Australian Government
Australian Transport Safety Bureau

Controlled flight into terrain – Cessna Aircraft Company 310R VH-XGX

Near Bathurst Island Aerodrome, Northern Territory | 5 February 2011


Modified image of a similar C310

Investigation

ATSB Transport Safety Report
Aviation Occurrence Investigation
AO-2011-017
Final

Australian Government

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ATSB TRANSPORT SAFETY REPORT

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Controlled flight into terrain – Near Bathurst Island Aerodrome, Northern Territory
5 February 2011
VH-XGX
Cessna Aircraft Company 310R

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

Report No. AO-2011-017

Publication date 14 June 2012

ISBN 978-1-74251-269-3

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

Publishing information

Published by: Australian Transport Safety Bureau
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SAFETY SUMMARY

What happened

On 5 February 2011, the pilot of a Cessna Aircraft Company 310R aircraft, registered VH-XGX, was conducting a return flight to Darwin, Northern Territory, following a charter flight to Bathurst Island. The pilot departed from Bathurst Island Aerodrome at approximately 2140 Central Standard Time and the aircraft collided with terrain shortly thereafter – approximately 1 km from the upwind end of the departure runway. The pilot, the sole occupant of the aircraft, sustained fatal injuries and the aircraft was destroyed by the impact forces and a post-impact fire.

What the ATSB found

The ATSB did not identify any technical deficiencies within the aircraft that may have contributed to the impact with terrain. The location of the wreckage, together with the dark night conditions and the relatively light load of the aircraft suggested that it was likely that the pilot was influenced by the effects of somatogravic illusion following takeoff. The somatogravic illusion is a powerful human physiological illusion that produces an upward-pitching sensation under conditions of acceleration accompanied by limited visual or other references.

What has been done as a result

Following the accident, the subcontracted operator (the pilot’s employer) advised of increased night operational checks of new pilots and low/medium time pilots operating from Darwin. These increased checks were implemented in November 2011.

Safety message

The somatogravic illusion can affect any pilot, and the ATSB highlights the importance of pilots being aware of the conditions under which the illusion may occur and the importance of understanding the ways in which they can manage the associated hazard. This includes strict vigilance in the use of the attitude indicator (artificial horizon) as the primary source of aircraft pitch angle information, and correct instrument scanning techniques to verify the attitude and performance of the aircraft.

Websites of the ATSB, the Civil Aviation Safety Authority and the US Federal Aviation Administration provide a number of sources of information on spatial disorientation and illusions.

CONTENTS

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The Bureau 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 fare-paying passenger operations.

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 safety factors related to the transport safety matter being investigated. The terms the ATSB uses to refer to key safety and risk concepts are set out in the next section: Terminology Used in this Report.

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 appropriate, or to raise general awareness of important safety information in the industry. 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 safety factor: a safety 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 safety factor would probably not have occurred or existed.

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

Other key finding: 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.

Safety issue: a safety factor that (a) can reasonably be regarded as having the potential to adversely affect the safety of future operations, and (b) is a characteristic of an organisation or a system, rather than a characteristic of a specific individual, or characteristic of an operational environment at a specific point in time.

Risk level: The ATSB’s assessment of the risk level associated with a safety issue is noted in the Findings section of the investigation report. It reflects the risk level as it existed at the time of the occurrence. That risk level may subsequently have been reduced as a result of safety actions taken by individuals or organisations during the course of an investigation.

Safety issues are broadly classified in terms of their level of risk as follows:

- **Critical** safety issue: associated with an intolerable level of risk and generally leading to the immediate issue of a safety recommendation unless corrective safety action has already been taken.
- **Significant** safety issue: associated with a risk level regarded as acceptable only if it is kept as low as reasonably practicable. The ATSB may issue a safety recommendation or a safety advisory notice if it assesses that further safety action may be practicable.
- **Minor** safety issue: associated with a broadly acceptable level of risk, although the ATSB may sometimes issue a safety advisory notice.

Safety action: the steps taken or proposed to be taken by a person, organisation or agency in response to a safety issue.

FACTUAL INFORMATION

History of the flight

On 5 February 2011, a charter of five aircraft had been arranged to return passengers to the Tiwi Islands (Melville and Bathurst Islands) from Darwin, Northern Territory (NT). Three aircraft were scheduled for flights to Bathurst Island Aerodrome and two for Snake Bay Aerodrome, Milikapiti, Melville Island, NT. Due to aircraft availability issues, on the day before the accident, the company responsible for the charter service (the charter operator), had engaged a second company (the subcontractor), to assist with the scheduled flights.

The occurrence pilot was originally assigned by his employer (the subcontractor) to operate the flight using their Cessna Aircraft Company 310 aircraft, registered VH-SKN (SKN). On the afternoon of 5 February 2011, that aircraft was reported to be unserviceable. The charter operator was advised and they indicated that they could supply the (subcontractor) pilot with a Cessna 310R aircraft, registered VH-XGX (XGX), which that pilot had flown the previous week. Prior to the departure from Darwin, the aircraft was refuelled to full main (wingtip) tanks.

