Australian Government

Australian Transport Safety Bureau

In-flight breakup involving Cessna 210, VH-HWY

22 km east of Darwin Airport, Northern Territory | 23 October 2017

Investigation

ATSB Transport Safety Report

Aviation Occurrence Investigation

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Addendum

Page	Change	Date

Safety summary

What happened

On 23 October 2017, a charter flight operated by Air Frontier using a Cessna C210L aircraft, registered VH-HWY (HWY), was tasked to transport a coffin with a deceased person from Darwin Airport to Elcho Island, Northern Territory. There were two pilots on board – the supervising pilot in command in the right seat and the pilot in command under supervision on the left. After departing Darwin at 1307 CST, the left seat pilot requested air traffic control (ATC) for a 5 NM diversion left or right of track to avoid adverse weather. The aircraft was cleared to divert right of track, and to climb to 9,500 ft. After 4 minutes, ATC asked whether further track diversions were required; first 10 NM, then 20 NM, which were accepted.

VH-HWY in Darwin

Source: Air Frontier

At 1332, the aircraft entered an uncontrolled descent before it collided with terrain. The pilots were fatally injured and the aircraft destroyed.

What the ATSB found

Shortly after VH-HWY diverted to avoid adverse weather, the aircraft entered an area of strong convective activity and rapidly developing precipitating cells, which resulted in it experiencing severe turbulence and possibly reduced visibility for the pilots. While flying in these conditions, a combination of airspeed, turbulence and control inputs probably led to excessive loading on the aircraft's wings, which separated from the fuselage in-flight before it collided with terrain.

The ATSB found that the pilots had no experience flying in the 'build-up' to the wet season in the Darwin area. Although pairing a supervisory pilot with a pilot new to the company was likely to reduce risk in other instances, in this case it did not adequately address the weather-related risks because neither pilot had experience flying in the region during the wet season.

Safety message

Recognising and avoiding tropical weather conditions that present significant hazards to flight can be particularly challenging for pilots without operational experience in the tropics. Knowing how to reduce the risk, including the appropriate distance to keep away from thunderstorms and cumulus clouds predominantly comes through exposure to those conditions. In many cases, deviations of 10 NM to avoid phenomena like towering cumulus clouds may not be sufficient.

Pilots are encouraged to use all available resources to avoid adverse weather, including forecasts and requesting ATC assistance. Awareness of the weather avoidance actions of other pilots in the area can also be useful. There is considerable value in ongoing education and guidance for pilots in recognising and responding to deteriorating weather conditions during flight. This can include additional (cue-based) training, guidance specific to the risks in the region, education initiatives from industry bodies, and learning from the knowledge and experience of peers.

Smaller operators employing pilots with limited exposure to local conditions, such as in the tropics, can better manage related risks by pairing new pilots with ones experienced in those conditions.

Contents

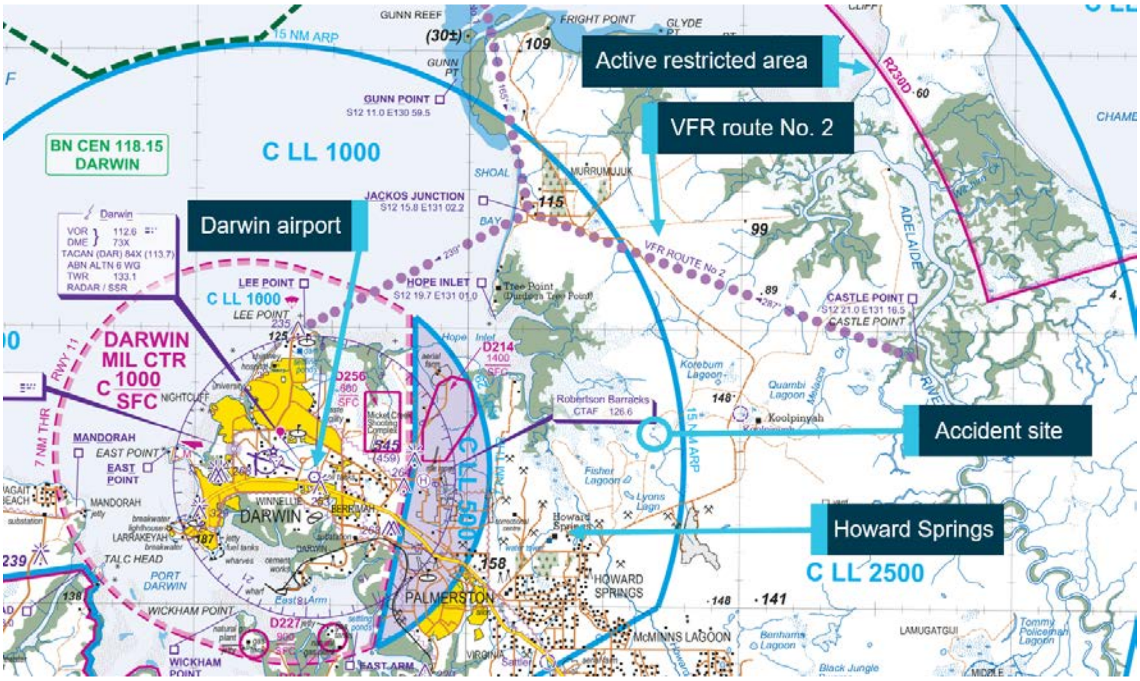
The occurrence

On 23 October 2017, a charter flight operated by Air Frontier using a Cessna C210L aircraft, registered VH-HWY (HWY), was tasked to transport a coffin with a deceased person from Darwin Airport to Elcho Island, Northern Territory. There were two pilots on board: the pilot in command under supervision (ICUS)[1] in the left seat (the 'left seat pilot'), and the supervisory pilot in the right seat (the 'right seat pilot'), the nominated pilot in command (PIC). The flight was operating under visual flight rules (VFR),[2] and the pilots submitted a flight plan that documented a planned cruising altitude of 7,500 ft to Elcho Island. They also checked the weather and NOTAMs,[3] and completed their flight planning at about 1045 Central Standard Time.[4]

At about 1100, a funeral services staff member arrived at Air Frontier's hangars at the airport with the coffin. The two pilots, the company's training manager and funeral services staff loaded the coffin into the aircraft's cabin and secured it. At about 1115, HWY taxied out to the engine run-up bay. During the engine run-up procedure, the pilots identified a drop in the magnetos. They returned to the hangars where the chief engineer identified a fouled spark plug. He resolved the issue by running the engine at a high RPM for a short period.

Shortly after, HWY again taxied out for departure. The pilots requested the VFR route 2 to Elcho Island (Figure 1). At 1304, the left seat pilot called 'ready' to air traffic control (ATC)[5], and was cleared for take-off on runway 29 at 1307.

Figure 1: Darwin Airport and pertinent features on the visual terminal chart



Source: Airservices, annotated by ATSB

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1 In command under supervision: according to CASA, 'a person flies an aircraft as pilot acting in command under supervision if, during flight time in the aircraft, the person performs the duties and functions of the pilot in command while under the supervision of the pilot in command approved for the purpose by the operator of the aircraft'.

2 Visual flight rules (VFR): a set of regulations that permit a pilot to operate an aircraft only in weather conditions generally clear enough to allow the pilot to see where the aircraft is going.

3 A Notice to Airmen (NOTAM): alerts pilots of potential hazards along a flight route or a location that could affect the safety of flight.

4 Central Standard Time (CST): Coordinated Universal Time (UTC) + 9.5 hours.

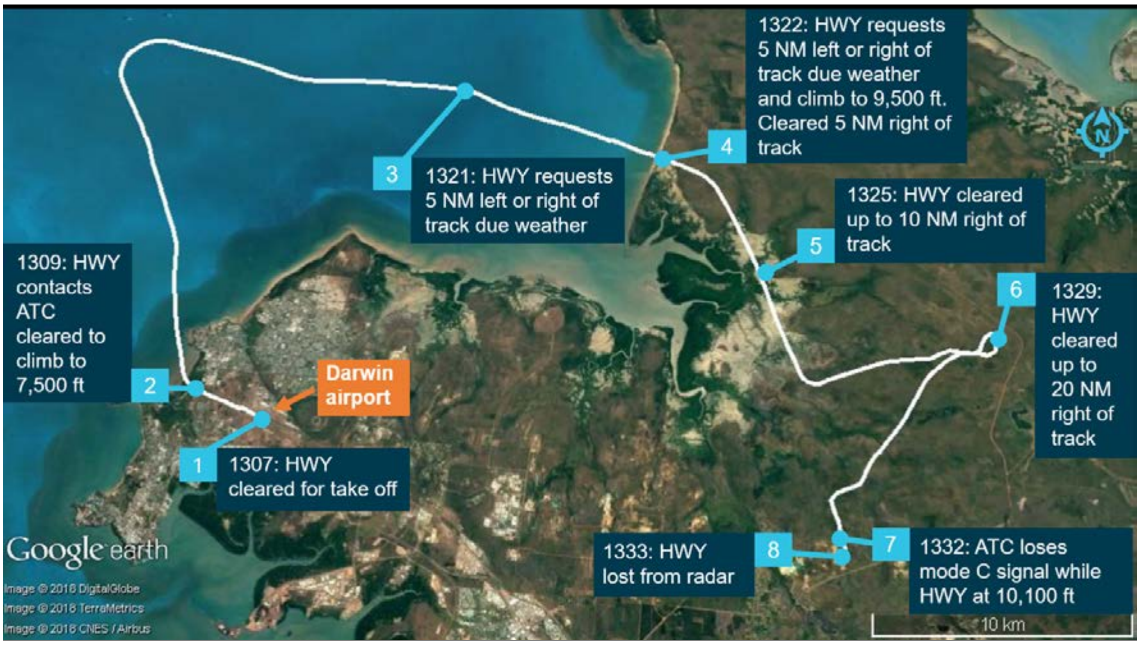
5 The Australian Defence Force provides the air traffic control services associated with Darwin Airport.

As the aircraft climbed through 700 ft, the left seat pilot contacted ATC and was cleared to climb to 7,500 ft and turn onto a heading of 320° (items 1 and 2 in Figure 2). About 5 minutes later, the controller cleared the aircraft to turn right onto a heading of 100° (item 3 in Figure 2).

