pilots may be exposed to hazardous situations with which they are ill-equipped to cope.

Most VFR into IMC accidents happen during the cruise phase of flight. Some research has shown that the chance of a VFR into IMC encounter increases as a flight progresses, with most occurring during the second half of a planned flight (Batt and O'Hare 2005). The United States National Transportation Safety Board (NTSB, 2005) also found that the chances of a weather-related general aviation accident increased as the length of a planned flight increased.

Various studies have shown that, compared to pilots involved in other types of accidents, pilots involved in VFR into IMC accidents are more likely to have a private pilot licence (as opposed to a higher-level licence), are less likely to have an instrument rating, and have less flight experience (Detwiler and other 2008, NTSB 1989, NTSB 2005). However, many pilots with a significant amount of experience are also involved in such accidents. Of the 14 pilots involved in VFR into IMC accidents in Australia during 2011–2021, most (12) had a private licence and 2 had a commercial licence. Only 4 pilots held a night VFR rating and none held an instrument rating (although 1 had previously held an instrument rating).

It is difficult to draw conclusions regarding research on pilot age and accident involvement, as it is often confounded with experience and other factors, and there are significant individual differences in a range of abilities (AOPA 2014). VFR into IMC accidents involve pilots from all age groups. Other information regarding pilot age includes:

- The NTSB's 1989 study noted that pilots in VFR into IMC accidents were, on average, older than comparison groups of all active pilots and older than pilots involved in other general aviation accidents.
- The NTSB's 2005 study compared pilots involved in weather-related general aviation accidents with a matched sample of pilots. It found that the non-accident group included a higher proportion of pilots less than 40, and the accident group included a higher proportion of pilots over 60. It also concluded that the age a pilot obtained their private licence was a better predictor of future accident involvement than age at the time of flight, with pilots obtaining their licence before 25 being less likely to be involved in a weather-related accident.

- The age of pilots involved in VFR into IMC accidents in the United States appears to have increased over time, with the proportion being over 60 being 8% in 1983–1987, 25% in 1990–2004 (Detwiler and others 2008) and 39% in 2003–2012 (Major and others 2017).[13]
- Of the 14 fatal VFR into IMC accidents in Australia during 2011–2021, at least 9 (64%) involved pilots aged over 60 (including 5 aged over 70) and at least 5 of these pilots (36%) were over 45 when they obtained their private licence (and 9 were over 35).[14,15] This did not include the pilot of VH-XWI, who re-validated their licence at 74 after not flying for more than 30 years.

Safety analysis

In-flight break-up

The distribution and nature of the wreckage indicated that the aircraft experienced an in-flight break-up prior to colliding with terrain. Prior to the break-up, the pilot conducted a series of right turns with airspeed and altitude fluctuations before conducting a left turn and rolling almost inverted. The aircraft accelerated past its never exceed speed (V_{NE}), and it was highly likely that this initiated rudder flutter, which led to catastrophic failures of the aircraft structure and subsequent in-flight break-up.

Examination of the aircraft wreckage did not identify any pre-existing defects, however wreckage at the accident site indicated cascading failures that likely followed the rudder and vertical stabiliser separating from the aircraft. Subsequently, the horizontal stabilisers likely failed and unbalanced the aircraft's aerodynamic forces, rapidly pitching the aircraft downward. The aerodynamic overload on the main wing structure resulted in the right-wing main spar failing in a downwards direction, and the right wing separated from the aircraft.

The nature of the in-flight break-up was similar to 2 other accidents involving the same aircraft type. In all 3 cases, the aircraft significantly exceeded V_{NE} while manoeuvring. In the 2 previous cases, the aircraft was involved in aerobatic activities. However, in the accident involving VH-XWI, the manoeuvres were the result of the pilot encountering adverse weather conditions.

Flight into non-visual conditions

The information available to the pilot in the evening before, and prior to departing from Winton on the morning of the accident, indicated that for at least part of that flight the conditions would not be suitable for flight under the visual flight rules (VFR).

After departure from Winton, the pilot likely entered instrument meteorological conditions (IMC) in the vicinity of Catumnal Station. This most likely led to spatial disorientation, and the subsequent stall, loss of control, and low-level recovery, as evidenced in the recorded data. On multiple other occasions during the flight, the pilot most likely attempted to avoid reduced visual conditions, as evidenced by the significant variations in altitude, from 10,000 ft to within 500 ft of the ground, orbits, and deviations from track.