At about 2013 Central Standard Time[1], the pilot of XGX flew the aircraft from Darwin Airport to Bathurst Island Aerodrome, with five passengers on board. The aircraft arrived at Bathurst Island Aerodrome at approximately 2125, and the passengers disembarked. Approximately 10 minutes later, the aircraft was prepared for departure from runway 33[2] for the return flight to Darwin. XGX was the first of the three aircraft to depart from Bathurst Island at approximately 2140.

Shortly after takeoff, a number of witnesses reported hearing a loud noise or seeing a light from the direction of departure. A search and rescue operation was initiated, with both air and ground responses. XGX was found to have impacted terrain approximately 1 km from the upwind end of runway 33 (Figure 1).

The pilot, the sole occupant of the aircraft, was fatally injured, and the aircraft was destroyed by the impact forces and a post-impact fuel-fed fire.

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[1] Central Standard Time was Coordinated Universal Time +9.5 hours.

[2] Runways are named by a number representing the magnetic heading of the runway.

Figure 1: Location of wreckage (arrowed) with respect to the runway at Bathurst Island Aerodrome

Pilot information

Aeronautical qualifications and experience

The pilot held an Australian Commercial Pilot Licence (CPL), issued on 13 February 2008. The pilot also held a Command Instrument Rating - multi engine (aeroplane), issued on 13 December 2010, and was endorsed on the Cessna 310.

The available information indicated that the pilot had about 1,465 hours total aeronautical experience, with 395.5 hours in Cessna 310 aircraft. The records also showed that he had 46.9 hours total night flying experience, 25.3 hours of which were on Cessna 310 aircraft.

In the 6 months prior to the accident, the pilot had completed approximately 18 night flying hours, all in Cessna 310 aircraft. This included two recent night flights to Bathurst Island; on 29 January 2011 in XGX and on 16 January 2011 in another aircraft. It could not be determined which runway was used for departure on those occasions.

The chief pilot reported that as part of a previous instrument rating test, the pilot was able to demonstrate proficiency using the instruments available following a simulated failure of the primary attitude instrument. It was mentioned that the pilot seemed to cope well and had good reactions in the higher workload environment.

Medical and health

The pilot held a Class-1 Medical Certificate, valid to 19 October 2011, with no restrictions.

A review of the pilot’s available medical records did not reveal any existing preconditions for incapacitation. The post-mortem examination did not identify any disease or indicators of likely physiological impairment, and no alcohol or drugs were identified in the toxicological analysis.

Witnesses reported that the pilot had worked during the hours of daylight on the 2 days immediately preceding the occurrence. The pilot's logbook recorded 2.9 hours flight time on 3 February 2011, and no flight hours for 4 February 2011. It was reported that the pilot had an uneventful day on 5 February 2011, and had eaten during the day. A witness reported that the pilot left for work about 1845 on the night of 5 February 2011. A number of witnesses that had contact with the pilot on the day of the accident, including on the ground at Bathurst Island, generally reported that the pilot was in good spirits and did not appear to show any indications of health problems.

Aircraft information

The Cessna Aircraft Company 310R, serial number 310R0058, was manufactured in the United States in 1975. The aircraft was powered by two Teledyne-Continental Motors IO-520 piston engines, driving three-bladed constant speed propellers. It was a low-wing aircraft with seating for six persons, including the pilot. The aircraft was certified and equipped for Instrument Flight Rules (IFR) operations.

Airworthiness and maintenance

The aircraft had current certificates of airworthiness and registration, and had a current maintenance release, which was issued during its last periodic (200 hour) maintenance inspection on 24 December 2010. The maintenance release was valid until 24 December 2011 or 15,950.1 hours total time in service (TTIS). The current maintenance release document was found at the accident site; however, it was severely heat affected, making most of the information illegible.

Items of additional work that were done during the last maintenance included a functional test of the vacuum system manifold check valve and the replacement of the left engine with a factory overhauled unit; the previous engine having reached its overhaul time limit.

Maintenance records showed that the aircraft's TTIS prior to the accident flight was 15,778 hours.

Fuel

The aircraft was refuelled just prior to the flight to Bathurst Island; it then flew to Bathurst Island with no reported issues. Several other aircraft were also refuelled utilising the same refuelling point as the accident aircraft, with no other incidents or fuel-related issues reported.