At 1322, as the aircraft tracked east and climbed through 6,100 ft, the pilot requested diverting 5 NM left or right of track due to weather (item 4 in Figure 2), and to climb to 9,500 ft. Air traffic control advised that diverting left of track was unavailable due to the active restricted airspace nearby (Figure 1), and cleared a diversion up to 5 NM right of track, and a climb to 9,500 ft. At 1325, the controller asked the pilot to advise if further clearance was required. The pilot responded, ‘affirm, request up to 10 miles right of track’.

Soon after, the aircraft turned north-east and continued to climb for 4 minutes to about 10,000 ft. At 1329, the controller recalled observing that the aircraft abruptly turned to the south-west. The controller asked the pilot if they required alternate tracking (item 8 on Figure 2). The pilot replied ‘affirm’ and the controller cleared the aircraft to deviate up to 20 NM right of track. The aircraft continued to track south-west.

Figure 2: Aircraft track with pertinent broadcasts between HWY and ATC



Source: RAAF radar data overlaid on Google Earth, annotated by ATSB

Between 1329 and 1331, ATC radar recorded the aircraft descending and climbing between 9,600 and 10,100 ft (see *Recorded data* section). At 1332:20, its altitude information (radar mode ‘C’) showed the aircraft descending before it disappeared from the radar display (item 8 in Figure 2). The controllers quickly assessed its disappearance as abnormal.

About 10 seconds later, ATC audio recorded three short transmissions, possibly from separate ‘push-to-talk’ activations from the aircraft’s radio. At 1332:45, the controllers recalled that the aircraft’s altitude (mode C) briefly reappeared (local radar data indicates the aircraft was at approximately 5,000 ft). The controllers reported that the aircraft disappeared from the radar screen 15 seconds later. Over the next 10 minutes, they unsuccessfully attempted to call the pilot. They then declared a ‘distress phase’[6] and requested an aircraft in the area to assist with looking for the missing aircraft.

Witnesses near Howard Springs (Figure 1) reported sighting the aircraft (HWY) descending rapidly in a relatively flat attitude, possibly rotating, with a portion of each wing missing. One of the

6 Distress phase: A situation wherein there is reasonable certainty that an aircraft and its occupants are threatened by grave and imminent danger or require immediate assistance

witnesses that saw the aircraft impact terrain called emergency services, and then attended the scene.

Emergency services started arriving within 10 minutes of the impact. The main fuselage was located less than 1 NM from the aircraft's last recorded radar position. Both of its wings were found about 700 m south-east of the fuselage.

The pilots were fatally injured in the accident and the aircraft was destroyed.

Context

Pilot information

Right seat pilot

The right seat pilot was the pilot in command of the aircraft and supervising the left seat pilot. He held a commercial pilot licence (aeroplane) issued in March 2016 and a class 1 medical certificate valid until December 2017. At the time of the accident, he had a total of 705.9 hours of aeronautical experience, including about 400 hours in C210 aircraft. He was appropriately endorsed to operate VH-HWY as pilot in command, and held an instrument rating for multi-engine aircraft. In the 7 months prior to the accident, he had not logged any instrument flight time.

After starting with Air Frontier in April 2017, the pilot had completed 415.8 hours of flying. He was based at Maningrida, NT from June 2017 onwards before being transferred to Elcho Island.

On the morning of 23 October before the accident flight, the pilot completed a proficiency check with the training manager to act as a supervisory pilot in single engine aircraft. The 0.9-hour check flight in the circuit at Darwin Airport included proficiency in aircraft handling, handover/takeover procedures and a discussion of aspects such as the potential for parallax error when viewing aircraft instruments, handling high workloads, supervisory pilot responsibilities and wet season operations. The pilot's training record indicated covering VFR procedures, including cloud separation, maintaining visual meteorological conditions (VMC), cockpit procedures, and airmanship.

Left seat pilot

The left seat pilot was the pilot in command under supervision (ICUS). He held a commercial pilot licence (aeroplane) issued in September 2012 and a class 1 medical certificate valid until May 2018 (with a restriction for distance vision correction). At the time of the accident, the pilot had a total of 381.4 hours of aeronautical experience, including 12.7 hours in the C210 aircraft. He was appropriately endorsed to operate VH-HWY as pilot in command, and held an instrument rating for multi-engine aircraft obtained in 2012. The left seat pilot underwent an instrument proficiency check in May 2017. He had a total of 34.4 instrument hours in flight and 35 hours in a simulator.

The pilot's first flight in a C210 aircraft was on 15 September 2017. He then logged a total of 5.4 hours dual time.

After moving to Darwin in early October 2017, the pilot conducted a number of observation flights. He started flying as pilot ICUS on October 14 and completed three flights with a total of 7.3 hours. He had not signed Air Frontier's operations manual or completed what they called a Professional Pilot Development Course agreement in accordance with its procedures for pilots ICUS.

Fatigue

The ATSB obtained available evidence to assess the likelihood of the pilots experiencing fatigue. This included factors that affect the ability to maintain adequate alertness, rostering, other aspects that affect sleep opportunity and sleep obtained. There was insufficient evidence to ascertain whether either pilot was likely experiencing a level of fatigue known to affect performance.

Medical and pathological information

A prescription medication belonging to the left seat pilot was found in the wreckage. The pilot's toxicology report confirmed the presence of this medication. The medication was not recorded in the pilot's medical file with Civil Aviation Safety Authority (CASA).

The ATSB followed up available information sources, including the pilot's DAME, but could not definitively determine why the medication was not recorded in the pilot's medical files. Civil Aviation Safety Regulations (1998) Part 67 describe the requirements for aviation medicals. One of the criteria for a class 1 medical certificate prohibits the use of 'any over-the-counter or prescribed medication or drug… that causes the person to experience any side effects likely to affect the person to an extent that is safety-relevant'.

Further, medical certificate applicants are required to answer 'every question asked by the examiner that the examiner considers necessary to help…CASA decide whether the applicant meets the relevant medical standard'. They are obliged to notify CASA of changes in medical conditions that impair their ability to 'do an act authorised by the license'.

The following extracts from CASA-developed brochures are particularly relevant to pilot medicals.

> DAMEs and pilots together should foster a culture where it is likely that pilots will feel comfortable disclosing medical problems, even if they may impact on their ability to maintain an aviation medical.
>
> Your DAME…will expect you to answer both written and verbal questions, honestly and fully...

Under the clinical practice guidelines for designated aviation medical examiners (DAMEs), certain risk assessment protocols allowed them to take into account the pilot's need for medication use. That assessment involved reviewing past and current symptoms of certain conditions, an applicant's compliance with medications and treatments, and any relevant side-effects.

A CASA brochure states 'only 0.29% of all initial and renewal medical certificates were refused by CASA during 2016-2017'. In the case of prescription medication, once it is declared the safety-relevance of the condition as well as medication can be considered.

Aircraft information

General overview

The Cessna Aircraft Company 210L is a six-seat, high cantilever wing, single-engine aircraft equipped with retractable tricycle landing gear and was designed for general utility purposes.

The accident aircraft, HWY, was manufactured in the United States (US) in 1974. It was first registered in Australia in 1988, with a total time in service of 1,456.1 hours. The aircraft was to operate in the charter category and maintained under a CASA-authorised system of maintenance.

The aircraft was powered by a Teledyne Continental IO-550P engine. The wing construction consisted of a forward spar, main spar, conventional formed sheet-metal ribs and aluminium skin. The inboard section of each wing, forward of the main spar, was sealed to form an integral fuel tank. The fuel system is essentially gravity-flow from the tank outlets to the selector valve, with pump augmentation from the valve to the engine.

The US Federal Aviation Administration's (FAA) Airworthiness Directive (AD) 2012-10-04 *Wing main spar lower cap inspection* applied to HWY. This AD required an inspection of the left and right wing lower main spar caps for cracks. An inspection of HWY conducted in accordance with the AD in June 2012 identified no defects. The aircraft did not fly between November 2014 and March 2016 (with a total time in service of 5,847 hours) and during this time, the wing main spar carry-through was replaced with a serviceable item due to corrosion. Since March 2017, HWY was operated and maintained by Air Frontier under an approved system of maintenance.

A review of the aircraft maintenance records did not identify any evidence of accident-related damage to the aircraft, including its wings. In addition, there was no evidence of overdue scheduled maintenance, including ADs.

On 26 September 2017, following a periodic inspection of the aircraft, a new maintenance release was issued (current at the time of the accident). A scheduled, 50-hourly inspection was conducted on the morning of the accident (6,499.2 airframe hours). There were no reported concerns with aircraft serviceability when it departed Darwin Airport before the accident flight nor did the pilots report any aircraft-related issues to ATC during the flight.

Aircraft load factors

The four forces acting on an aircraft in flight are lift, weight, thrust and drag. The ratio of lift to weight is the load factor (n). In straight and level flight, lift and weight are the same, so n=1 and the pilot experiences a force of 1 g. Lift can be calculated using the following equation.

$L = C_L \frac{1}{2} \rho V^2 S$

{that is, lift (L) is equal to the coefficient of lift (C_L) x half the density (ρ) x velocity squared x the wing surface area (S)}.

For a given wing design, lift is proportional to the angle of the wing relative to airflow (angle of attack) and proportional to the square of wing velocity (airspeed). The pilot increases or decreases lift either by changing the angle of attack or the airspeed. As the aircraft's wings produce lift, its structural limit is the strength of the wings. Structural limits are based on the load factor, which is affected by any one or combination of the following:

- full or abrupt control movement above V_A
- banking or turning – for example, a 60-degree turn is 2 g[7]
- windshear, turbulence or gusts – severe turbulence is defined as variations in vertical acceleration greater than 1 g
- disorientation, unusual attitude and/or recovery can result in exceeding load factor limits
- spiral dive and/or recovery.