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[13] This would be due in part to the average age of general aviation pilots gradually increasing over time (see AOPA 2014). The sample of accidents in these 3 studies were slightly different, with NTSB examining general aviation accidents involving aeroplanes and helicopters, Detwiler and others examining general aviation accidents that involved pilot error, and Major and others examining private flights (Federal Aviation Regulation Part 91) involving aeroplanes.

[14] In one accident it was unknown which pilot was controlling the aircraft, with 2 pilots with private licences being aged 68 and 55 and obtaining their licences at 48 and 38 respectively.

[15] Of the 26 VFR into IMC accidents during 1991–2010, 4 pilots were aged over 60 and none were aged over 70. Nine pilots (35%) were over 45 when they obtained their private licence. This proportion was higher than for other types of fatal accidents (15%). Information about ages for these accidents was available from a previous ATSB research study General Aviation Fatal Accidents: How do they happen? (A review of general aviation accidents 1991 to 2000).

When the aircraft was south of Charters Towers, it is likely that the pilot again entered into reduced visual conditions. Recorded data indicated abnormal flight manoeuvres, commencing with an abrupt turn to the south. Analysis of the recorded data, coupled with the increased likelihood of reduced visual cues, indicated that the pilot most likely experienced spatial disorientation in the period immediately prior to the in-flight break-up.

Continuing flight into IMC with no instrument rating significantly increases the risk of spatial disorientation due to the absence of visual cues and powerful and misleading orientation sensations altering the pilot's perception of the aircraft's position, motion and attitude. This disorientation can affect any pilot, no matter what their level of experience, and has been associated with many previous accidents.

In-flight decision making

It was very likely that after the near collision with terrain near Catumnal Station, the pilot decided to return to Winton. In most cases, return to an area of known good weather is a safe and prudent option.

However, for reasons that could not be established, about 11 km into the return journey towards Winton, the pilot elected to resume course for Bowen. This may have been prompted by airborne communications on weather and flight visibility at altitude from the pilots of the other aircraft in the group, travelling to Bowen. However, the pilot of the accident flight may not have been aware that the 3 other aircraft were tracking about 30 km to the south, and may have been less affected by the weather encroaching from the north. It is also possible that, having encountered IMC and being able to recover the aircraft, the pilot may have become more confident in their ability to operate near such weather.

Although the pilot was aware of the forecast weather, and had already encountered IMC, they still continued towards Bowen. Research has shown that many aviation accidents involve a 'plan continuation bias' or 'plan continuation error'.[16] That is, pilots decide to continue with the original plan of action despite the presence of cues or information that suggests changing the course of action would be the safer option (Orasanu and others 2001, Dismukes and others 2007, Orasanu 2010). Plan continuation bias is often associated with situations involving dynamically changing risk and pilots underestimating the risk level (Orasanu and others 2001; Wiegmann and others 2002).

Research has also shown that many personal, social and organisational pressures can influence pilot decision-making, including in terms of whether to conduct or continue flights in unsuitable weather conditions (Paletz and others 2009, Michalski and Bearman 2014, Harris and others 2022). These can include observing other pilots successfully flying in the conditions and 'reluctance to admit defeat', as well as normalisation of deviance (or acceptance of risk with exposure).

In this case, a witness that spoke with the pilot the night before the accident about the forecast weather indicated that the pilot had a strong desire to remain with the group. Therefore, the pilot probably had self-imposed motivation or pressure to continue towards Bowen, despite the changing weather conditions. There was no operational reason for the pilot to continue the flight, given they had plenty of fuel to return to Winton or divert to other aerodromes away from the adverse weather.

Pilot experience and other characteristics

The pilot was 74 and relatively inexperienced, having only about 270 hours total flight hours, with much of this obtained over 30 years prior to the accident. The pilot had also had some difficulty

[16] In terms of continuing a flight to the original destination, plan-continuous bias is often known as 'mission-it is', 'get-home-itis' and 'press-on-itis'.

regaining the level of skill required to pass a flight review. However, the extent to which flight experience, skill level, age or other factors was involved in this specific accident (as opposed to motivational factors) is difficult to determine.

All pilots of VFR flights need to understand the risks of conducting flights into deteriorating weather conditions, and a range of educational resources are available to help pilots appreciate these risks and improve weather-related decision making (see Appendix B for examples). There are also some indications that pilots who are older and obtained (or re-obtained) their private licence later in life, and/or have limited flight experience, may be at increased risk and should therefore pay particular attention to the guidance material that is available.

