AVIATION OCCURRENCE REPORT

CONTROLLED FLIGHT INTO TERRAIN

ATHABASKA AIRWAYS LIMITED
CESSNA 310R C-GILR
SANDY BAY, SASKATCHEWAN 1 mi NE
12 OCTOBER 1993

REPORT NUMBER A93C0169

Transportation Safety Board of Canada | Bureau de la sécurité des transports du Canada

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Synopsis

The aircraft departed Sandy Bay, Saskatchewan, on a chartered night flight to La Ronge. Shortly after take-off, the aircraft struck trees and crashed on the rocky shoreline of the Churchill River. All four occupants of the aircraft were fatally injured.

The Board determined that the pilot established, and the aircraft remained in, a very shallow climb after take-off and struck trees during the initial departure, while in controlled flight prior to reaching cruise climb speed.

Other factors that may have contributed to the accident were the poor ground and sky illumination, the absence of illumination from the landing lights, and the deviation from the recommended night departure profile.

Ce rapport est également disponible en français.

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OCCURRENCE NUMBER:	A93C0169
TYPE OF OCCURRENCE:	Controlled Flight into Terrain (Accident)
DATE OF OCCURRENCE:	12 October 1993
LOCAL TIME:	2130 CST
LOCATION:	Sandy Bay, Saskatchewan 1 mi NE(M)
TYPE OF AIRCRAFT:	Cessna 310R
REGISTRATION:	C-GILR
TYPE OF OPERATOR:	Air Carrier
TYPE OF OPERATION:	Charter
DAMAGE CATEGORY:	Destroyed
PILOT LICENCE:	Commercial - Aeroplane

PILOT-IN-COMMAND

PILOT HOURS:	Last 90 Days	Total
All Types	80	4,700
On Type	80	500

INJURIES:	Crew	Passengers
Fatal	1	3
Serious	-	-
Minor	-	-
None	-	-

1.0 Factual Information

1.1 History of the Flight

The aircraft departed Sandy Bay, Saskatchewan, on a chartered night flight to La Ronge. Shortly after take-off, the aircraft struck trees and crashed on the rocky shoreline of the Churchill River. All four occupants of the aircraft were fatally injured.

1.2 Witnesses' Accounts of the Accident

Several residents of the Sandy Bay community witnessed the accident from the vicinity of the aerodrome terminal building. The pilot and the three passengers arrived at the aerodrome by car just before 2130 central standard time (CST)[1] and boarded the twin-engine Cessna 310 aircraft, which was parked near the terminal building. The aircraft's engines were started immediately and the aircraft remained stationary on the ramp for approximately three minutes before taxiing to the departure runway. The runway lights illuminated as the aircraft began to taxi to the threshold of runway 05. Witnesses also noted the illumination of the aircraft's navigation lights.

During take-off, the aircraft appeared to accelerate normally, lifted off approximately two-thirds of the way down runway 05, and began a very shallow climb. Several moments later, witnesses noted a brilliant flash that occurred approximately one-half mile to the northeast of the aerodrome. The witnesses informed the RCMP that a crash had occurred, and emergency response to the accident was directed and coordinated by the police.

1.3 Wreckage and Impact Information

The aircraft struck the trees approximately 2,400 feet beyond the upwind end of runway 05, on a heading of 040 degrees magnetic (M)[2]. The initial impact point was estimated to be about 5,400 feet from the point where the take-off roll was initiated, 40 feet above the aerodrome elevation and 150 feet left of the extended centre line of the runway.

Damage to the trees indicates that the aircraft was in a wings-level attitude and at a low climb angle when it first hit the trees. The initial impact caused extensive damage to the right wing and engine areas.

Following the initial tree strikes, the aircraft entered a right-hand roll, continued approximately 750 feet through the trees, and struck the shoreline of the Churchill River in an inverted attitude. It then slid approximately 150 feet on a heading of 066 degrees (M) before coming to rest.

1 All times are CST (Coordinated Universal Time [UTC] minus six hours) unless otherwise stated.

2 See Glossary for all abbreviations and acronyms.

Both engines and propellers, and many of the cockpit instruments were torn free from the aircraft during the collision with the ground. Fuel from the left main fuel tank ignited and the crash site was completely engulfed in a fireball which quickly dissipated; the fuselage and cabin area continued to burn and were heavily damaged by fire. The accident was non-survivable as a result of the high impact forces and the post-crash fire.

1.4 Wreckage Examination

1.4.1 Site Examination

Continuity and integrity of the flight control systems were confirmed during a post-accident examination of the wreckage. The rudder trim was found to be between zero and three degrees nose right, the elevator trim was found at approximately 11 degrees nose up, and the aileron trim was neutral. The landing gear and the wing-mounted landing lights were fully retracted, and the flaps were in the retracted position.

The left throttle lever was found in the idle position; the right throttle and both propeller and mixture levers were found to be slightly aft of their fully forward positions. Both left-engine magneto switches were found in the OFF position; the right engine magneto switches were ON. The condition of the cockpit instruments and lighting controls could not be determined because of damage caused by the post-crash fire.