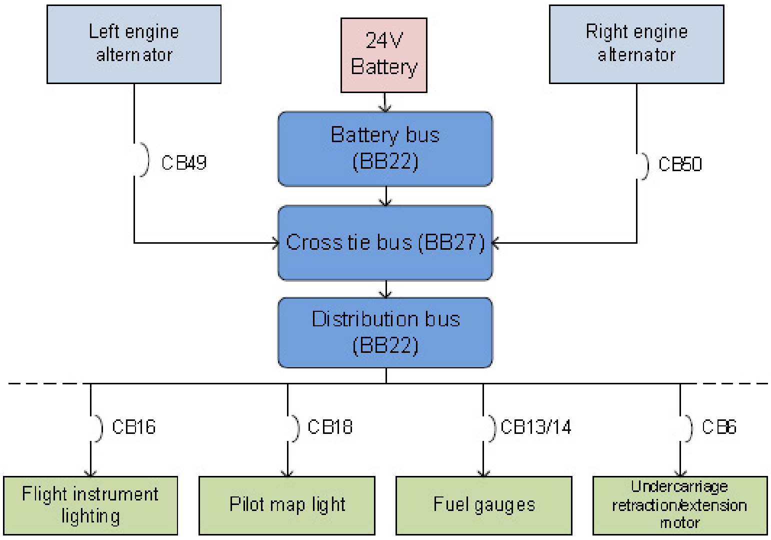
Electrical system operation

The Analysis section of this report considers the possibility of some form of electrical failure contributing to the accident. As such, a brief description and understanding of the electrical system on the C310 is necessary. The manufacturer's electrical power distribution diagram for the 310R aircraft showed the supply of battery power through a cross-tie bus bar (BB27) to the distribution bus bar (BB22). Through individual circuit breakers, that bus bar supplied power to the engine start relay, undercarriage (landing gear) extension/retraction motor, fuel gauges, instrument panel and cabin lighting. The wiring diagram indicated that the circuit between the battery and BB22 did not contain any fuses or circuit breakers.

Generated electrical power from the engine alternators was supplied to bus bar BB27 via individual circuit breakers; CB49 for the left alternator, and CB50 for the right alternator (Figure 2).

Cockpit lighting was provided by the instrument panel floodlight, instrument post lights (or instrument wedge lights), map light for the pilot and electroluminescent lighting for various panel placards.

Figure 2: Simplified electrical system diagram



A photograph of a Cessna 310R, reported to have the same electrical installation as XGX, showed an optional circuit breaker configuration. The wiring diagram for this optional configuration showed four circuit breakers associated with interior lighting for:

- flight instruments
- engine instruments
- radio lighting
- cabin/cockpit lighting.

The flight instrument lighting was controlled by a rheostat located on the switch and circuit breaker panel bar and supplied via circuit breaker CB16. The pilot map light was controlled by a rheostat located on the control wheel, and was powered via CB18, providing an independent source of electrical power between the lighting circuits.

The fuel quantity indicator was electrically powered from bus bar BB22, either via the engine gauge or fuel gauge circuit breakers. Alternator power output was monitored via the volt/ammeter gauges and an alternator failure was signalled by illumination of the ALTERNATOR FAIL light (located just in front of the throttle quadrant). A gang bar[3] could be used to turn off both alternators and the battery at the same time. It was not a normal procedure to operate the aircraft with the alternators turned off and a placard noting 'DO NOT TURN GENERATORS OFF INFLIGHT EXCEPT IN EMERGENCY' was affixed to the switch and circuit breaker panel.

System checks

During preparation for takeoff, the Cessna 310R Pilots' Operating Handbook (POH) requires that a number of independent checks and tests be made on the aircraft systems. A review of the normal pre take-off checks found that the electrical system operation would be assessed at three separate times before the aircraft could be assessed as ready for flight.

Electrical system failures - history

Complete electrical failures in aircraft are a rare event. A review of the Civil Aviation Safety Authority (CASA) and US Federal Aviation Authority (FAA) service difficulty reports from 2001 to 2011 did not reveal any incidences of electrical system/lighting failures in Cessna 310 aircraft. The ATSB accident/incident notification system identified two reported incidents across a fleet of 117 Cessna 310 aircraft in Australia. The first was a double generator failure and the other was an electrical failure that was reportedly rectified in flight. Both events were satisfactorily managed and did not result in accidents.

Meteorological information

Bathurst Island Aerodrome had no meteorological observer or observing instruments. The nearest aerodrome with recorded weather observations was Darwin Airport, about 75 km to the south-east. The Bureau of Meteorology weather facility at Darwin Airport generated periodic routine weather reports (METAR) which were available to pilots for planning and flight operations. The 2130 METAR on 5 February 2011 was issued at about the time of the accident and indicated there was good visibility and a westerly (290º true) 12 knot wind.

Witnesses on Bathurst Island, including the pilots that flew the other charter aircraft that night, reported that there had been some thunderstorms earlier in the day and that there was some cloud in the vicinity, but the night was mostly clear at the time of the accident. Witnesses also reported that it was a very dark night, with no moon or stars visible. Information from the Geoscience Australia website indicated that the moon had risen at 0810 on 5 February 2011 and set at 2036; approximately 1 hour before the accident.

Aerodrome information

Bathurst Island Aerodrome had a 1,470 m sealed runway, aligned in a south-east to north-west direction of 146/326° magnetic. The aerodrome was equipped with lighting for night operations. There were no ground lights or night visual references

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[3] A gang bar is a device that couples a number of individual switches in such a manner that they may be operated together.

to the north of the airstrip; at times presenting what was anecdotally known by pilots as a ‘black hole’[4] during night operations.

The township of Nguiu was located to the east of the airstrip, and under the same conditions, may have provided an outside visual reference for flight operations taking off from the reciprocal runway (Runway 15).

Wreckage and impact information

The aircraft impacted terrain in a heavily wooded area (Figure 2). Heat damaged wreckage and burnt foliage in the local area indicated that a significant fire had developed following the initial impact with the trees.

The wreckage trail was approximately 140 m in length, and was oriented in line with, and on the same heading as runway 33 (Figures 1 and 3).

Figure 3: Overview of wreckage trail

Contact marks on a number of trees indicated that the aircraft was wings-level and had a shallow angle of entry into the slightly rising terrain (Figure 4).