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 VFR into IMC and in-flight break-up involving the Van's Aircraft RV-7A, VH XWI, 90 km south of Charters Towers, Queensland, on 23 April 2021.

Contributing factors

- The pilot departed for the flight from Winton to Bowen, Queensland, knowing that the weather conditions en route were unlikely to be suitable for flight under the visual flight rules (VFR).
- The pilot likely entered weather conditions not suitable for flight in visual meteorological conditions, leading to spatial disorientation and loss of aircraft control.
- The aircraft's airspeed exceeded V_{NE} (never exceed speed or maximum airframe speed), leading to rudder flutter, airframe structural failures, and subsequent in-flight break-up.

Other factors that increased risk

- Earlier in the flight, the pilot entered a degraded visual environment over Catumnal Station, most likely resulting in spatial disorientation. This resulted in a loss of control, stall, and subsequent low-level recovery.
- Although the pilot turned back to Winton after the near collision with terrain at Catumnal Station, the pilot then resumed the flight towards Bowen and degrading weather conditions.

Other findings

- There were no operational reasons for the pilot to continue the flight to Bowen, and the pilot probably had a self-imposed motivation or pressure to continue the flight.

Sources and submissions

Sources of information

The sources of information during the investigation included:

- the flight training facilities
- airborne and ground witnesses
- Van's Aircraft
- the Civil Aviation Safety Authority

- the Bureau of Meteorology
- Airservices Australia.

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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:

- a flight crew member of an accompanying aircraft
- the Civil Aviation Safety Authority
- the Bureau of Meteorology
- Airservices Australia
- Van's Aircraft Incorporated
- the National Transportation Safety Board.

Submissions were received from:

- the Civil Aviation Safety Authority
- Airservices Australia.

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

General details

Occurrence details

Date and time:	23 April 2021 0952 EST	
Occurrence category:	Accident	
Primary occurrence type:	In-flight break-up	
Location:	90 km south of Charters Towers, Queensland	
	Latitude: 20º 51.97' S	Longitude: 146º 16.62' E

Aircraft details

Manufacturer and model:	Amateur built aircraft, Van's RV-7A	
Registration:	VH-XWI	
Operator:	Owner	
Serial number:	73427	
Type of operation:	Private-Pleasure / Travel - (Private)	
Activity:	General aviation / Recreational-Sport and pleasure flying-Pleasure and personal transport	
Departure:	Winton Aerodrome	
Destination:	Bowen Aerodrome	
Persons on board:	Crew – 1	Passengers – 0
Injuries:	Crew – 1 (fatal)	
Aircraft damage:	Destroyed	

Appendices

Appendix A – Other in-flight break-ups involving Van's RV-7 aircraft

Two previous accidents involving Van's RV-7/A variants involved in in-flight break-ups demonstrated similar airframe failure modes to that of VH-XWI.

New Zealand CAA investigation 17/8080

On 1 January 2018, a Van's Aircraft RV-7, registered ZK-DVS, departed Whangarei, New Zealand, with 2 people on board. About 17 minutes after departing, the aircraft entered a high angle of bank (AoB) manoeuvre, achieving about 70° AoB. Five seconds later the AoB increased to about 130° and the aircraft began to pitch nose-down. During the resulting descent, the indicated airspeed was recorded at 244 kt, which exceeded the aircraft's never exceed speed (V_{NE}). About 30 seconds after entering the high AoB manoeuvre, witnesses observed the aircraft break up in flight and then impacted terrain.

The New Zealand Civil Aviation Authority (CAA) investigation concluded:

- The aircraft entered a high-speed descent from an unusual attitude.
- The pilot did not recover the aircraft from the unusual attitude or subsequent high-speed descent, which resulted in structural failure and in-flight breakup.
- In-flight breakup occurred as a result of rudder flutter, as the aircraft airspeed exceeded the design limitations.

Figure A1 shows the damage to the aircraft's rudder and vertical stabiliser.

Figure A1: Rudder and vertical stabiliser from ZK-DVS

Source: CAA New Zealand, annotated by the ATSB

The Civil Aviation Authority of New Zealand found that to avoid the potential of structural failure and in-flight break-up, pilots must fly within the aircraft limitations. Accidents can occur whenever the aircraft limitations and/or the pilot's own capabilities are exceeded. It is important to understand and be familiar with the aircraft characteristics, limitations, and associated risks. These risks can be minimised by preparation, awareness, and training.