The indicator needles for the fuel quantity gauge were captured at a reading of 235 pounds (lb) for each tank. The right fuel-selector valve was found in the main tank detent position. The left fuel-selector valve position could not be determined as it was driven past the limit stop.

The emergency locator transmitter (ELT) was in the armed position but had been destroyed by fire. No ELT signal had been detected.

1.4.2 Engine Teardown

Both engines had torn free from their mounts during the initial ground impact and had been overrun by the fuselage. As a result, both engines displayed severe impact damage. All damage was assessed to be overload in nature and was attributed to the impact forces. The engines were removed from the accident site and taken to the TSB Central Region wreckage examination facility for further examination. A complete teardown of both engines revealed no pre-existing mechanical faults that would have contributed to a loss of engine power.

Pine needles were embedded around the right engine's propeller governor which is located in the forward, lower-left quadrant of the engine. The propeller governor lever was also damaged and the governor was separated from its mounting base.

The left engine oil sump was crushed in the vicinity of the camshaft gear and displayed scuff marks associated with contact and rotation of the camshaft. It was determined that the crushing and subsequent scuffing of the oil sump occurred after the engine had broken free of the nacelle. This damage is indicative of high rotational energy at impact.

1.4.3 Propeller Examination

The propellers were removed from the accident site and transported to the McCauley Accessory Division, in Vandalia, Ohio, for teardown and examination. Damage to the propeller blades and hub indicated that both propellers had been rotating at impact.

The left propeller blade angle was captured between 16.6 and 20.2 degrees (normal governing range). In addition, two of the three propeller blades exhibited bending and twisting which is associated with high power.

The right propeller blade angles were captured between 43 and 48 degrees; this blade angle occurs when the propeller is in a transition mode, moving toward or away from the feather position. Light counterweight signature markings were found on the propeller hub corresponding to a blade angle in the normal operating range (near low pitch).

1.5 Aircraft Systems

1.5.1 General

The Cessna 310R is certified under Civil Airworthiness Regulation (CAR) 3 and portions of Federal Aviation Regulation (FAR) 23. The aircraft is powered by two Continental (IO-520-MB) engines, each of which is capable of producing 285 horsepower (hp). The engines are coupled to two full-feathering, 3-bladed McCauley propellers. The low pitch stop for this propeller type is set to 13.9 degrees and the feather stop is set at 81.7 degrees. The aircraft was properly equipped for both instrument flight and night visual flight operations.

1.5.2 Aircraft Technical Records

Examination of the aircraft technical records revealed that the aircraft was being maintained on a 200-hour progressive care maintenance schedule, with inspections every 50 hours.

Six days prior to the accident, an intermittent "miss" was reported in the right engine. Both engines were checked for proper compression, fuel flow, and ignition, and the reported miss could not be duplicated. The aircraft was returned to service with no further difficulties reported.

On the day of the accident, the aircraft underwent a 50-hour inspection at a total airframe time of 3,796.0 hours. In addition, the propeller hubs were inspected for cracks in accordance with Cessna Multi-Engine Bulletin (MEB-3), the vacuum air filter inspection was completed, and the right-hand induction air filter was inspected. The aircraft was returned to service upon completion of these inspections. There were no outstanding discrepancies documented in the aircraft's technical records.

At the time of the crash, the aircraft's total airframe time was approximately 3,798 hours.

1.6 Operational Information

1.6.1 Flight Dispatch

The charter flight had been dispatched on a Flight Notification in accordance with the requirements of the company's approved operations manual. The aircraft departed Prince Albert at 1640, picked up an additional passenger at La Ronge, and proceeded directly to Sandy Bay. The passengers were to attend a community planning meeting. The return flight from Sandy Bay was scheduled to commence at 2030, but was delayed for approximately one hour in order to meet passenger requirements.

1.6.2 Weight and Balance

The aircraft's weight and balance were within prescribed limits. The take-off weight at Sandy Bay was estimated at 5,300 lb and the distribution of that load would have placed the aircraft's centre of gravity (C of G) near the forward edge of the weight and balance envelope. A load control sheet was completed in advance of the flight in accordance with company procedures.

The normal take-off trim setting for an aircraft loaded with a forward C of G would be approximately 11 degrees nose-up.

1.6.3 Flight Operational Requirements

Sandy Bay is situated in uncontrolled airspace; flights through uncontrolled airspace may be flown either under visual flight rules (VFR) or instrument flight rules (IFR). Visual flight, at night or otherwise, is governed by the *Air Regulations*, which state that "when operating in accordance with Visual Flight Rules, aircraft shall be flown with visual reference to the ground or water...." The company's operations manual amplifies this order and provides a further limitation for night VFR flights, by stating that these flights are, "...to be operated with visual reference to ground objects solely as a result of lights on the ground or adequate celestial illumination."