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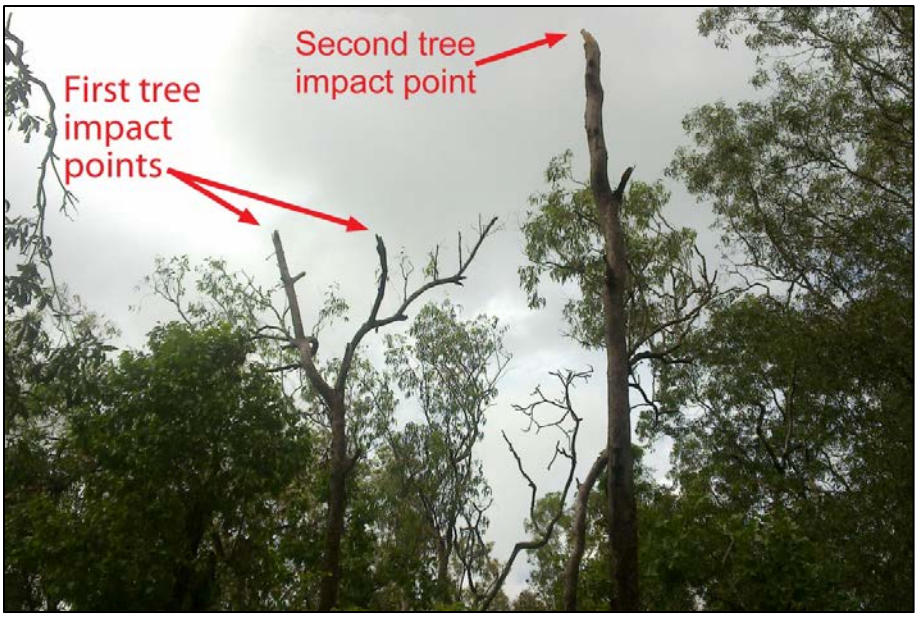
[4] This refers to the surrounding area around the aerodrome being devoid of any human activity that may be lit at night. Without lights around an aerodrome, the risk of spatial disorientation rises. Many aerodromes throughout rural Australia are affected by this phenomenon.

Figure 4: Initial tree impact points



The aircraft had been significantly disrupted during the impact sequence, breaking into numerous sections, which were distributed throughout the accident site.

Examination of the wreckage at the accident site accounted for all the major parts of the aircraft, including all the flight control surfaces. All structural fracture surfaces for the aircraft were examined, with no evidence of pre-existing defects identified. Considerable disruption of the wreckage precluded a check for continuity of the engine and flight controls. However, the engine and flight control cables and push pull tubes were examined at their fracture points, with no pre-impact defects identified.

The position of the aircraft landing gear retraction motor and actuator indicated that the landing gear was in the retracted position at the time of impact. The right main gear was confirmed to be in the fully-retracted position; however, the left gear and nose gear had separated from the aircraft during the impact sequence. The aircraft landing lights were located in the underside of the wing tips and retract when not in use. Both landing lights were located at the accident site and were in the retracted position (Figure 5).

Figure 5: Left and right landing lights in retracted position

Both engines had detached from the aircraft during the accident sequence. The extent of the rotational damage observed on both propellers indicated that both engines were producing significant power at the time of impact (Figure 6).

The right propeller assembly was attached to the engine and was intact apart from a small section of the tip of one blade which was located in the wreckage trail. The left propeller assembly had sustained a direct impact at the hub; the propeller subsequently breaking into several pieces and releasing the propeller blades. Only two of the three blades were located at the accident site; however, all of the other components of the propeller assembly were accounted for. The propeller hub fracture surfaces were inspected, with no pre-existing defects identified. Figure 6 shows the left engine with the relocated propeller components placed back in position.

Figure 6: Left and right engines

One of the persons involved in the initial search and rescue party reported that when they had arrived onsite on the night of the accident, a battery-operated torch (flashlight) was found illuminated within the wreckage. The torch was reported as a small, light-coloured unit with a push button on the end (opposite the light), and was reportedly found approximately half way between the end of the wreckage trail and the left engine (as shown in Figure 3). A specific search of the site by the ATSB following arrival onsite did not locate the torch. Ownership of the torch and whether it was on the aircraft at the time of the accident could not be verified.

Aircraft component examination

Several flight instruments and components were recovered from the accident site and examined at the ATSB's technical facilities in Canberra.

The artificial horizon instruments (AH) from both the pilot's and copilot's instrument panels were examined. The pilot's AH had been significantly damaged during the impact sequence; the gyroscope rotor had been ejected from the outer casing and was not recovered. The copilot's AH was dismantled and the gyro rotor and internal case were examined (Figure 7a). Rotational scoring was found on both the bottom of the gyro rotor (Figure 7b) and on the bottom of the gyro case, indicating that the gyro was rotating at impact.