Before an aircraft is certified, its structures must meet structural design standards. Section 2 of the Pilot Operating Handbook for HWY specified load limits with the flaps up as +3.8 g and -1.52 g, and flaps down as +2.0 g. The handbook stated that the 'design load factors are 150 per cent of the above, and in all cases the structure meets or exceeds design loads'. Thus, the ultimate load for the aircraft was 5.7 g, and US Federal Aviation Regulation 23 (which governed its design) stipulated that the structure must be able to support ultimate loads without failure for at least 3 seconds.[8]

The operating flight strength presented in a V-n diagram (Figure 3) shows the flight envelope. The manoeuvring speed (V_A) for HWY was 118 kt (at maximum take-off weight)[9], maximum structural cruise speed (V_{NO}) was 165 kt and never exceed speed (V_{NE}) was 196 kt. An aircraft must be operated within the envelope[10] to prevent structural damage, or stall.[11]

An envelope exists for gust loads to outline the aircraft's limitations to withstand a 30 ft per second gust load. Moderate turbulence, for example, is defined as 20-35 ft per second gusts and severe is 36-49 ft per second.

Exceeding the flight load limit below V_A results in a stall, whereas exceeding the flight load limit at a speed above V_A has the potential to damage the aircraft's structure.

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

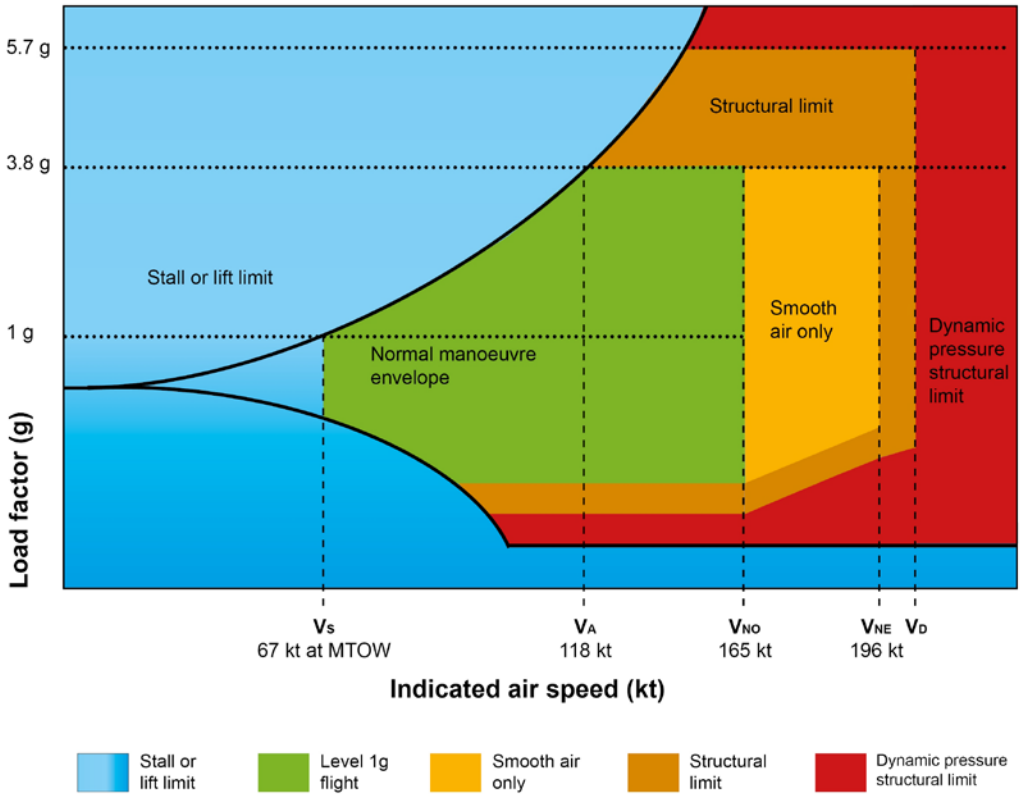
8 Ultimate load: the limit load multiplied by prescribed factors of safety. The aircraft structure must be able to support the ultimate load without failure for at least three seconds.

9 Note that the manoeuvring speed decreases with aircraft weight.

10 Flight envelope: the range of combinations of speed, altitude, angle of attack etc., within which a flying object is aerodynamically stable.

11 Aerodynamic stall: occurs when airflow separates from the wing's upper surface and becomes turbulent. A stall occurs at high angles of attack, typically 16˚ to 18˚, and results in reduced lift.

Figure 3: Representation of operating flight strength (V-n) diagram



Source: ATSB

Operational information

Planned flight path

The flight plan documented a planned altitude of 7,500 ft and a magnetic track of 082° direct to Elcho Island. The recorded fuel upload was 336 litres, with a planned fuel burn of 55 litres over the estimated flight time of 1 hour 52 minutes. The planned departure time was 1130.

On departure, the pilot of HWY amended the plan to track via the published VFR route 2. Airservices Australia En Route Supplement Australia – *Flight plan requirements*, stated 'VFR aircraft departing and arriving [Darwin] DN…are required to plan via a published DN VFR Route,' VFR route 2 was the published route in the direction of Elcho Island.

Weight and balance

The aircraft was loaded within its weight and centre of gravity limitations for the flight. The recorded weight of the coffin was 95 kg. The estimated aircraft weight at take-off was 1,624 kg, and at its last position was 1,603 kg. There was no evidence to indicate any weight and balance issues, including a possible load shift in flight.

Meteorological information

Weather in the 'build-up' to the wet season

Weather conditions in Darwin and surrounding areas are typical of the Australian tropics, and in the wet season (October to April), the prevailing conditions are more hazardous to flying. Among the Bureau of Meteorology's (BoM) weather advice pamphlets for pilots, *Flying the Tropics* (2012) is particularly relevant. It describes the wet season as ‘a time of unstable atmospheric conditions due to high humidity and temperatures’. The build-up to the monsoonal part of the wet season (October and November) is typified by a ‘gradual increase of the convective cloud and humidity’.

Thunderstorms and towering cumulus cells

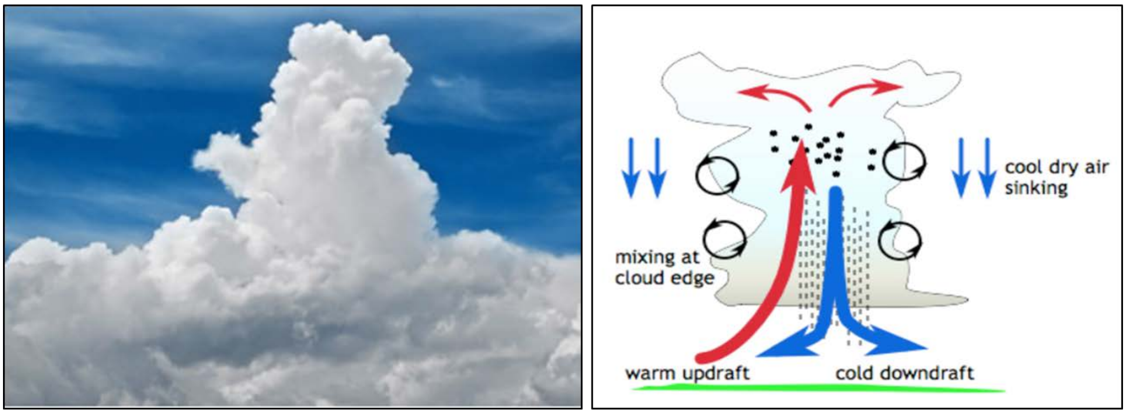
According to BoM, weather conditions in Darwin during the build-up can include thunderstorms with clouds up to 45,000 ft that usually develop in the afternoons, and cells that develop rapidly. As a thunderstorm is growing, updrafts in the range of 15 to 30kts are common with potentially higher speeds. The BoM *Flying the Tropics* guide (2012) includes the following about thunderstorms in the area.

> The peak frequency of thunderstorms is in the vicinity of Darwin with over eighty thunder-days per year…Thunderstorms in the transition periods tend to be more isolated than during the wet season. These frequently have high bases, flying below which may result in strong downdrafts being encountered…These updrafts can exist alongside downdrafts of similar strength…resulting in potential for severe turbulence and loss of aircraft control if flying into such conditions.

With regard to speed of development, BoM indicated that a cell could develop from ‘not much’ to a towering cumulus with a cloud top of 15,000 ft within 15-20 minutes. In the Howard Springs area (near the accident site), cells develop at least once a fortnight in the wet season.

Towering cumulus clouds are more prevalent in the wet season (Figure 4, left). They differ from cumulonimbus clouds (CBs) in that they are not accompanied by lightning and thunder. However, they have powerful updrafts, downdrafts and lateral air movements (Figure 4, right).

Figure 4: A towering cumulus (left) and the typical cycle of up- and down-drafts (right)



Source: namesofclouds.com and kiwi.atmos.colostate.edu

Risks of turbulence

The risks to flying posed during build-up conditions, and thunderstorms lie in the turbulence produced. The BoM’s *Hazardous Weather Phenomena: Turbulence* guide (2014) describes convective turbulence and its potential impact on flight safety. Although the guide references cumulonimbus clouds, the following information about turbulence is equally relevant to towering cumulus clouds.

> Convective turbulence in association with cloud is initiated by surface heating and/or low-level convergence…The convection is enhanced by the release of latent heat during the process of condensation and subsequent warming and destabilisation of the cloud environs. All cumulonimbus clouds should be considered to be turbulent. Hence within an aviation weather forecast the mention of cumulonimbus flags severe turbulence…The most likely turbulent areas in cumulonimbus clouds are:
>
> - the updraft/downdraft boundaries within the cloud
> - the leading edge of the gust front
> - above the cloud tops
> - in any funnel clouds extending from the cloud base...

- in the upper parts of the updraft within the cloud

Updrafts are generally stronger than downdrafts, and tend to be strongest in the middle and upper parts of the cumulonimbus.

In conditions such as towering cumulus clouds or thunderstorms, the speed of vertical updrafts has the potential to cause severe turbulence, which BoM defined as 'large abrupt changes in attitude and/or altitude' with a 'momentary loss of control'.

Forecast weather

The area forecast for Darwin valid at the time of the accident flight, included winds of 10 kt from the south-east at 3,000 ft above mean sea level (AMSL) and from the south at 10,000 ft AMSL. Isolated cumulonimbus and towering cumulus clouds were forecast, with tops at 45,000 and 25,000 ft AMSL, respectively. The forecast included broken[12] stratus clouds in thunderstorms and showers of rain and scattered cumulus/stratocumulus. Thunderstorms with rain and visibility reducing to 1 km, and showers with visibility reducing to 2 km were forecast, along with smoke and 'dust devils' over land.