Weather minima for VFR flight are outlined in the Air Navigation Orders and would require a ceiling of 1,500 feet above ground level (agl) and a flight visibility of one nautical mile (nm) for a VFR aircraft to reach the normal circuit altitude after departure.

1.7 Environmental Conditions

1.7.1 Weather

There are no actual Atmospheric Environmental Service (AES) weather observations available for Sandy Bay. However, the AES area forecast (FACN5 CWWG 122330Z) for the Sandy Bay region indicates that there was a broken ceiling at 3,000 to 4,000 feet above sea level (asl). This layer was topped at 8,000 feet, with a high scattered (above 20,000-foot) layer above. The visibility in the region was forecast to be more than six miles. A few stratus ceilings were expected in the area with an occasional visibility forecast to be as low as two to four miles in light freezing drizzle and fog. RCMP personnel and other witnesses indicated that local ceilings were approximately 3,500 feet agl. The temperature was reported to be approximately minus two degrees Celsius. The wind was very light.

The pilot received a full weather briefing from the Prince Albert Flight Service Station at 1410 and again at 2110 just prior to his departure from Sandy Bay.

1.7.2 Ambient Lighting Conditions

The Sandy Bay aerodrome is located in a relatively remote northern community. Sunset occurs early over the fall and winter months and, during the hours of darkness, the ambient light produced by the night sky is often negligible. There are very few ground lights northeast of the aerodrome and witnesses agreed that, at the time of the accident, there was little or no illumination from either the lights of the community or from the night sky.

1.8 Aerodrome Information

Sandy Bay is a registered aerodrome that is owned and operated by the Saskatchewan Highways and Transportation Department. The aerodrome elevation is listed in the *Canada Flight Supplement* (CFS) as approximately 1,000 feet asl.

The aerodrome's 3,000-foot by 75-foot treated gravel runway is oriented on a 050-degree magnetic heading. The runway is equipped with threshold and runway end lights and with low intensity runway edge lights. These lights are controlled using Aircraft Radio Control of Aerodrome Lighting (ARCAL - Type J) on frequency 122.8 MHz. The pilot can activate the aerodrome lighting system by keying the aircraft microphone transmitter five times within a five-second period. The lights will then remain illuminated for approximately fifteen minutes; the timing cycle can be restarted at any time by repeating the keying sequence. A rotating airport beacon is located adjacent to the terminal building but had been unserviceable for an extended period of time; this beacon was unavailable on the night of the accident.

Based on an inspection of the local area following the accident, it was determined that low rolling hills are located beyond the departure end of runway 05. These hills are forested with a mixture of deciduous and coniferous trees which rise to an average height of approximately 30 to 40 feet above ground level. The tops are well below the obstacle limitation surface that would normally be applied to the departure end of a certified airport.

1.9 Communications

The Sandy Bay aerodrome has an aerodrome traffic frequency (ATF) of 122.8 MHz. That frequency is also used by a local operator, Jackson Air Service, to provide private advisory services in the Sandy Bay area. Jackson Air Service was monitoring the ATF on the night of the accident and reported hearing a short-duration, radio frequency side-band transmission at approximately 2130. A communications search was conducted by Transport Canada Air Traffic Services following the accident; no other reports of radio communications were noted.

1.10 Aerodrome Take-off and Departure Procedures

Transport Canada's *Aeronautical Information Publication* (AIP) indicates that "aircraft departing an uncontrolled airport should climb straight ahead on the runway heading until reaching the circuit traffic altitude before commencing a turn in any direction to an en route heading." The normal circuit altitude for an aerodrome is approximately 1,000 feet agl.

1.11 Aircraft Climb Profiles

1.11.1 Cessna 310 Initial and En Route Climb Profiles

The Cessna 310R aircraft flight manual indicates that "after takeoff, it is important to maintain the intentional one engine inoperative speed (92 KIAS) to 50 feet..." and that, "as the airplane accelerates still further to all engines best rate-of-climb speed (107 KIAS), it is good practice to climb rapidly to an altitude at which the airplane is capable of circling the field on one engine."

Once an aircraft has reached a safe altitude after take-off, the pilot may transition to one of several recommended climb profiles. The climb profile selected will depend on operational and weather conditions at the departure aerodrome. The Cessna 310R aircraft flight manual states that a "normal cruising climb is recommended where practical and should be conducted at 115 to 130 Knots Indicated Air Speed (KIAS), using approximately 75% power (2,500 RPM and 24.5 inches of manifold pressure)." The aircraft flight manual indicates that the rate of climb in a cruise climb configuration is approximately 900 feet per minute (fpm).

1.11.2 Company Procedures

The pilot had developed a habit of establishing a shallow climb angle immediately after take-off, and of accelerating to the cruise climb speed range before commencing a climb. The pilot's use of this technique had precipitated a number of safety concerns among the company's operational and training staff.