Figure 7: Rotational scoring observed on the copilot's artificial horizon

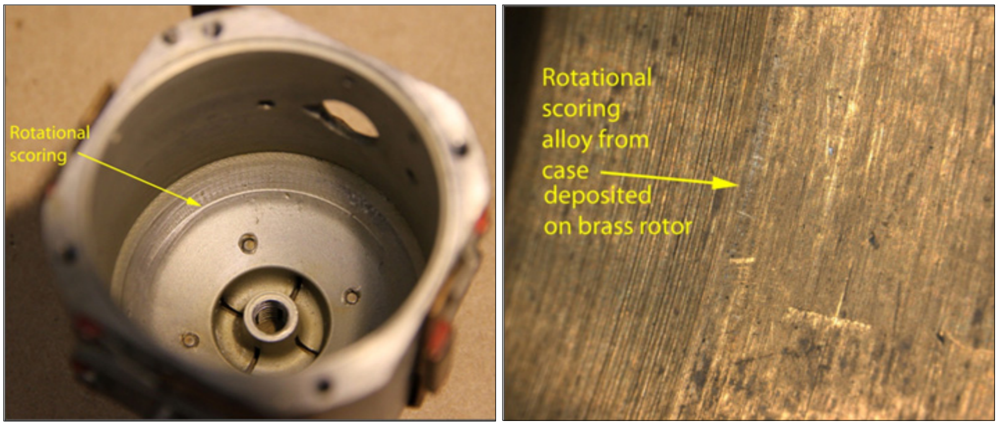
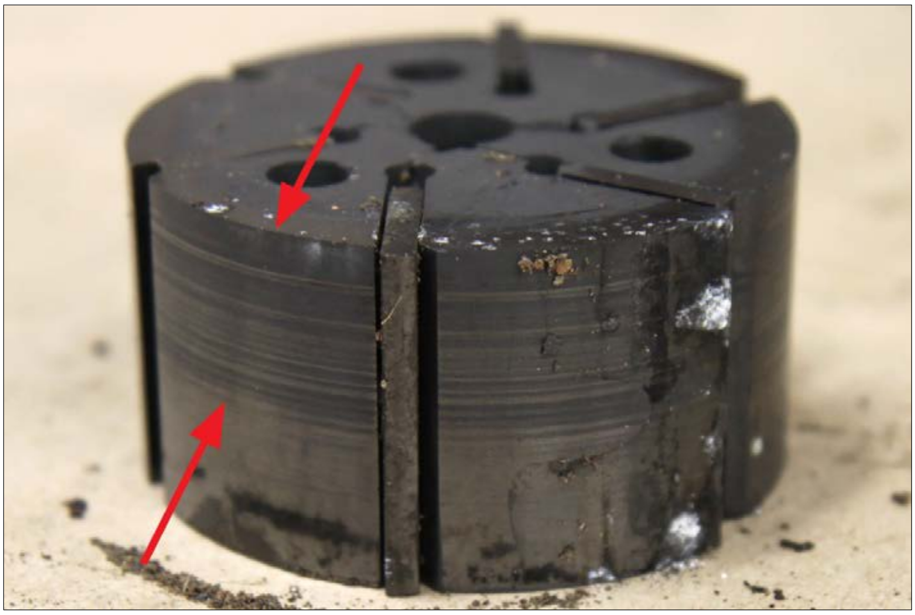


Figure 7a: Copilot AH case **Figure 7b:** Copilot AH rotor

The aircraft's vacuum system provided a means of powering some of the flight instruments. This system consisted of a vacuum pump on each engine, two relief valves, vacuum manifold, operating instruments and necessary plumbing. The manifold had check valves to prevent reverse flow and vacuum loss in the event of failure of either vacuum pump. Hoses were routed from the manifold to the directional gyro, artificial horizon (AH) gyros and the suction gauge.

The left engine vacuum pump was examined and exhibited body damage, but the frangible drive mechanism was intact. Disassembly of the vacuum pump revealed a fractured rotor; however, the carbon vanes were intact and operated normally. Evidence of rotational scoring was observed on the external surfaces of the rotor components (Figure 8).

Figure 8: Rotational scoring on left vacuum pump



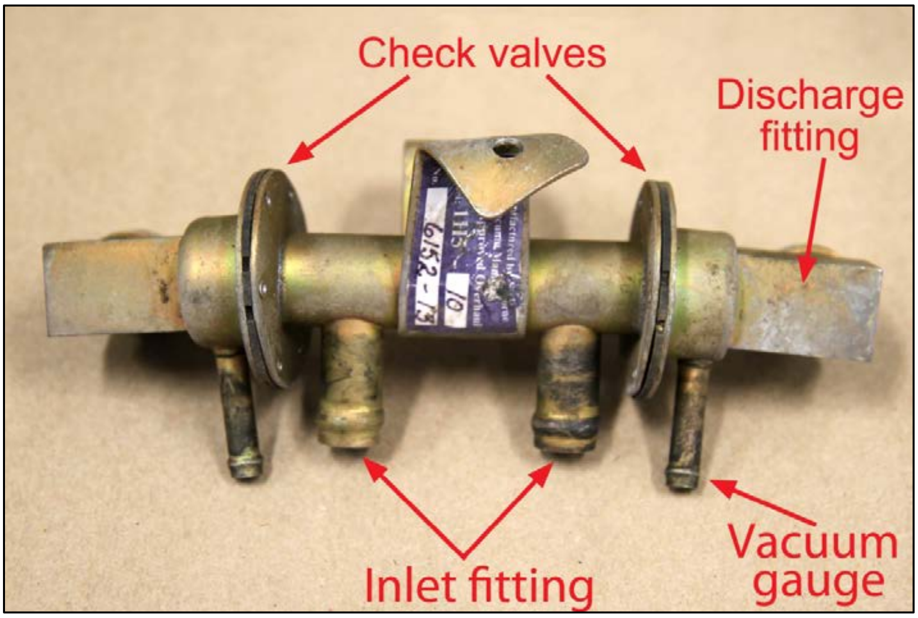
The right engine vacuum pump also exhibited external damage, with the frangible drive mechanism intact. Internally, the pump showed severe damage of the internal drive, with a number of the carbon rotor segments and two of the vanes shattered. Evidence of rotational scoring was observed on some segments.