The aerodrome forecast (TAF) for Darwin issued at 0843 and valid from 0930 to 1530 included south-easterly wind at 5 kt, visibility greater than 10 km and few cloud at 3,000 ft. The temperature at 1230 was forecast to be 31°C and the QNH[13] 1009 hPa.

Weather encountered by the aircraft

On the day of the accident, the environment was typical of the start of the Northern Territory wet season known as the 'build-up' period.

A thunderstorm to the north of Darwin, combined with the north-west sea breeze, triggered a convective cell to rapidly develop between 1300 and 1330, about 19 km to the north-east, that is, between Howard Springs and Koolpinyah (Figure 1). The top of the cell was 6,000 to 7,000 ft at 1300, 9,000 ft at 1320, 13,000 to 14,000 ft at 1330, and about 14,000 ft at 1340. The developing cumulus clouds likely produced strong updrafts or downdrafts.

Figure 5 shows the aircraft's track superimposed on weather radar (showing precipitation) and the satellite images (showing cloud). These images indicate the aircraft tracking in close proximity to a precipitating cell and a rapidly developing towering cumulus cloud.

At about the same time (from 1300 to 1330), ATC data shows that other aircraft to the east of Darwin Airport deviated around the weather. An inbound aircraft from the east that deviated south to avoid a large cell reported it having a cloud top of 14,000 ft. Shortly after, another aircraft reported a large, black cell in the area.

Witnesses saw a large cumulus cell form over the Howard Springs area before the accident, and described it as a regular occurrence in the build-up season. Some recalled the cloud went 'very black' at the time of the accident.

The pilots of a number of aircraft arriving into Darwin at about 1300 recalled that the adverse weather in the region was 'growing'. One pilot reported that the cell over Howard Springs had an anvil shape that was flattening out. This pilot also indicated that he may have had reservations flying at 9,500 ft, and would have requested a deviation of at least 20 NM south of their planned track. Another pilot inbound to Darwin on an IFR flight undertook a deviation around the storm.

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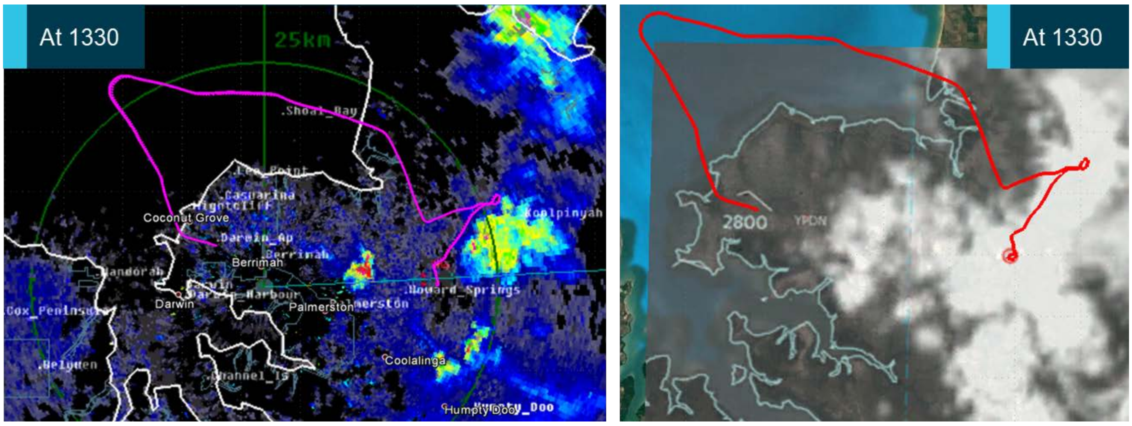
[12] Cloud cover: in aviation, cloud cover is reported using words that denote the extent of the cover – 'few' indicates that up to a quarter of the sky is covered, 'scattered' indicates that cloud is covering between a quarter and a half of the sky, 'broken' indicates that more than half to almost all the sky is covered, and 'overcast' indicates that all the sky is covered.

[13] QNH: the altimeter barometric pressure subscale setting used to indicate the height above mean seal level.

Figure 5: Aircraft track superimposed on weather radar (left) and satellite image (right)



Source: Bureau of Meteorology, annotated by ATSB

Air traffic control

The Royal Australian Air Force (RAAF) provides air traffic control (ATC) services for Darwin. The ATSB interviewed a number of controllers on duty at the time of the occurrence. Audio recordings and other relevant information were also obtained.

Pilot requests for weather deviations

Audio data confirms that one of the pilots requested ‘five miles left and right of track due weather’ and ATC cleared HWY to ‘deviate up to five miles right of track only due Restricted airspace’. The Restricted airspace was active due to a military exercise but none of the aircraft involved in it were airborne at the time. Therefore, had the pilot of HWY indicated a need to deviate left of track only (by using the phraseology ‘require’), ATC indicated that it would have facilitated this request.

However, it could not be determined how the pilots perceived the weather to their left. Further, weather radar (Figure 5) also indicated significant cloud and precipitation to the left. The approach controller reported that a deviation right of track allowed HWY to deviate as far south as required, and at their cleared altitude of 9,500 ft, it would remain above incoming traffic. Additionally, the controller said that if the pilots wanted to return to Darwin, they would be able to track them via Lee Point without conflict with other aircraft.

All the RAAF controllers interviewed indicated that if HWY had requested a deviation left of track, this would have been granted. Some Darwin-based pilots said it was not well-known pilots could ‘require’ a specific deviation. During visits to the ATC facility that were sometimes arranged for new pilots in the region, the controllers encouraged pilots to be assertive with any requirements, especially as the pilots always have better visibility of the weather and the track deviations they need than ATC.

Weather avoidance responsibilities

The Airservices Australia Aeronautical Information Publication (AIP) Australia describes the respective responsibilities of pilots, meteorologist and air traffic services (ATS) to avoid hazardous weather as follows.

> Pilots, meteorologists and ATS cooperate to ensure accurate information is promulgated to assist pilots in the avoidance of hazardous weather…and phenomena associated with thunderstorms.
>
> The pilot must advise ATS promptly of any hazardous weather encountered, or observed either visually or by radar…Hazardous weather includes, in particular, thunderstorms, severe turbulence, hail, icing, line squalls, and volcanic ash cloud…Pilots are responsible for the safety of their own aircraft using advices and clearances passed by ATS and information obtained from their own visual or airborne radar observations.

In this case, there were no specific pilot reports provided by those in- or out-bound from Darwin.

Limitations of weather radar

The AIP states that ATS is responsible for the following.

> …distributing reports of hazardous meteorological conditions to pilots as a part of the Flight Information Service. ATS also makes visual and limited radar weather observations for the information of meteorologists and pilots, and is responsible for relaying pilot weather reports to the BoM. At some locations, ATS may supplement weather advice with weather radar data.

The RAAF controller had only the BoM weather radar (set to 128 km range) displayed on a console screen. In addition to any difficulties monitoring these screens, an accurate understanding of the weather using the radar image is limited as only precipitation is displayed (not cloud) and also due to time delays.

A Federal Aviation Administration (2005) guide for weather planning and decision making, advises pilots to keep abreast of changing weather conditions by noting if other GA aircraft in the area are requesting diversions, and asking ATC for information. The guide also indicates that ATC's ability to provide this information has the following limitations.

> When you ask ATC for weather information, though, you need to be aware that radar – the controller's primary tool – has limitations, and that operational considerations (e.g., use of settings that reduce the magnitude of precipitation returns) will affect what the controller can see on radar.
>
> Radar "sees" only those entities that reflect energy. These include precipitation, the density of which is indicated by the strength of the return. Radar does not detect or "see" turbulence, but its existence may sometimes be implied by the intensity of a precipitation return: the stronger the return, the more likely the presence of turbulence.

In this case, several other aircraft to the east of Darwin requested track diversions due to weather.

Accident site information and wreckage examination

Wreckage location

The fuselage was located in scrub near Howard Springs, about 22 km east of Darwin Airport and about 700 m north of Gunn Point Road. The wings were located about 24 m apart from each other, and about 740 m south-southeast of the fuselage, consistent with an in-flight breakup (Figure 6). There was no evidence of fire. Various aircraft components were located between the fuselage and an area about 70 m beyond the wings, over 810 m in total.

On-site examination

On-site examination of the severely impact-damaged fuselage (Figure 7), engine and propeller identified no pre-existing faults or anomalies that could have contributed to the accident. Examination of the wreckage indicated that the aircraft impacted terrain from a vertical descent, right side slightly down, in an almost level attitude.

A number of aircraft components were retained for further examination and testing. The propeller did not exhibit any evidence of rotation at impact, consistent with fuel exhaustion resulting from the integral wing-fuel tanks rupturing with the separation of the wings.

The evidence indicated that both pilots were secured in their seats prior to impact. Notwithstanding the severe disruption to the airframe, examination identified that both pilot seats were about mid-travel with one locator pin on each seat still engaged in the seat rails.