Several weeks prior to the accident, in response to the above-noted concerns, the company training pilot disseminated a recommended climb procedure for use during night departures from remote aerodromes. That procedure advocated a "performance climb" at blue line speed (107 KIAS) to 500 feet agl before commencing any turns to the on-course heading. The emphasis of this memorandum was that company pilots were to ensure that departure airspeeds would not be higher than 107 KIAS until the aircraft was well clear of the ground. The pilot involved in this occurrence (acting in his capacity as the company operations manager), subsequently questioned the chief pilot regarding the validity of the recommended departure procedure and argued in favour of using a cruise climb profile rather than a performance climb to minimize passenger discomfort during departure.

1.12 Aircraft Performance

1.12.1 Aircraft Climb Performance

The aircraft flight manual indicates that the aircraft's climb rate, based on a FULL POWER performance climb at 107 KIAS, and under the same weight and environmental conditions as those of the accident, would be approximately 1,800 fpm. The climb angle of the aircraft under these conditions was calculated to be approximately ten degrees up.

The aircraft flight manual lists the aircraft's rate of climb in a cruise climb configuration to be approximately 970 fpm. Based on a forward velocity of 115 - 130 KIAS, the climb angle for a cruise climb was calculated to be approximately five degrees up.

1.12.2 Aircraft Acceleration Performance

It was determined from the aircraft flight manual that the ground run for a normal take-off with a zero-degree flap setting would be 1,700 feet, and that the total distance required to clear a 50-foot obstacle would be approximately 2,080 feet. A maximum performance take-off with a 15-degree flap setting would require a ground run of approximately 1,300 feet. The distance required to clear a 50-foot obstacle in this take-off configuration would be approximately 1,700 feet.

The aircraft flight manual does not provide detailed information on the time or distance that would be required by the aircraft to accelerate from the start of its take-off roll to its cruise climb speed range of 115 to 130 KIAS. For that reason, further information regarding the acceleration performance of the Cessna 310R aircraft type was obtained by observing and recording the instrument readings of a similar aircraft during a number of take-off and climb sequences. Data from those observations were then used, along with information from the aircraft flight manual, to project the acceleration performance of the accident aircraft.

From those calculations, it was estimated that the time taken for the accident aircraft to accelerate from the start of its take-off run to its cruise climb speed would have been approximately 40 seconds. The distance that the aircraft would have travelled from the start of its take-off roll at Sandy Bay to the point where the cruise climb speed had been obtained was calculated to be approximately 6,400 feet. These calculations took into account known differences in outside air temperature, wind direction and speed, and runway surface conditions.

1.13 Regulations and Standards

1.13.1 Company Operations Manual

Transport Canada regulates the aviation industry and monitors and controls licensing and operational standards. The Athabaska Airways Ltd. operations manual is a fundamental document that governs the manner in which flight operations will be conducted within the company. The content of the operations manual and any of its amendments must be approved by Transport Canada before becoming company policy.

The operations manual details the formal organizational structure for the airline. Within that structure, the chief pilot is assigned the responsibility and authority "...for the administration of all matters concerning pilots, the pilot training program, examinations, competency tests, and for establishing operating limitations for the aircraft and the crews." Specifically, the chief pilot is responsible for ascertaining the ability of pilots to meet Transport Canada's requirements and has "final authority in matters pertaining to pilot standards." The chief pilot works directly for the operations manager.

1.13.2 Company Training Program

Transport Canada requires each air carrier to establish and maintain a training program that will satisfy the requirements of the Air Navigation Orders. In early 1990, Transport Canada authorities noted a number of deficiencies in Athabaska's training program. As part of an action plan to correct the noted deficiencies, the company hired a training pilot and then established new procedures for ensuring the operational control of its personnel. Following this corrective action, no further deficiencies were noted during Transport Canada audits.

1.14 Pilot Qualifications and Experience

The 49-year-old pilot was licensed and qualified to fly the Cessna 310 in accordance with the requirements of the *Aeronautics Act* and the company's operating certificate. He held a valid commercial pilot licence and a Group I instrument rating; his licence was annotated with a medical restriction requiring the use of glasses while flying. This pilot also held the position of company operations manager.

The majority of this pilot's experience was on single engine aircraft. He was generally recognized as being very well qualified and competent at flying the Cessna 185 and the de Havilland (DHC-2) Beaver aircraft types. His flight check reports and training file indicate a consistently strong flying performance in single-engine, VFR operations.

In early 1990, he began conversion training onto the twin-engine Cessna 310 aircraft type. This conversion required the pilot to obtain a multi-engine rating, an instrument endorsement for his commercial licence, and a pilot proficiency check (PPC) on the Cessna 310 aircraft. The pilot's transition to the Cessna 310 occurred at the time when the company's training program was under scrutiny by Transport Canada.