The vacuum regulator valve was severely damaged by impact forces. Disassembly of the valve did not reveal any pre-existing defects.

The vacuum manifold also exhibited damage consistent with the impact forces during the accident sequence (Figure 9). Operational leak tests were conducted on the unit using procedures from the manufacturer's maintenance manual. A slight leak was observed through the check valve seals; however, the seals were physically in good condition, and the leakage was considered to be the result of distortion in the manifold, sustained during the impact sequence.

No evidence was found to suggest that the vacuum system was partially or completely inoperative at the time of the accident. All equipment damage observed was consistent with forces sustained during the accident impact sequence.

Figure 9: Vacuum manifold valve



Survival aspects

The 406 MHz emergency locating transmitter (ELT) on-board the aircraft had dislodged from its fixed position and was found adjacent to the furthermost section of fuselage in the wreckage trail. The *auto/on* switch was selected to the *auto* position and the operation indicator light had illuminated to show that the internal inertial switch had turned the transmitter on. Functional checks indicated the ELT was not radiating a signal. This was attributed to the visible damage sustained by the external antenna cable.

Due to the extensive damage sustained by the aircraft and the disruption of the cabin/cockpit space, the accident was not considered to have been survivable.

Organisational and management information

The accident pilot was employed by an organisation subcontracted to assist with a charter flight operation from Darwin to Bathurst and Melville Islands and return. That charter was principally conducted by another operator, who held a business contract for providing private passenger transport services to the Tiwi Islands. Arrangements for supply of the operating aircraft (VH-XGX) from the charter operator to the subcontractor were made following the earlier unserviceability of the subcontractor's intended aircraft (VH-SKN).

Following the accident, a Civil Aviation Safety Authority (CASA) investigation into the organisational arrangements for the flight services determined that the flights involving XGX on February 5 2011 were being operated by the subcontracting organisation (the pilot's employer), as the pilot remained under their employ and direction at all times. Under these circumstances, the pilot held the correct ratings, endorsement and was properly authorised to fly the Cessna 310. The subcontractor was authorised to conduct the flights in question and the aircraft type was included on their Air Operator's Certificate (AOC).

Human factors

There are three human sensory systems used for maintaining spatial awareness in the physical world; the visual system, the vestibular system (the balance organs located in the inner ears) and the somatosensory system (nerves in the skin, muscles and joints sense position based on gravity).

In the aviation context, *spatial disorientation* is a condition where a pilot is unable to correctly interpret the aircraft's attitude, altitude or airspeed in relation to the Earth, or other points of reference, and tends to occur in conditions of limited visibility outside the cockpit.

There are a number of different types of spatial disorientation phenomena which can be experienced by pilots. Research has shown that spatial disorientation can affect any pilot and that nearly all pilots will experience it at some time during their flying career[5].

Somatogravic illusion

The somatogravic illusion is a vestibular illusion, and is also known as the dark night take off illusion, the pitch up attitude illusion, and the inversion illusion.

The vestibular system consists of the semi-circular canals and the otolith organs[6] within the inner ear. Acceleration in any direction causes the fluid within the semicircular canals to deflect the fine hairs of the otolith and stimulate nerve impulses. The vestibular nerve then transmits the impulses to the brain[7] to interpret the motion. Due to the nature of the otolith organs, tilt and acceleration produce the same sensation (Figure 10).

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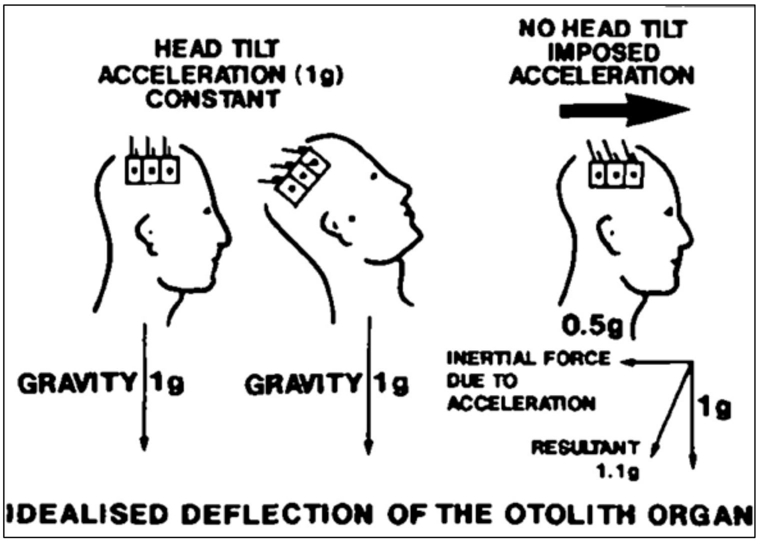
[5] Bureau of Air Safety Investigation, SAB/RP/05/01, *"Dark Night Take-off Accidents in Australia",* April 1995.