Figure 6: The accident site and location of fuselage and wings

Source: Google Earth, modified by ATSB

Figure 7: The fuselage, left and right wings

Source: Northern Territory Police and ATSB, modified by ATSB

Examination of the aircraft wings

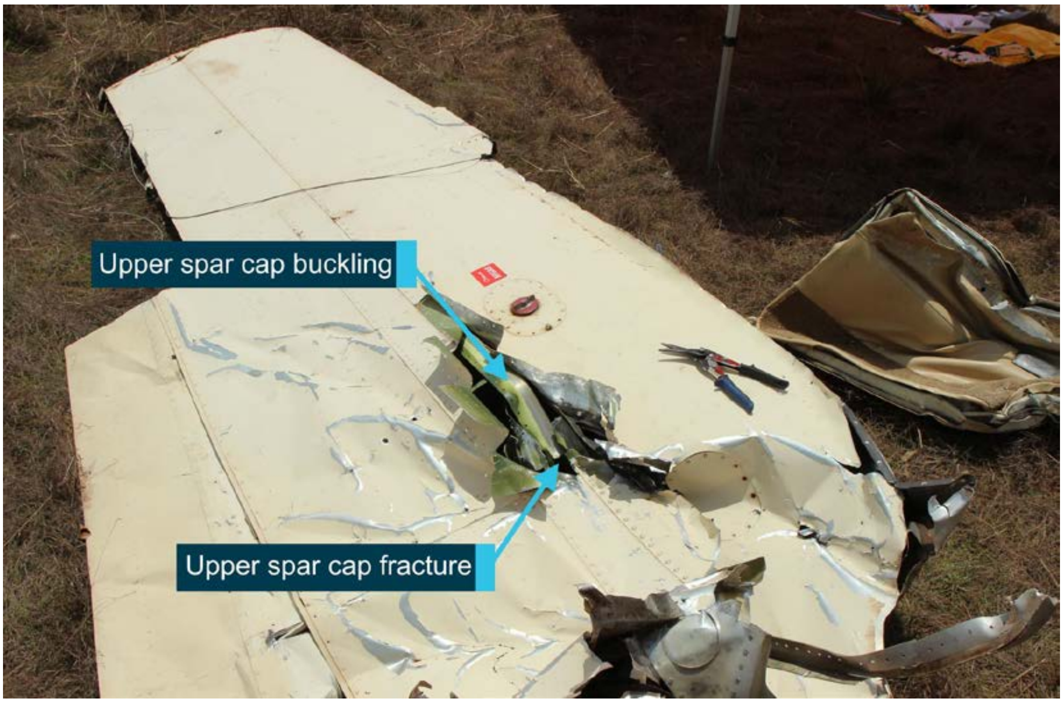
Both wings had separated between 0.5 and 1.5 m outboard from the wing-to-fuselage attachment. Morphology of all fractures within the wing spars indicated that they failed due to overstress, and exhibited bending deformation consistent with forces acting upwards and rearwards on the wings. Examination of the wings showed no evidence of pre-existing defects.

Figure 8: Fractured main spar caps from the right wing

Source: ATSB

The lower spar cap shows significant local deformation in an upwards and rearwards direction. The upper main spar caps had fractured at two points along their length. The left upper spar cap failed at the location shown in Figure 8. Further inboard, the same spar cap had sheared from the webbing that secured it to the rest of the wing spar. The deformation observed was consistent with buckling due to compressive loads, as the wings were bent upwards with forces in excess of the ultimate positive flight load (Figure 9). In short, the left upper main spar cap deformed enough to damage the wing skin, consistent with buckling due to compressive loads.

Figure 9: The left upper main spar cap deformation due to compressive loads



Source: ATSB

Survivability

Survival in an aircraft accident depends on various aspects, including impact forces imparted on the occupants being within human tolerance, occupant/seat restraints and liveable space inside the aircraft. The impact forces alone in this accident meant that it was not survivable.

Recorded information

Track data

The aircraft was not equipped with a flight data recorder or cockpit voice recorder, nor was it required to be. The aircraft's GPS unit did not record any data. All recorded data to determine the aircraft's track is based on ATC radar data (local and system) and OzRunways data. Analysis of this data indicated the following.

- There were no apparent aircraft handling problems, up to the recorded point at 1332:28.
- Between 1332:20 and 1332:28, there was a loss in height of 300 ft, and from this point, the speed of the vertical descent increased rapidly.
- The aircraft impacted the ground approximately 30-40 s after it was at about 10,000 ft.
- After the aircraft was below 8,000 ft, its average vertical speed exceeded 10,000 ft/min, with periods above 15,000 ft/min and up to 32,000 ft/min.
- There were no on-board recording devices to accurately determine the aircraft's actual airspeed. While the forecast winds can be used to estimate airspeed, the actual airspeed cannot be accurately determined given the likelihood of wind shear and turbulence in the air mass.

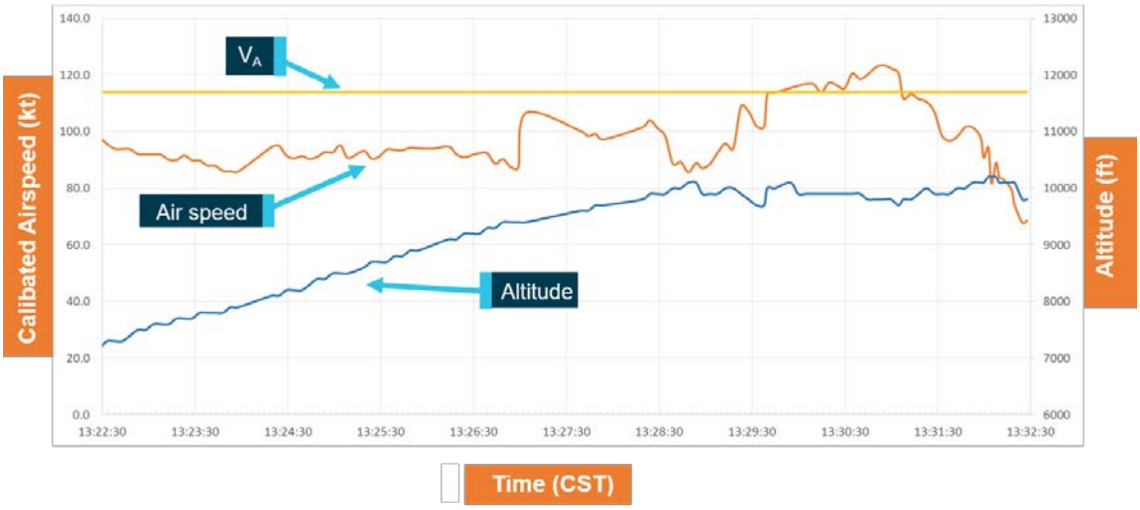
Manoeuvring speed

The aircraft's manufacturer specified a manoeuvring speed of 118 kt at its maximum take-off weight. The aircraft's weight at the time of the breakup was about 1,603 kg, which equates to a manoeuvring speed of 114 kt (calibrated airspeed), as shown in Figure 10.

At airspeeds above the manoeuvring speed, full or abrupt control inputs or turbulence may produce wing loading that can damage the aircraft's structure. At airspeeds above about 145 kt, this loading can result in failure of the aircraft structure.

The following graph depicts the calibrated airspeed with wind corrections based on the forecast, noting that actual wind conditions were unavailable, and may be significantly different due to the proximity to a rapidly developing cell.

Figure 10: VH-HWY recorded altitude and groundspeed for the last 10 minutes of flight



Source: RAAF radar data and OzRunways data analysed by ATSB

Company information

Supervisory pilot role

Air Frontier's new pilots often had limited exposure to the weather conditions of the tropics, and some had relatively low overall flying experience. In order to prepare them for the work and assess their suitability, Air Frontier had developed a line operational training process. In a March 2014 Notice to Aircrew (NOTAC), the chief pilot had outlined the pilot ICUS training, and the role of company appointed supervisory pilots as follows.

> ICUS Operations [are when] potential pilot recruits (Trainee Pilots) may gain experience on Company aircraft and operations as Pilot In-Command-Under Supervision (ICUS) whilst under the supervision of an experienced Company-approved ICUS Supervisory pilot...
>
> ICUS supervisory pilots are company-approved pilots for supervising Trainee Pilots while they are undergoing line operational training and suitability assessment…A supervisory pilot is not necessarily a qualified flight instructor and is expected only to provide training in regards to company procedures and routes.

Newly recruited pilots completed ground training first and at least one check flight with the chief pilot before conducting flights with supervisory pilots. Supervisory pilots were responsible for ensuring the 'trainee' followed regulatory requirements and the company's standard operating procedures at all phases of flight. If the aircraft was approaching an 'unsafe state' during flight, supervisory pilots were to issue verbal instructions to the trainee but, if required, take over immediately. The supervisory pilot was considered the pilot in command at all times.

Supervisory pilots were selected by the chief pilot and managing director, after reviewing the pilots' logbooks, proficiency check results, and their 'standing' in the company. The operator's NOTAC outlined minimum requirements for supervisory pilots, and for single engine operations if the pilot had under 1,000 hours (as was the case with the accident flight), to have worked for the company for 6 months, have at least 400 hours as PIC and 50 hours on type. The operator had proactively implemented these minimum (non-mandatory) requirements for supervisory pilot experience and training to improve their capabilities. They then undertook a training and checking flight with the chief pilot or delegate, including a training and proficiency assessment in a take-off, landing and go-around from the right seat, recovery from unusual attitudes in VMC and (simulated) IMC.

Wet season guidance to pilots

Air Frontier provided pilots with policies and guidance relating to conditions experienced in the wet season, and the operations manual included the following.

> …thunderstorms, line squalls and other conditions denoting areas of violent turbulence and/or hail must be regarded as extremely dangerous and be positively avoided. Avoid flying within 10 km horizontally of a fully developed cumulonimbus cloud and also directly below the base of the cloud wherever possible.
>
> Vertical air movement capable of producing extremely severe turbulence is often present near the edge of the cloud's base, or in clear air below the overhang of the top. An early decision to divert around a thunderstorm will need a relatively small heading change and result in minimal distances added to the flight.

About a week before the occurrence, Air Frontier distributed its Wet Season Guide, developed internally to assist pilots understand weather conditions to which they would be regularly exposed. The company aimed to ensure that its many new pilots were prepared to handle various 'challenging scenarios'.

In its informal style, the Guide included the following topics.

- The importance of planning: encouraged pilots to source forecasts and actual weather conditions from a range of sources including BoM (including their Rain Radar app) and OzRunways.
- Fuel management: advised pilots they should ensure that holding and alternate requirements are met, and take into account additional fuel required to handle conditions indicated by TEMPOs[14] in the forecast.
- Flying conditions during the wet season: advised pilots to 'accept either low cloud or low visibility but not both', and advising that if a cloud base is high, it is preferable to track lower through showers, although with cautions about the risks of lower visibility conditions. It stated that it is better to fly on the upwind side around a storm, and tracking over water if possible. See Figure 11 for an example of the images included in the guide.
- The role of ATC: stated that ATC is there to help pilots, and to not be afraid of requesting left or right of track (by 3, 5, or 10 NM) and specific heights to avoid weather. It mentioned that an area around 'Jacko's Junction' to the east of Darwin was known to have adverse weather.
- Commercial considerations: 'The decision to fly or not fly can at times be very tough and you have to use every resource available to you to help you make that decision.'