In January 1993, the pilot failed a recurrent instrument flight test and was given extra flight training by company training personnel. During that period, the training personnel noted that the pilot was nervous while operating in instrument flight conditions. This nervousness was characterized by constant body movement, the shuffling of maps and approach plates, and the repetitive removal and replacement of his corrective lenses. Training personnel assessed the pilot's flying performance to be below the standard that is required to obtain and hold an instrument rating, and the chief pilot recommended that further training on the Cessna 310 be curtailed until the pilot gained more experience and confidence in the IFR environment. The chief pilot recommended that this experience be obtained as a first officer flying the company's scheduled Cessna 404 flights. The company president decided to allow additional training, but on the C-310 aircraft. However, in order to alleviate any possibility of conflict of interest between the trainee (in this case, the operations manager) and the chief pilot or his training staff, the president directed that the additional training would be conducted in Prince Albert, and under the guidance and control of the general manager.

The company's training records indicated that the pilot's performance improved during a subsequent 6.4-hour training period that was conducted by the company's general manager. However, in March 1993, the pilot again attempted, and once again failed, an instrument flight test and PPC administered by a Transport Canada inspector. An additional 2.8 flight training hours followed and the pilot then passed a Transport Canada instrument flight test and PPC on the Cessna 310, with satisfactory performance. No special restrictions were applied to the licence nor to the operational employment of the pilot by either Transport Canada or by company management.

Only one of the training flights had been conducted at night.

1.15 Medical Issues

1.15.1 General

All holders of Canadian pilot licences must undergo a periodic medical examination to determine their medical fitness to exercise the privileges of their licence. The frequency of medical examinations depends on the age of the applicant and the type of licence held. For some examinations, supplementary tests may also be required. The Health Canada Regional Aviation Medical Officer (RAMO) acts on behalf of Transport Canada and is responsible for ensuring that each applicant is medically fit to hold an aviation licence; a pilot's medical validation certificate is issued on the authority of the RAMO.

Historically, a small percentage of applicants will be on the borderline of the medical standard. In these cases, the candidate's medical information will be reviewed by the Aviation Medical Review Board (AMRB). That board comprises a group of specialists in neurology, cardiology, psychiatry, ophthalmology, internal medicine, otolaryngology, and aviation medicine. The underlying goal of the medical assessment is to allow licence holders to maintain their flying privileges whenever possible within the bounds of aviation safety. In some cases, flexibility may be applied to certain medical standards in order to allow a pilot to retain a licence. This decision to allow flexibility is based primarily on medical information, but may also include a practical assessment of the pilot's ability to compensate for the deviation from the standard. The Transport Canada *Licensing Manual*, Volume 3, section 2.0, indicates that "in most cases where flexibility is applied, the privileges of the licence are restricted."

1.15.2 Pilot Vision

Corrective lenses had been prescribed for this pilot and he was required to wear a specific pair of bifocal glasses while flying. The corrective lenses that had been prescribed were necessary to compensate for astigmatism which had developed following a corneal transplant in 1967, and an additional correction was also necessary to compensate for a degree of presbyopia, a reduction in the ability of the human eye to focus at near distances.

The pilot's medical situation had been considered by the AMRB and, following the conduct of a practical flight test conducted under day VFR conditions, he had been issued a commercial licence in accordance with medical criteria allowing flexibility for vision. His vision was subsequently monitored by medical professionals on a semi-annual basis. There were no indications of any ophthalmologic problems over the time period that the pilot was being monitored, based on a review of the medical forms.

A common problem with the use of bifocal glasses is the possibility that the user may look through the wrong portion of the lens during a visual scan; the result would be the perception of an un-focused image and possible disorientation. In addition, it takes a certain amount of time for the eye to refocus and accommodate between the different lenses of the bifocal glasses. This adjustment function, referred to as the accommodation reflex, is an involuntary physiological function of the eye that enables an object to be focused on the retina. In adjusting for near vision, the pupils constrict, the lenses become more convex, and the eyes converge; in adjusting for far vision, the reverse changes occur. The accommodation reflex of the eye slows with age.

Under ideal circumstances, it would take an extended period of time for the eye to become accustomed to the degree of correction prescribed for the previously noted astigmatism. It would be important that the pilot wear the glasses on a continuing basis in order to maintain this adjustment; irregular use of the glasses would impair this process.

The pilot's glasses were equipped with a string tie which allowed the glasses to be removed from the bridge of the nose and yet retained around the neck.

1.15.3 Toxicology

A toxicology examination revealed that antihistamines were evident in the pilot's urine but not in the blood. Antihistamines are commonly used as decongestants but are also known to have sedative side effects. Warnings regarding the effects of self-medication are routinely promulgated to all pilots.

The Transport Canada published AIP states at section AIR 3.12 that, "simple remedies such as antihistamines...may seriously impair the judgement and co-ordination needed by the pilot." The AIP points out that, "the condition for which the medicine is required may itself reduce a pilot's efficiency to a dangerous level, even though the symptoms are masked by medicine."

1.15.4 Somatogravic Illusion

Somatogravic illusion is an erroneous sensation of pitch (rotation in the vertical plane) caused by linear acceleration; it is most common during rapid acceleration as would be experienced during an aircraft's take-off roll and initial climb.