[6] The otolith organs are a structure in the inner ear consisting of the utricle and saccule which detect both horizontal movement and vertical acceleration.

[7] Melchor J. Antunano MD, *Spatial Disorientation*, AM-400-03/1, Federal Aviation Administration, Civil Aerospace Medical Institute, Aerospace Medical Education Division, pp 2-3

Figure 10: Tilt and acceleration as felt by the otolith organ[8]



The somatogravic illusion generally occurs in conditions with limited external visual cues, such as night operations or flight in instrument meteorological conditions (IMC). Under limited visibility, the brain is unable to differentiate between the sensations associated with tilt and those associated with acceleration. The illusion is generally most strongly felt at takeoff, which increases the risk of a pilot intentionally lowering the aircraft's nose in response to a sensation that the aircraft is climbing too steeply. This serves to increase the acceleration further and will compound the illusion, with the aircraft ultimately descending into terrain if the illusion is not recognised and overcome. The illusion has been linked to a number of dark night take-off accidents where the normally-operating and otherwise under control aircraft has impacted terrain a short distance from the end of the departure runway.

Pilots with limited recent night or instrument flying experience appear more susceptible to the effects of spatial disorientation, as they may be unable to recognise the misleading acceleration sensations. The level of training and recency may also affect the pilot's instrument scan technique used to combat the somatogravic illusion.

The development and severity of the somatogravic illusion can be influenced by physiological factors such as an illness affecting the vestibular system (including the common cold), anxiety and stress, medication, alcohol and fatigue. Some operational factors can also contribute, including workloads associated with single pilot operations or failure of critical flight instruments.

More information about dark night take-off accidents and the somatogravic illusion can be found in the ATSB Aviation Research and Analysis Report SAB/RP/95/01, *Dark night take-off accidents in Australia* (available at www.atsb.gov.au).

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[8] Bureau of Air Safety Investigation, Investigation report B/901/1047, *Beech King Air E90 VH-LFH, Wondai, Queensland, 26 July 1990,* April 1991, p 16.

Human factors training

Pilots are taught to identify and manage the perceptual illusions that can occur during flight. The CASA *Day VFR* (Visual Flight Rules) syllabus details the specific requirements that pilots needed to be aware of prior to the completion of the commercial pilot licence (CPL) training. For a CPL, the day VFR syllabus states that it is essential for pilots to have basic knowledge of the anatomy of the ear, and to be able to describe the nature and characteristics of associated perceptual illusions (including the somatogravic illusion).

Pre-flight planning is also thought to be an effective mechanism to minimise the risk of a spatial disorientation event occurring, or minimising the outcome in the case of an event. Consideration of the environment in which the flight will be undertaken will remind pilots of the potential hazards and they may be better prepared to deal with them if or when they arise.

During interview, the operator’s chief pilot noted that he had informally discussed the somatogravic illusion with the company pilots (including the accident pilot) and that they had shown an understanding of the phenomena.

ANALYSIS

Introduction

The low angle of entry into the trees, the wings-level orientation of the aircraft and the relatively long wreckage trail indicated that the aircraft was under control at the time of the initial impact with terrain. The aircraft probably stopped climbing and started to pitch down shortly after takeoff, until it collided with the ground approximately 1km from the end of the departure runway. The likely aircraft trajectory was consistent with the pilot being influenced by the somatogravic illusion.

Analysis of the factors that contributed to this accident was limited by the extent of damage to the aircraft from the impact and post-impact fire. While there were no mechanical issues identified during the on-site inspection of the wreckage, the significant disruption to the aircraft and its systems during the impact sequence limited the conclusions that could be drawn from the physical evidence.

There was no indication of pilot impairment or incapacitation prior to the accident. The pilot held a Class-1 aviation medical certificate and there were no reports of any illness or condition likely to increase the risk of impairment or incapacitation. Post-mortem examination did not identify any preconditions for, or existence of, pilot impairment or incapacitation.

Somatogravic illusion

Spatial disorientation is a risk in night and instrument flying and by definition is difficult for the pilot to detect.

The dark night environment, together with the runway-33 departure from the aerodrome being a ‘black hole’ with minimal external visual cues, presented conditions conducive to pilot spatial disorientation. Further, the location of the aircraft’s impact (approximately in line with and 1 km from the end of runway 33), and the distribution of the aircraft wreckage along the direction of flight (suggestive of the pilot being unaware of any unusual attitude or flight profile) was generally consistent with the pilot having experienced the effects of the somatogravic illusion soon after takeoff.

There was no evidence that the pilot had any common preconditions or aggravating factors for disorientation, such as a lack of instrument flying qualifications, physiological symptoms or high workload. A review of the pilot’s ability to manage the environmental conditions indicated that he was qualified to operate the aircraft at night in instrument meteorological conditions and he had the required minimum night flying experience. While the pilot had flown to Bathurst Island at night on two previous occasions, including the week before the accident, his overall night flying experience was limited.

There was no evidence of any aircraft airworthiness issues that may have contributed to the accident, and while the possibility of an anomaly or system failure with the potential to contribute to spatial disorientation existed, it was considered unlikely. In the context of this accident, any failure of the flight instruments or instrument lighting might have been a distraction that allowed the aircraft flight path divergence to remain undetected.