The training manager also mentioned that pilots received 'extensive verbal training' about the different weather conditions in NT.

A number of Air Frontier's staff and pilots, and other operators in the region provided comment on the inherent challenges of the wet season. They knew thunderstorms could form rapidly, were not always easily detectable on weather radar (dependant on precipitation). They also acknowledged that pilots had to experience the conditions to get better at managing them and making 'good judgements early' was important.

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[14] TEMPO: a temporary deterioration in the forecast weather conditions, during which significant variation in prevailing conditions are expected to last for periods of between 30 and 60 minutes.

Figure 11: Large storm cell images illustrated in Air Frontier's Wet Weather Guide

Source: Operator, with permission

An Air Frontier pilot identified 'command decision making in high stress environments' including operating in Arnhem Land among the skills and knowledge that pilots had to develop after joining the company. Other company pilots indicated having an iPad with the OzRunways application installed to see weather radar during flight. They also identified reports from other pilots in the area or from ATC to manage weather conditions.

Comments about managing weather conditions from pilots working for other operators in the region included the following.

- One pilot believed a Howard Springs cell was predictable during the wet season as it was an almost-daily occurrence, and recommended avoiding such cells by 20-40 NM.
- One pilot noted the importance of carrying additional fuel in the wet season, as diverting to avoid a thunderstorm by 10 NM often was not enough. He had also encountered strong up- and down-drafts in these conditions.
- Some pilots indicated that it was unlikely an aircraft such as a C210 could out-climb fast-developing cells that occur in the wet season, and 'staying low' was much more preferable.
- A few pilots noted that the practice of 'Territory VFR' was prevalent amongst pilots in the Top End (a reference to VFR pilots briefly climbing through cloud for less turbulent conditions).

After this accident, Air Frontier's chief pilot spoke with the pilots about the dangers of flying in the wet season. He encouraged them to inform ATC of their requirements, including the option to fly into Restricted airspace.

Next of kin notification

As part of the investigation, the ATSB was informed of a delay in being able to notify one of the pilot's family. About 15 minutes after the aircraft's disappearance from ATC radar, controllers informed Air Frontier's chief pilot (the emergency point of contact). He called the police, which confirmed it was attending the accident site. The chief pilot next reported the accident to CASA and ATSB. He was then able to provide the police with the next of kin details for one pilot, but found that Air Frontier did not have the same details on file for the other pilot.

Consequently, there was a delay of several hours in informing that pilot's family while the police worked to obtain information from alternate sources (previous employment history). On-site, ATSB investigators later found the pilot's completed next of kin details form, which had not been provided to the company.

Regulatory oversight

The ATSB reviewed CASA's surveillance activities and reports for Air Frontier from about 7 years leading up to this occurrence. These included some relevant findings and observations, mostly pertaining to operational document control, incomplete documentation on roles such as the supervisory pilots, and concerns about chief pilots not fulfilling all aspects of their role (mostly due to workload).

The CASA post-occurrence surveillance report (provided to the operator in November 2017) had 13 findings, and themes including the following.

- Deficiencies in the record keeping for files associated with the new pilot, including flight and duty time information, licenses and qualifications.
- Absence of evidence around the left seat pilot having acknowledged he had read the operations manual, or key NOTACs such as the March 2014 on ICUS and supervisory pilots.
- Not having completed some updates to the operations manual to ensure procedures for cargo loading, ICUS flying, training programs and supervisory pilots were included.
- Perceived deficiencies in the selection and management of supervisory pilots

The report's summary stated that, based on the findings, there were perceived 'deficiencies in the appropriateness of the operator's organisation and the soundness of its management structure'. In its response to this report, Air Frontier raised some questions about the accuracy of observations relating to supervisory pilots but agreed to take all the remedial actions required.

Human performance considerations

The ATSB considered key human factors topics relating to this accident to explore possible influences on the pilots' in-flight weather-related decision making and physiological effects associated with the adverse weather conditions.

Decision making

Naturalistic decision making

It is important to consider pilot decisions it in the context in which the sequence of events occurred. Orasanu (2000) outlines the concept of naturalistic decision making:

> Naturalistic decision-making focuses on understanding how people with domain expertise use their knowledge to make decisions, typically in safety-critical environments (Cannon-Bowers et al., 1996; Zsambok & Klein, 1997).

The basis for recognising situations that requires decisions is knowledge (Orasanu, 2000). This includes 'determining what information is relevant to the decision, and deciding on an appropriate course of action…in order to manage risk, threats must be perceived and accurately assessed.'

Orasanu asks, 'how can flight crews be trained and supported to make the best decisions possible, especially under challenging high-risk conditions?'

Weather-related decision making

The ATSB (2005) report, *General Aviation Pilot Behaviours in the Face of Adverse Weather,* states that 'weather-related general aviation accidents remain one of the most significant causes for concern in aviation safety' which requires pilots to continuously evolve their decision making.

Pilots in general aviation often operate in an 'uncertain and risky operational domain where they are confronted with a range of meteorological phenomena about which a series of in-flight decisions need to be made' (Hunter, Martinussen and Wiggins, 2003). This information often comes from a range of sources 'including meteorological briefings, inflight weather reports, visual information from the cockpit, and on-site reports.'

Wiggens and O'Hare (1995) define weather-related decision making as 'those skills necessary to recognize and avoid meteorological phenomena that present a hazard to the flight.' It is a skill which is developed 'gradually through practical experience [but] in developing this type of experience, relatively inexperienced pilots may be exposed to hazardous situations with which they are ill-equipped to cope'.

One of the reasons why pilots may decide to continue a flight into adverse weather is that 'they make errors when assessing the situation. That is, pilots are seen to engage in VFR flight into [instrument meteorological conditions] because they do not accurately assess the hazard (Wiegmann and Goh, 2000). Risk perception can be influenced by personal experience and ability (Sanders and McCormick, 1993).

The Federal Aviation Administration produced a guide in 2005 called *General Aviation Pilot's Guide to Pre-Flight Weather Planning, Weather Self-Briefings, and Weather Decision Making*. They suggest that it is the abundance of weather information that may make it difficult for pilots to focus on key information and 'correctly evaluate the risk resulting from a given set of circumstances'.

Weather-related cue-based training and guidance

It may be possible to provide pilots with greater knowledge of adverse weather conditions (and how the handle them) through training. Wiggins and O'Hare (2003) discussed the benefits of cue-based training to help pilots 'recognise and respond to deteriorating weather conditions during flight.' Training 'improved…pilots' initial response times to deviate around the thunderstorm' (Ball, 2008).

In recent times, pilots will often use information ascertained from apps on their tablets / iPads, including graphical weather displays based on radar information. However, Ball (2008) outlined that 'previous research suggested that giving pilots the ability to see accurately the weather they are flying in and around may tempt some pilots to try to fly through small breaks in the convective activity'. Some pilots would attempt to navigate through or very close to the hazardous weather, and there are others that used the graphical information to plan and maintain a safe distance (20 NM or greater) from a storm.

Air Frontier's chief pilot acknowledged that the wet season can be a very challenging time to fly. He said pilots should 'never out-climb the weather' and aim to be at least 10 NM away from the weather. The training manager said that during flights with their pilots, he tested them on their knowledge of weather conditions, and expected they brief on the weather conditions en route.

The CASA-conducted seminars in Darwin address risks of flying in the wet season. The seminars include briefings from BoM staff, and are designed for junior pilots, or those new to the region.

Effect of experience and familiarity

Blickensderfer and others (2018) assessed that 'the manner in which expert pilots respond to hazardous weather scenarios differs from that of less experienced pilot.' The NTSB (2005) furthered this by outlining that:

> Errors in decision-making, such as plan continuation errors or incorrect assessments of weather-related risk, may be made by pilots who are unfamiliar with the climate of the local area, who lack total and/or recent experience identifying marginal weather conditions, or who lack experience accessing or reading weather reports.

Air Frontier's training manager commented that many pilots start work with Air Frontier without having previously encountered the weather conditions in Darwin. Other pilots recalled their own encounters with the weather soon after they arrived in Darwin, where they were sometimes unsure of the best action to take when adverse weather was encountered.

Plan continuation bias

It is possible that pilots do not divert (or divert further) as it is perceived as a loss. Ball (2008) outlined that the pilots in their study 'could see it was going to take longer to fly around the edge of the storm than it would take to cut through the areas of broken activity, which would result in a significant savings of time'.

An NTSB study (2005) outlined that one class of decision making in weather-related occurrences was the presence of plan continuation error, which is defined by Orasanu and others (2001) as ''failure to revise a flight plan despite emerging evidence that suggests it is no longer safe'. Rather than revisiting the intended route by making a decision such as returning to the departure airport, pilots 'may opt to press on in deteriorating weather'.

Perceived pressures to continue a flight

Pilots may perceive that there are some pressures to continue a flight, as opposed to returning or diverting. In small commercial operations, there can be a risk for pilots 'balancing the competing demands of safety and productivity [becomes] difficult for many small operators, which places a heavy reliance on the decision making of individuals' (Bearman and others, 2009). In a survey of pilots working for small Alaskan operators, they reported encountering 'both explicit and implicit norms and expectations to fly in marginal conditions.

Orasanu (2009) supports this notion:

> An organization's emphasis on productivity may inadvertently set up goal conflicts with safety. Mixed messages, whether explicit or implicit in the norms and organizational culture, create conflicting motives, which can affect pilots' risk assessment and the course of action they choose.

The owner of Air Frontier said he speaks with individual pilots to explain that there is no pressure to continue a flight, and they would be supported if they decided to return or divert. Likewise, the chief pilot of Air Frontier commented that from his standpoint, no job is worth pushing the limits for'. He felt, 'if the weather's no good get them to delay it'. He said they wanted the pilots to stay on the ground rather than try to push it in marginal weather situations.

Increased workload and stress

The ATSB considered whether the pilots likely experienced the effects of increased workload and stress in a situation where they were undertaking weather-related deviations in conditions they had limited (if any) exposure to in the past.