This problem was first recognized during night operations in World War 2 when aircrew experienced a number of accidents during night take-offs in conditions of clear visibility but inadequate external visual references.[3] Typically the aircraft would be established in a climb, but would then fly into the ground one to two minutes after take-off. Evidence from survivors of such crashes and from experiments designed to reproduce similar flight profiles indicated that the error in pitch attitude is unperceived. Although part of the problem in the earlier years may have been the result of a lag in the gyro-horizon instruments, the physiological basis of the problem was also significant.

A forward acceleration of as little as 0.1 g is sufficient to produce a powerful illusion that the aircraft is climbing.[4] Under visual flight conditions, this illusion is rarely perceived, as it will be over-ridden by available visual information. However, the effect of the illusion becomes more serious at night, when reduced or deceptive visual conditions may distract the pilot's attention away from the flight instruments. If the illusion goes unrecognized, the

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3 J.R.R. Stott, "Spatial Disorientation in Flight", *International Journal of Aviation Safety* December 1984.

4 David O'Hare and Stanley Roscoe, *Flightdeck Performance: The Human Factor*, 1st ed. (Ames: Iowa State University Press, 1990) 48-49.

aircrew may respond inappropriately by pushing the control column forward. The extent to which somatogravic illusion contributed to the accident, if any, cannot be determined.

2.0 Analysis

2.1 Flight Preparation and Take-off

The pilot and the three passengers were observed to enter the aircraft directly upon their arrival at the terminal building; the engines were started immediately and a delay of several minutes followed before the aircraft began to taxi. This delay is normal and can be accounted for by the requirement to complete cockpit pre-flight checks and by requirements to bring the engine oil to its operating temperature range prior to take-off.

The aircraft navigational lighting systems and the runway lights were seen to illuminate when the aircraft began to taxi. As the activation of ARCAL runway lights is radio-controlled, it can be concluded that the aircraft's electrical power generation and radio transmitter systems were functional prior to take-off.

The aircraft was observed to become airborne in approximately 2,000 feet (two-thirds of the runway length). Analysis of take-off distance charts in the aircraft flight manual indicates that, under the existing conditions, the aircraft's ground run should have been approximately 1,700 feet. This theoretical take-off distance is consistent with the witness' accounts and leads to a conclusion that the take-off was likely normal with respect to the documented capability of the aircraft.

2.2 Shallow Climb Profile

2.2.1 Initial Climb

The aircraft was observed to enter a very shallow climb immediately following its take-off. Although the witnesses had no aviation experience, they were resolute in their assertion that this departure profile was shallower than others that they had observed. The essential element of these observations is that the aircraft departed on a shallow flight profile and remained low from lift-off until impact with the trees. It did not appear to climb normally and then subsequently descend. Two possibilities which may explain this deviation from the recommended night departure profile are described below.

2.2.2 Possibility of Undetected Malfunction

It is possible that the aircraft was subjected to some undetected malfunction or abnormality immediately after take-off, and that this malfunction either restricted the aircraft's climb performance, or otherwise distracted the pilot during this critical phase of the flight. This hypothesis is not supported by either the witnesses' description of the flight profile, or by data from the post-accident wreckage analysis.

If the pilot had used the recommended company procedure for night departures from remote aerodromes, he would have established a performance climb to an altitude of 500 feet agl. The climb angle for a performance climb at 107 KIAS is approximately ten degrees, and is more than double that of a cruise climb profile. Under these circumstances, the witnesses should have perceived a steeper-than-normal departure angle; however, the observed climb angle was shallower than normal.

If a mechanical malfunction had occurred, some evidence of the failure should have been identified in the wreckage. Examination of both engines found no pre-existing discrepancies that would have contributed to a loss of engine power. The left engine oil sump was scuffed by contact with the camshaft gear teeth. This scuffing occurred after the engine was free of the nacelle and is indicative of high rotational energy. Two of the three left propeller blades exhibited bending and twisting normally associated with high engine power; impact markings on the hub indicated that the propeller was in the normal governing range. This evidence indicates that the left engine was producing power at impact. The precise level of power could not be determined but would likely have been in the high power range. Because there is no other contrary evidence, it has been concluded that the positioning of the left magneto switches and throttle was likely due to impact forces. It is normal for aircraft switches and controls to change position during a crash sequence.

The right propeller was found in the mid-feathering range at impact; however, light counterweight signature markings, corresponding to a lower blade angle, were found on the propeller hub. The initial tree strikes made by the right propeller were very clean, suggesting a lower pitch angle and high rotational energy. It is believed that the counterweight signature markings were made as a result of this initial tree contact. This evidence of a lower blade angle and high rotational energy indicates that the right engine was likely producing power upon initial tree contact. However, the extent of this power is unknown.