Canadian TSB aviation investigation report A10O0018

On 23 January 2010, a Van's RV-7A, registered C-GNDY, was part of a formation of 3 aircraft that departed Lindsay, Ontario, Canada, on a flight to Smiths Falls. During the flight, 1 of the 3 aircraft diverted to Bancroft. The remaining aircraft continued with C-GNDY in tandem. The lead conducted a series of aerobatic manoeuvres, which C-GNDY was to film. While manoeuvring, the lead lost contact with the aircraft. The aircraft's wreckage was subsequently located in a wooded area.

The Canadian Transportation Safety Board (TSB) concluded:

- After painting, the rudder was not likely balanced, nor the aircraft reweighed. As a result, the rudder was susceptible to flutter at a lower speed than designed and the aircraft was over the maximum aerobatic gross weight during the manoeuvres.
- During the manoeuvring sequence, the speed of the aircraft reached 234 knots, exceeding the 124 knot manoeuvring speed and the 200 knot never exceed speed (Vne).
- The aircraft encountered either flutter or overstress of some rudder components. Subsequently, the vertical stabilizer and parts of the rudder separated from the empennage during flight. Consequently, the aircraft became uncontrollable resulting in the impact with terrain.

Figure A2 shows the damage to the aircraft’s rudder and vertical stabiliser.

Figure A2: Rudder and vertical stabiliser from C-GNDY

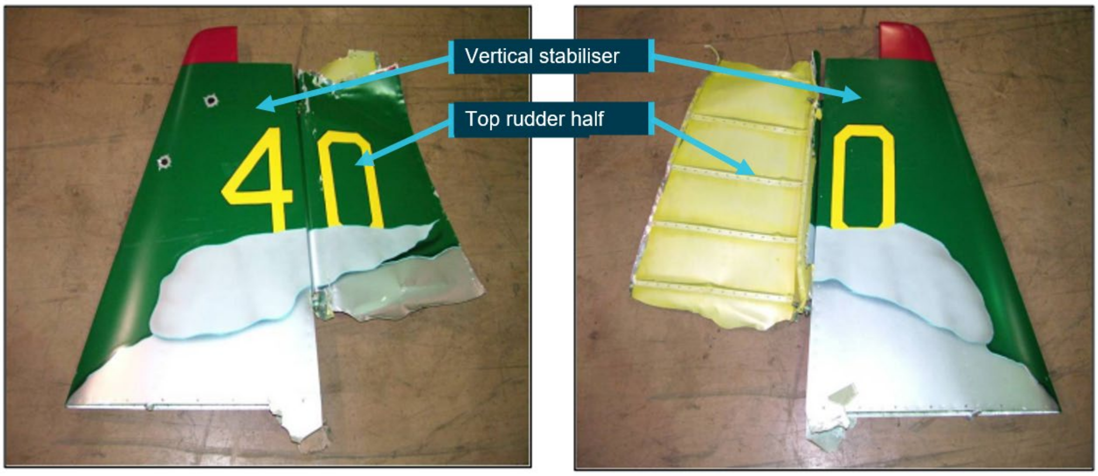

Photo 2. Left side of rudder

Photo 3. Right side of rudder

Source: TSB of Canada, annotated by the ATSB

Appendix B – VFR into IMC accidents and related resources

Recent VFR into IMC accidents in Australia

During the 11 years from January 2011 to December 2021, the ATSB investigated 14 fatal accidents (with 29 fatalities) involving VFR into IMC in VH-registered aeroplanes and helicopters in Australia:

- AO-2011-085 - VFR into IMC - South Turramurra, New South Wales, 22 July 2011, VH-CIV, Bell 206L Helicopter (private flight, 2 fatalities)
- AO-2011-100 - VFR flight into dark night conditions and loss of control involving Piper PA-28-180, VH-POJ, 31 km north of Horsham Airport, Vic., 15 August 2011 (private flight – community service, 3 fatalities)
- AO-2012-076 - Visual Flight Rules in Instrument Meteorological Conditions and controlled flight into terrain involving Cessna 182Q, VH-CWQ, 15 km north of Tooraweenah, NSW, 4 June 2012 (private flight, 1 fatality) (private flight, 1 fatality)
- AO-2012-130 - VFR flight into IMC involving de Havilland DH-84 Dragon VH-UXG, 36 km SW of Gympie, Qld, 1 October 2012 (private flight, 6 fatalities)
- AO-2013-186 - Collision with terrain involving Cessna 182, VH-KKM, 19 km WSW of Mount Hotham Airport, VIC on 23 October 2013 (private flight, 1 fatality)
- AO-2015-131 Collision with terrain involving Airbus Helicopters EC135 T1, VH-GKK, 10 km NNW Cooranbong, NSW, on 7 November 2015 (private flight, 3 fatalities)
- AO-2016-006 - Loss of control and collision with water involving Piper Aircraft Corp PA-28-235, VH-PXD, 33 km SSE of Avalon Airport, Victoria on 29 January 2016 (private flight, 4 fatalities)
- AO-2017-061 - VFR into IMC and loss of control involving Cessna 172, VH-FYN, 13 km NNW of Ballina, NSW, on 16 June 2017 (private flight, 1 fatality)
- AO-2017-069 Collision with terrain involving SOCATA TB-10 Tobago, VH-YTM, near Mount Gambier Airport, South Australia, on 28 June 2017 (private flight – community service, 3 fatalities)
- AO-2018-078 - VFR into IMC and controlled flight into terrain involving Pilatus Britten-Norman BN2A, VH-OBL, 98 km west-south-west of Hobart Airport, Tasmania, on 8 December 2018 (charter flight – ferry, 1 fatality)
- AO-2019-018 - Controlled flight into terrain involving Cessna 182, VH-DJN, 14 km south-south-west of Atherton Airport, Queensland, on 8 April 2019 (private flight, 1 fatality)
- AO-2019-052 - Controlled flight into terrain involving Mooney M20J, VH-DJU, 26 km west of Coffs Harbour Airport, New South Wales, on 20 September 2019 (private flight, 2 fatalities)
- AO-2020-004 VFR into IMC and loss of control involving Wittman Tailwind, VH-TWQ, Tooloom National Park, New South Wales, on 12 January 2020 (private flight, 2 fatalities)
- AO-2021-017 - In-flight break-up involving Vans Aircraft RV-7A, registered VH-XWI, 90 km south of Charters Towers, QLD, 23 April 2021 (private flight, 1 fatality)

Multiple additional accidents that involved VFR into IMC in 2022 are still under investigation. Additional fatal VFR into IMC accidents occurred during the same period that involved non VH-registered aircraft.

During the same period (2011–2021), there were also 3 other fatal accidents (with 6 fatalities) involving VFR flights into adverse weather conditions:

- AO-2011-160 - In-flight breakup - Cessna C210, VH-WBZ, 100 km NNW Roma, Qld, 7 December 2011 (private flight, 1 fatality)
- AO-2013-063 - Loss of control and collision with water involving Cessna 210 VH-EFB, 160 km south-west of Darwin, NT, 1 April 2013 (private flight, 3 fatalities)

- AO-2017-102 - In-flight breakup involving Cessna 210, VH-HWY, 22 km E of Darwin Airport, Northern Territory, on 23 October 2017 (charter flight – freight, 2 fatalities).

In addition, during the same period, there have been 10 fatal accidents involving VFR flights in dark night conditions, which carry the same risks as VFR into IMC. Some examples of these include:

- AO-2011-102 - VFR flight into dark night involving Aérospatiale, AS355F2 (Twin Squirrel) helicopter, VH-NTV, 145 km north of Marree, SA on 18 August 2011 (charter flight – passenger, 3 fatalities)
- AO-2013-057 - VFR flight into dark night conditions and loss of control involving Cessna T210N, VH-MEQ, 2 km north-west of Roma Airport, Qld on 25 March 2013 (private flight, 2 fatalities)
- AO-2019-050 - Loss of control and collision with water involving Bell UH-1H, VH-UVC, 5 km south-west of Anna Bay, New South Wales, on 6 September 2019 (private flight, 5 fatalities).

VFR into IMC educational resources

A discussion of some VFR into IMC accidents and advice to pilots regarding how to the risk of being involved in such accidents is provided in the ATSB Avoidable Accidents publication *Accidents involving Visual Flight Rules pilots in Instrument Meteorological Conditions* and related communication Don't Push It - DON'T GO.

Other relevant information is provided in the ATSB reports:

- ATSB Aviation Research and Analysis Report B20070063, *An overview of spatial disorientation as a factor in aviation accidents and incidents*
- ATSB Aviation Research Investigation B2005/0127, *General Aviation Pilot Behaviours in the Face of Adverse Weather*.

A cue-based training system, called *Weatherwise,* was made available to pilots by the Civil Aviation Safety Authority (CASA). Additionally, CASA has produced:

- *Weather to fly, an* education program which focused on topics such as the importance of pre-flight preparation, making decisions early, and talking to ATC
- '178 seconds to live', a campaign on highlighting the dangers of VFR flight into IMC.