Orlady and Orlady (1999) define workload as 'reflecting the interaction between a specific individual and the demands imposed by a particular task'. The outline that to understand the effect of workload, it is important to understand the strategies a pilot uses for managing tasks:

> An individual has a finite set of mental resources they can assign to a set of tasks (i.e. performing a takeoff). The resources available to an individual can change given the experience and training they have had or the level of stress and fatigue they are experiencing…When workload becomes excessive, the individual must shed tasks.

Orlady and Orlady (1999) also outline that workload varies with 'training, procedures, experience, and sometimes with stress levels…'. Morris and Leung (2006) build on this idea, outlining that pilots in higher mental workload conditions experience more errors in tracking and communication.

An increased workload can result in an increase in stress experienced. When in stressful situations (such as needing to take actions that are different to those planned), there can be some effect on the ability to consider all of one's options. Staal (2004) adds that 'individual judgment and decision making is degraded under stressful conditions' and that 'in addition to experiencing greater rigidity, individuals may tend to persist with a method or problem-solving strategy even after it has ceased to be helpful'.

In this case, the ATSB considered whether increased workload resulting from deviating from the track and aircraft handling in turbulence could have resulted in high stress levels, which in turn could have affected the pilots' decision making. The air traffic controllers reported that they did not detect any signs of stress in the pilot's voice, although the pilot's responses became increasingly short in length and word use. However, apart from these considerations and information, there was insufficient evidence to identify to what extent increased workload or stress affected decision making.

Risk of spatial disorientation

Gibb and others (2010) explain that seeing the horizon is 'crucial for orientation of the pilot's sense of pitch and bank of the aircraft'. In conditions of low visibility, the horizon may not be visible to the pilot, during which time they can become rapidly disorientated. Newman (2007) found that 'the major environmental factors [that contribute to spatial disorientation] are related to time of day and the ambient weather conditions. Poor visual cues are a function of most disorientation illusions, so flight…in conditions of bad weather can set a pilot up for a disorientation experience'.

In a discussion of spatial disorientation, Benson (1999) defined the experience as follows:

> Spatial disorientation is…[where] the pilot fails to sense correctly the position, motion or attitude of the aircraft or of him/herself [resulting in] errors in perception by the pilot of their position, motion or attitude with respect to their aircraft...

Newman (2007) outlined that spatial disorientation can affect 'any pilot, any time, any where, in any aircraft, on any flight, depending on the prevailing circumstances'. Extensive research on spatial disorientation indicates that loss of control will likely occur between 60 seconds (Benson, 1983 in Gibb and others, 2010) and 178 seconds (Newman, 2007) after the loss of visual reference. Gibb and others (2010) state that 'spatial disorientation accidents have fatality rates of 90–91 percent'.

In this case, both pilots involved in this occurrence held a current instrument rating at the time, which may have reduced the risk of experiencing spatial disorientation in low visibility conditions. The ATSB considered whether the pilots were likely to have experienced spatial disorientation in any areas of reduced visibility, leading to either a loss of control and/or an unusual attitude, but there was insufficient evidence to demonstrate that the aircraft likely entered low visibility conditions.

Related occurrences

A review of the ATSB occurrence database found that since 1969 (which corresponds to the availability of electronic data), there had been 45 in-flight breakups, four involving Cessna 210's, the most commonly-involved aircraft. Of those 45 occurrences, 10 were associated with adverse weather and/or turbulence. In the same period, there have been 47 occurrences reported to the ATSB considered to be 'VFR into IMC' occurrences.

As a basis of comparison, the US National Transportation Safety Board investigated seven in-flight breakups of Cessna 210 aircraft since 2000. All those occurrences involved flight into thunderstorms or associated turbulence, a loss of control following inadvertent flight into instrument meteorological conditions or a combination of both.

In one case, a Cessna T210L flew into IMC in 2005, where icing or spatial disorientation likely resulted in a loss of control. Excessive speed then resulted in the aircraft exceeding its design limits, resulting in the breakup. The right wing was found approximately 800 m from the main wreckage. Damage observed on one of the wings was similar to that in the HWY breakup.

Two in-flight break up occurrences investigated by the ATSB are summarised below.

ATSB investigation 199905037

The Cessna Silver Eagle aircraft, a turbine-powered, pressurised Cessna 210, was conducting a private flight from Maroochydore to Bankstown under the instrument flight rules (IFR), cruising at flight level (FL)[15] 160. The pilot faced adverse weather en route and requested a diversion around the weather, and then subsequent descents from their cleared flight level. The pilot reported an engine failure then a loss of generator power. No further broadcasts were received, and several hours later, the wreckage was found 380 m south-east of its last position.

Onsite investigation revealed that the right wing had failed before impact because of aerodynamic forces that exceeded the wing structural load limits. The empennage had also separated from the fuselage before impact. Interpretation of the en route weather reports suggested that the aircraft might have passed through a line of showers and thunderstorms.

The in-flight breakup resulted from the airframe being stressed beyond its design limit.

ATSB investigation AO-2011-160

On 7 December 2011, the owner-pilot of a Cessna 210M, registered VH-WBZ, was conducting a private flight under the visual flight rules from Roma to Dysart in Queensland. Thunderstorms with associated cloud, rain and severe turbulence were forecast. About 30 minutes into the flight, the outer sections of the wings and parts of the tail separated and the aircraft collided with terrain, fatally injuring the pilot.

The ATSB established that ground-based weather radar showed thunderstorms in the vicinity of the accident site, and recorded engine data showed cruise power setting was maintained until recording ceased. Although the precise circumstances leading up to the accident were not known, a combination of aircraft airspeed with the effects of turbulence and/or control inputs generated stresses that exceeded the design limits of the aircraft structure.

Airspeed is a critical factor in the stress sustained by an aircraft. Pilots need to be aware of the manoeuvring speed (VA) for the aircraft weight, and to control airspeed so as not to exceed that value when full control deflection is required or severe turbulence or wind/gusts are encountered. Severe turbulence and wind gusts are among the hazards associated with thunderstorms.

15 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 370 equates to 37,000 ft.

Safety analysis

Encountering adverse weather and turbulence

When VH-HWY departed Darwin Airport at 1307 on 23 October, the area forecast indicated the presence of thunderstorms and reduced visibility. However, the weather conditions that the aircraft encountered developed rapidly meant that its pilots could not have accurately and easily predicted them before departure.

Fourteen minutes after departure, the left seat pilot requested a diversion left or right of track to avoid weather. The subsequent diversions of 10 and 20 NM were prompted by ATC through their transmission to HWY including ‘advise if you need further right of track’. While it was possible for ATC to clear HWY to divert left instead, there was adverse weather in that area too.

The aircraft’s recorded track during these weather-related diversions, when overlaid on the weather radar and satellite cloud images, showed that HWY tracking in close proximity to both a precipitating cell and a rapidly developing towering cumulus cloud. The last position of the aircraft at 1332 was in the rapidly developing cell, in an area likely to have strong convective activity including up- and down-drafts. The altitude changes in the final minutes indicate that the aircraft was likely experiencing severe convective turbulence.

It is possible the aircraft entered an area of reduced visibility associated with the precipitating cells and other clouds. This would meant an increased risk of the pilots losing visual cues to determine the horizon, and then experiencing spatial disorientation. This could lead to losing, or being unable to regain control of the aircraft in the case of an unusual attitude. Regardless, the load on the airframe could have been increased by any momentary loss of control.

In summary, shortly after VH-HWY diverted to avoid adverse weather, the aircraft entered an area of strong convective activity and rapidly developing precipitating cells, which resulted in it experiencing severe turbulence and possibly reduced visibility for the pilots.

Wing separation from fuselage in-flight

The aircraft’s track data as well as witness reports indicate a very high rate of descent from about 10,000 ft until it impacted terrain. The aircraft wings were found in close proximity to each other, likely tethered to each other until a low altitude or till they impacted trees. The deformation in the fractured wing spars was in an upward and rearward direction. The combination of this evidence indicates that the wings separated from the aircraft in flight, likely due to excessive wing loading beyond the wing loading limits.

In accordance with aircraft design load factors, the wing loading, relative to the airspeed, was too high. The evidence indicates that the aircraft likely encountered severe turbulence. The ATSB could not establish the precise airspeed before or at the point of the uncontrolled descent, nor what control inputs were made by the pilots. However, based on calculations of the calibrated airspeed and the recorded ground speed (albeit without known localised wind), the effects of turbulence, any control inputs (however small) would increase wing loading. Therefore, any control inputs would have increased aerodynamic load and, as such, any attempt by the pilot's to control the aircraft or avoid the cloud increased the load factor.

In summary, a combination of airspeed, turbulence and control inputs probably led to excessive loading on the aircraft’s wings, which separated from the fuselage in-flight before the aircraft collided with terrain.

Crew pairing in the wet season

It is possible that after diverting right of track to avoid weather, the pilots perceived an opportunity to return to the planned track, but then re-diverted south to avoid further hazardous conditions. However, this inadvertently positioned the aircraft in adverse weather that resulted in the separation of the wings. The ATSB considered whether the pilots' in-flight weather-related decision making was influenced by certain motivational factors such as:

- concern about having departed Darwin later than intended,
- perceived need to deliver the coffin to Elcho Island in a timely manner, and/or:
- perceived implicit pressures to continue, given they were new in their respective roles.

These factors could lead to a plan continuation bias. However, it was not possible to determine if any of these factors influenced their decision making. Nevertheless, a likely influence, supported through extensive research relating to in-flight weather-related decision making, was the level of operational experience the pilots had in the wet season.

The 'build-up' period to the wet season in Darwin is known for weather conditions hazardous to flying activities. Pilots in tropical areas need to recognise and respond to these conditions to avoid the hazards including turbulence, windshear and reduced visibility. However, this is more challenging when a pilot has not experienced these conditions, and therefore may not accurately assess the situation or perceive the risks. Ball (2008) states that the lack of hazardous weather flying experience plays 'a role in the pilot's ability to make timely and safe decisions about flying in and around hazardous weather'. Many of the pilots that the ATSB spoke with indicated that they only learned how to handle the weather during the wet season through their own exposure to the conditions, particularly the distance to keep from rapidly-developing cells. There were differences in the perception of how much distance to keep from them, ranging from 10 to 40 NM.