The fact that pine needles were found imbedded around the propeller governor suggests that some damage to the propeller governor likely occurred during tree contact. With the propeller governor disabled at this point, the propeller blades would have begun to feather automatically. However, this feathering action would not have been completed before ground impact. The propeller was captured, therefore, in the mid-feathering range.

The continuity of all aircraft controls was checked following the accident and no discrepancies were apparent. Elevator, rudder, and aileron trim settings were all determined to be in the normal take-off range for the weight of the aircraft. In summary, the post-accident investigation could find no evidence of any pre-impact, mechanical faults in the engine, propeller, or flight control systems.

The aircraft's flight profile does not support the hypothesis that an unidentified malfunction had occurred. Evidence indicates that the aircraft was in a controlled flight attitude (wings-level, at a slight climb angle, and with normal trim settings) at the time of its initial contact with the trees. Additionally, there was only slight lateral deviation of the aircraft's flight path from the extended centre line of the runway.

All of the above factors support a conclusion that the engines were producing power and that the aircraft was under positive control at the time of the crash; this conclusion tends to discount a hypothesis that the pilot was responding to an unusual control or propulsion emergency. There was no evidence of any malfunction prior to impact that would have affected the aircraft's initial climb performance.

2.2.3 Possibility of the Pilot Establishing the Shallow Climb Profile

During training, it was noted that this pilot would deviate from the recommended night departure profile and allow the aircraft to maintain a shallow climb angle immediately after take-off. The pilot would allow the aircraft to accelerate to its cruise climb speed (115 - 130 KIAS) before commencing a climb to the planned en route altitude. The evidence is consistent with the conclusion that the pilot deviated from the recommended night departure profile and established the shallow climb profile observed during the accident flight.

Information derived by test flying a Cessna 310R following the accident indicates that, under flight conditions similar to those of the accident flight, a Cessna 310R will cover a distance of approximately 6,400 feet horizontally from the commencement of its take-off roll to the point where it has accelerated to 130 KIAS (maximum cruise climb speed). The trees that were struck at Sandy Bay were 5,400 feet beyond the initial take-off point and were 40 feet above the runway elevation. If the pilot had established a climb profile similar to the one he had been observed to use in the past, the aircraft could have struck the trees before it had accelerated to its cruise climb speed of 115 to 130 knots.

2.3 Ambient Light Conditions

2.3.1 Ground and Sky Illumination

A night departure from a remote northern aerodrome can be a task requiring extra caution. Even in VFR weather conditions, this type of departure requires the pilot to place increased reliance on vision and on basic instrument flying skills. The transition from outside visual references that are used during the take-off run to instrument references used during the initial climb also demands extra vigilance.

At night, a reduction of external visual references caused by inadequate ground and sky illumination, coupled with the requirement to use cockpit lighting to illuminate the instrument panel, will increase the difficulty of the departure procedure. Such a lack of external visual reference could have adversely affected the pilot's ability to maintain required visual reference with the ground during the initial climb, or to see and avoid obstacles.

2.3.2 Forward Illumination of Flight Path by Landing Lights

Forward illumination of the flight path would be provided by both the nosewheel-mounted taxi light and the two wing-mounted landing lights. As the landing gear was found in the retracted position, the nosewheel-mounted taxi light would not have provided any illumination at the time of impact. It could not be determined whether or not the wing-mounted landing lights were on during the take-off. However, the fact that they were in the stowed position at impact indicates that the wing-mounted landing lights would not have provided forward illumination prior to impact. The absence of forward illumination of the flight path from the aircraft's landing lights during or after the take-off would have prevented the pilot from being alerted to the presence of obstacles and taking action to avoid collision.

2.4 Medical Issues

The pilot had been issued a commercial licence under flexibility for vision and his eyesight was being monitored by medical professionals on a semi-annual basis. Corrective lenses had been prescribed for this pilot and he was required to wear a set of bifocal glasses while flying. It was important that he wear these corrective lenses on a continuing basis in order to maintain his eyes' adaptation to the large degree of correction in the lenses.

Failure to properly use his glasses would have deprived him of the corrective qualities of his lenses, which could have affected his instrument visual scanning ability, created difficulty in transitioning from visual to instrument flight, and adversely affected his level of instrument flying ability. There is no evidence that he made improper use of his glasses.

Although the pilot's current duties required that he fly at night and under IFR conditions, the practical flight test that the AMRB originally required him to take was conducted during daylight hours in VFR conditions. Flight at night or under IFR conditions would have placed greater demands on the pilot's vision, and a practical flight test conducted under these conditions would have been more difficult for the pilot to pass.

Although the medical category had been issued with flexibility for vision, and the AMRB had required a practical flight test and semi-annual eye examinations, the Transport Canada licensing authority did not apply any restrictions to this pilot's licence, as referred to in the Transport Canada *Licensing Manual*, Volume 3, section 2.0, other than requiring the use of glasses while flying.