Pre-flight planning can be an important factor in minimising a pilot's susceptibility to a spatial disorientation event. Consideration of the specific operational environment pre-flight will aid in the identification of the potential hazards and assist the pilot to consider the ways in which those hazards can be managed.

Possible electrical/instrument failure

In the dark-night take-off conditions, failure of either the cockpit/instrument panel lighting or key flight instrument/s had the potential to adversely affect the pilot's ability to control the aircraft and maintain a constant climb.

The reported discovery of an illuminated torch at the accident site could have indicated that the pilot might have been using it after failure of instrument lighting; however it could also have been switched on by the dynamic forces and impacts associated with the terrain collision.

An examination of the aircraft electrical systems showed that several alternate illumination sources may have been available to the pilot in the event of the failure of the primary instrument lights. These lights (including map and overhead panel lighting) were on different circuits and independent of the primary flight instrument lighting – linked only by the main aircraft electrical buses.

The wreckage examination showed that other electrically-operated equipment, such as the landing gear and landing light retraction systems had operated normally in the moments before the accident. As such, if failure of the main electrical buses had occurred (thus removing *all* instrument lighting), it could only have been *after* these operations had been performed and *before* the aircraft started to descend as a result of that failure.

A review of the electrical system and wreckage indicated that a complete electrical failure was unlikely. The ATSB considered the possibility of a circuit breaker opening on the flight instrument light system, or an individual lighting failure to one of the primary flight instruments (such as the artificial horizon) following retraction of the landing gear and lights, however, there was no evidence to support a finding.

There was no evidence of flight instrument malfunction and the vacuum system that powered the artificial horizon instruments appeared to have been operational.

Operational aspects

The subcontracting arrangements between the two companies conducting flight operations were not considered to have increased safety risk in this occurrence, as the accident pilot was flying under his employer's AOC and organisational systems, and the pilot had recent experience in the aircraft.

Short-notice operations such as the aircraft cross hire arrangements in this case *do* have the potential to influence safety, if those activities are not addressed within either party's safety systems, or if the activities are conducted outside the provisions of those systems.

FINDINGS

From the evidence available, the following findings are made with respect to the controlled flight into terrain accident involving Cessna 310R aircraft, registered VH-XGX, which occurred near Bathurst Island Aerodrome, Northern Territory on 5 February 2011. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing safety factors

- The pilot commenced the take off from Bathurst Island in a direction (away from horizon lights) and in conditions (after last light, with no moon) that provided no visual references outside of the cockpit during the initial climb; significantly increasing the likelihood of the pilot experiencing the somatogravic illusion.
- Shortly after the takeoff and initial climb, the pilot most likely became disorientated due to the effects of a somatogravic illusion and placed the aircraft in a shallow descent as the aircraft accelerated, leading to a controlled flight into terrain approximately 1 km from the end of the runway.

Other key findings

- Subject to the limitations presented by the damage sustained, there was no evidence of a problem within the aircraft systems or equipment having contributed to the accident.

SAFETY ACTION

While no safety issues were identified during this investigation, the Australian Transport Safety Bureau (ATSB) would like to highlight the following safety actions that have been taken following the accident involving VH-XGX on 5 February 2011.

Proactive safety action

Subcontracted charter operator

Following the accident, the subcontracted operator (the pilot's employer) advised of their intention to initiate increased night operational checks of new pilots and low/medium time pilots operating from Darwin.

The operator indicated that a new system had been introduced in November 2011 whereby new pilots were required to demonstrate competency in a number of areas whilst performing supervised night circuits.

The ATSB reviewed a number of aircrew records after revision of the training and supervision requirements. The records reflected the implemented changes, with several pilots having undergone the check and training sessions prior to being cleared for single pilot operations.

APPENDIX A: SOURCES AND SUBMISSIONS

Sources of Information

The sources of information during the investigation included:

- witnesses present on the night of the accident
- the pilot's employer
- the operator of VH-XGX
- the owner and maintainer of VH-XGX
- the Civil Aviation Safety Authority (CASA)
- Geoscience Australia
- the Bureau of Meteorology (BoM)
- The Cessna Aircraft Company

References

Bureau of Air Safety Investigation, *Beech King Air E90 VH-LFH, Wondai, Queensland, 26 July 1990,* April 1991.

Bureau of Air Safety Investigation, SAB/RP/05/01, *"Dark Night Take-off Accidents in Australia",* April 1995.

Melchor J. Antunano MD, *Spatial Disorientation*, AM-400-03/1, Federal Aviation Administration, Civil Aerospace Medical Institute, Aerospace Medical Education Division.

Submissions

Under Part 4, Division 2 (Investigation Reports), 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. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the Civil Aviation Safety Authority, the pilot's employer, the operator of VH-XGX, a representative of the pilot's next of kin (NOK) and the Cessna Aircraft Company. Submissions were received from the operator and the representative of the pilot's NOK, and where considered appropriate the report was amended.

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Investigation

ATSB Transport Safety Report
Aviation Occurrence Investigation

Controlled flight into terrain – Cessna Aircraft Company 310R, VH-XGX, near Bathurst Island Aerodrome, Northern Territory, 5 February 2011

Final