In this case, neither pilot had flown during a previous wet season in Darwin. Whilst the ATSB could not determine whether the pilots had ever experienced conditions similar to wet season conditions ever before, there was sufficient evidence to indicate that there were limited opportunities to have done so.

Orasanu (2000) outlined that when flying with other pilots, team members likely expand cognitive resources. For Air Frontier, supervisory pilots were paired with new company pilots to gain experience on their aircraft and operations. However, in this context as a risk mitigation, this can only be effective if one pilot has knowledge the other has not. It cannot be definitively stated that more experienced pilots would have avoided all hazardous weather that day, but there was an increased likelihood others would have recognised the risks posed to the safety of flight, and perhaps decided to take different actions.

In summary, the risk mitigation provided by pairing a supervisory pilot with a trainee did not adequately address the weather-related risks because neither pilot had experience flying in the region during the wet season

Disclosure of medical history

The investigation identified that medication the left seat pilot was taking was not recorded in his medical file. However, there is no evidence that his performance, including decision making, was influenced by the medication or any medical condition, or otherwise contributed to this occurrence.

Notwithstanding the above, it is important to recognise that the purpose of declaring medical history is to address risks associated with medications or conditions that could affect performance. It is acknowledged that some pilots may often be concerned about not meeting medical certificate requirements if they declare using medications or have a medical condition. However, they then miss the opportunity to have their concerns addressed by a medical professional qualified in aviation medicine.

Documented pathways exist for managing certain medical conditions and medications that do not preclude a pilot from maintaining a medical certificate (including in this case). Both CASA and designated aviation medical examiners (DAME's) have an important role in increasing pilot awareness about these pathways, and encouraging disclosure of medical history.

Findings

From the evidence available, the following findings are made with respect to the in-flight breakup involving a Cessna 210L, registered VH-HWY, that occurred 12 NM east of Darwin Airport, Northern Territory. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing factors

- Shortly after VH-HWY diverted to avoid adverse weather, the aircraft entered an area of strong convective activity and rapidly developing precipitating cells, which resulted in it experiencing severe turbulence and possibly reduced visibility for the pilots.
- A combination of airspeed, turbulence and control inputs probably led to excessive loading on the aircraft's wings, which separated from the fuselage in-flight before the aircraft collided with terrain.

Other factors that increased risk

- The risk mitigation provided by pairing a supervisory pilot with a pilot new to the company did not adequately address the weather-related risks because neither pilot had experience flying in the region during the wet season.
- While there is no evidence that it contributed to this occurrence, the left seat pilot was taking a medication that was not recorded in his medical file. The disclosure and recording requirements for a pilot's medical certificate aim to address the risks associated with medications or conditions that could affect performance.

General details

Occurrence details

Date and time:	23 October 2017 at 1332 (CST)	
Occurrence category:	Accident	
Primary occurrence type:	In-flight breakup	
Location:	12 NM east of Darwin Airport, Northern Territory	
	Latitude: 12° 26.45' S	Longitude: 131° 05.78' E

Right seat pilot details – Supervisory pilot

Licence details:	Commercial pilot licence (aeroplane), issued March 2016
Endorsements:	Manual Propeller Pitch Control; Retractable Undercarriage
Ratings:	Single-engine and multi-engine aeroplane; Instrument – multi- and single-engine aeroplane, instrument approach 2 and 3 dimensional
Medical certificate:	Class 1, valid to December 2017
Aeronautical experience:	705.9 hours
Last proficiency check / flight review:	22 March 2016

Left seat pilot details – Pilot in command under supervision

Licence details:	Commercial pilot licence (aeroplane),, issued September 2012
Endorsements:	Float Plane, Manual Propeller Pitch Control; Retractable Undercarriage
Ratings:	Single-engine and multi-engine aeroplane; Instrument – multi-engine and single-engine aeroplane, instrument approach 2 and 3 dimensional
Medical certificate:	Class 1, valid to May 2018
Aeronautical experience:	381.4 hours
Last proficiency check / flight review:	Instrument proficiency check May 2017, Night VFR single-engine aeroplane July 2017

Aircraft details

Manufacturer and model:	Cessna Aircraft Company 210L	
Year of manufacture:	1974	
Registration:	VH-HWY	
Operator:	Air Frontier Pty Ltd	
Serial number:	210-60263	
Total Time In Service	6,499.2 hours	
Type of operation:	Charter	
Persons on board:	Crew – 2	Passengers – 0
Injuries:	Crew – 2 (Fatal)	Passengers – 0
Damage:	Destroyed	

Sources and submissions

Sources of information

The sources of information during the investigation included:

- Air Frontier
- Airservices Australia (Airservices)
- the Bureau of Meteorology (BoM)
- the Civil Aviation Safety Authority (CASA)
- a number of witnesses and other pilots in the region
- Northern Territory Police
- OzRunways
- Royal Australian Air Force
- Textron Aviation.

References

Ball, J., 2008, *The Impact of Training on General Aviation Pilots' Ability to Make Strategic Weather-Related Decisions*, Civil Aerospace Medical Institute, Oklahoma City, USA

Batt, R. and O'Hare, D., 2005, *General aviation pilot behaviours in the face of adverse weather*, ATSB Aviation Research Investigation Report B2005/0127, available at www.atsb.gov.au

Bureau of Meteorology, 2012, *Weather Advice for your Safety: Flying the Tropics*, available at www.bom.gov.au

Bureau of Meteorology, 2012, *Hazardous Weather Phenomena: Thunderstorms*, available at www.bom.gov.au

Bureau of Meteorology, 2012, *Hazardous Weather Phenomena: Turbulence*, available at www.bom.gov.au

Bearman, C., Paletz, S., Orasanu, J. and Brooks, B., 2009, *Organizational Pressures and Mitigating Strategies in Small Commercial Aviation: Findings from Alaska*, Aviat Space Environ Medicine, 80:1055-8

Blickensderfer, B., Lanicci, J., Guinn, T., King, J., Ortiz, Y. and Thomas, R., 2018, Assessing General Aviation Pilots' Understanding of Aviation Weather Products, *The International Journal of Aerospace Psychology*, Vol. 27

Federal Aviation Administration, 2005, *General Aviation Pilot's Guide to Preflight Weather Planning, Weather Self-Briefings, and Weather Decision Making*, available at www.faa.gov

Hunter, D., Martinussen, M. and Wiggins, M., 2003, Understanding How Pilots Make Weather-Related Decisions, *International Journal of Aviation Psychology*

National Transportation Safety Board, 2005, *Risk Factors Association with Weather-Related General Aviation Accidents*, Washington, D.C, USA

Newman, D., 2007, An overview of spatial disorientation as a factor in aviation accidents and incidents, ATSB Aviation Research and Analysis Report B2007/0063, available at www.atsb.gov.au

Morris, C. and Leung, Y., 2006, *Pilot mental workload: how well do pilots really perform?*, Ergonomics Journal Vol. 49 pp. 1581-1596.

Orasanu, J., 2010, Flight Crew Decision-Making, in Kanki, B., Helmreich, R. and Anca, J., *Crew Resource Management*, Elsevier, San Diego, USA

Orlady, H. and Orlady, M., 1999, *Human Factors in Multi-Crew Flight Operations*, Ashgate Publishing, Vermont, USA

Sanders and McCormack (1993) – Human Factors in Engineering and Design (7^{th} edition)

Staal, M., 2004, *Stress, Cognition and Human Performance: A Literature Review and Conceptual Framework*, Ames Research Centre, California

Wiegmann, D. and Goh, J., 2000, *Visual Flight Rules (VFR) Flight into Adverse Weather: An Empirical Investigation of Factors Affecting Pilot Decision Making*, Federal Aviation Administration, Washington DC, USA

Wiggins, M., 2003, *Weatherwise: Evaluation of a Cue-Based Training Approach for the Recognition of Deterioration Weather Conditions during Flight*, University of Western Sydney, Sydney, Australia

Wiggins, M. and O'Hare, D., 1995, Expertise in Aeronautical Weather-Related Decision Making: A Cross-Sectional Analysis of General Aviation Pilots, *Journal of Experimental Psychology: Applied*, Vol. 1

Woods, D. and Patterson, E., <year>, *How Unexpected Events Produce An Escalation Of Cognitive And Coordinative Demands*, Ohio State University, USA

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 Air Frontier, the Civil Aviation Safety Authority (CASA), the Bureau of Meteorology (BoM), the Northern Territory Police and the next of kin of both pilots.

Submissions were received from Air Frontier, CASA, BoM, and the next of kin of both pilots. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

Australian Transport Safety Bureau

The 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.

Terminology used in this report

Occurrence: accident or incident.

Safety factor: an event or condition that increases safety risk. In other words, it is something that, if it occurred in the future, would increase the likelihood of an occurrence, and/or the severity of the adverse consequences associated with an occurrence. Safety factors include the occurrence events (e.g. engine failure, signal passed at danger, grounding), individual actions (e.g. errors and violations), local conditions, current risk controls and organisational influences.

Contributing factor: a factor that, had it not occurred or existed at the time of an occurrence, then either:

(a) the occurrence would probably not have occurred; or

(b) the adverse consequences associated with the occurrence would probably not have occurred or have been as serious, or

(c) another contributing factor would probably not have occurred or existed.

Other factors that increased risk: a safety factor identified during an occurrence investigation, which did not meet the definition of contributing factor but was still considered to be important to communicate in an investigation report in the interest of improved transport safety.

Other findings: any finding, other than that associated with safety factors, considered important to include in an investigation report. Such findings may resolve ambiguity or controversy, describe possible scenarios or safety factors when firm safety factor findings were not able to be made, or note events or conditions which ‘saved the day’ or played an important role in reducing the risk associated with an occurrence.

Australian Transport Safety Bureau

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Investigation

ATSB Transport Safety Report
Aviation Occurrence Investigation

In-flight breakup involving Cessna 210, VH-HWY
22 km east of Darwin Airport, NT on 23 October 2017

AO-2017-102
Final – 9 April 2019