2.5 Pathology/Toxicology

Levels of non-prescription antihistamines, which were termed therapeutic by the examining laboratory, were evident in the pilot's urine; this indicates that the medication was taken long enough before the occurrence to allow for metabolism and clearance of the drug, thus avoiding any sedative effect. Moreover, although drowsiness may be a side effect of such drugs, since therapeutic levels of antihistamines were not detected in the pilot's blood, an active effect at the time of the accident would not be anticipated. Therefore, it is unlikely that the presence of these antihistamines had affected the pilot's performance.

2.6 Behavioral Factors - Illusions and Disorientation

The forward acceleration of the Cessna 310 aircraft is sufficient to produce a powerful illusion of increasing pitch. Under extremely dark night conditions, with restricted outside visual references, a somatogravic illusion could cause the pilot to erroneously conclude that the aircraft was rotating to an increasingly high pitch angle. This illusion would be intensified if the pilot were denied accurate visual information because of a weak instrument scan, degraded eyesight, or poor ambient external lighting.

2.7 Management and Regulatory Issues

The pilot was licensed and certified for the flight in accordance with governing regulations and statutes. However, a number of weaknesses in the pilot's basic instrument flying performance had been identified and documented by Transport Canada and the company training personnel. Senior management within the company were also aware of the pilot's weak instrument flying performance. The underlying cause of the weak performance had not been identified, nor documented in either the company or the Transport Canada files.

The monitoring of a pilot's performance is a joint responsibility that is shared by the airline company and by Transport Canada. However, despite ongoing difficulties, and despite early identification of weaknesses in instrument flying skills, no effective control mechanism was applied by either agency to monitor the pilot's performance trends, or to ensure that the pilot was not placed in a situation that was beyond his ability to cope successfully.

Transport Canada did not forward information concerning the pilot's weak instrument flying performance to the RAMO, nor was there a requirement for them to do so. The performance degradation could have been indicative of inadequate vision and the provision of such information to the RAMO might have resulted in a re-evaluation of the pilot's medical status.

The chief pilot recommended that the pilot be given the opportunity to gain additional operational experience in the multi-engine IFR environment by flying as first officer on the company's scheduled Cessna 404. Such an arrangement could also have provided an opportunity to better assess the pilot's performance during instrument flight.

The chief pilot was effectively prevented from exercising this responsibility when the company president decided to allow additional training on the C-310 aircraft, and directed that the additional training be conducted in Prince Albert, under the guidance and control of the general manager. Despite the pilot's subsequent failure of the Transport Canada instrument flight test and the PPC and the further additional training required for him to finally pass the flight test and the PPC on the Cessna 310, there were no particular restrictions subsequently applied to the operational employment of the pilot by the company's management.

3.0 Conclusions

3.1 Findings

1. Weather at the time of the departure from Sandy Bay was VFR.

2. There are very few ground lights northeast of the Sandy Bay aerodrome and, at the time of the accident, there was little or no illumination from either the lights of the community or from the night sky.

3. Poor ground and sky illumination may have prevented the pilot from maintaining adequate visual reference with the ground and may have required that the pilot rely on instrument flying skills, especially during the initial climb portion of the flight.

4. The absence of forward illumination of the flight path from the aircraft's landing lights during or after the take-off may have prevented the pilot from being alerted to the presence of obstacles and from taking action to avoid collision.

5. Tree-covered terrain beyond the departure end of runway 05 presents obstacles which extend upwards to approximately 40 feet above ground level; these obstacles are well below the normal climb gradient for a departure.

6. The pilot had developed a habit of establishing a shallow departure climb angle after take-off, and of climbing out after reaching cruise climb speed.

7. The shallow climb angle departure profile deviated significantly from the recently published company procedure for night departures from remote aerodromes.

8. A cruise climb profile gives approximately one-half the climb rate and climb angle of the recommended performance climb.

9. The aircraft was established in a very shallow departure climb after take-off.

10. The aircraft struck trees approximately 2,400 feet beyond the end of the runway in a wings-level attitude and at a low climb angle.

11. Control of the aircraft was lost during the tree strikes, and the aircraft struck the ground.

12. The accident was non-survivable because of high deceleration forces and the post-crash fire.

13. Continuity and integrity of the flight control systems were confirmed.

14. No evidence was found of pre-existing mechanical faults that would have caused a loss of engine power.

15. No evidence was found of mechanical discrepancies that would have affected the aircraft's performance.

16. Damage to the propeller systems was consistent with power being in the governing range.

17. The aircraft's weight and balance were within prescribed limits.

18. The pilot's twin-engine instrument flying performance was recorded as weak during training and previous flight tests.

19. The pilot was licensed with a medical restriction requiring glasses to be worn.

20. The pilot's current duties required that he fly at night and under IFR conditions; however, the practical flight test that the AMRB originally required him to take was conducted during daylight hours in VFR conditions.

21. Transport Canada did not forward information concerning the pilot's weak instrument flying performance to the RAMO, nor was there a requirement for them to do so.

22. It is unlikely that the non-prescription antihistamines present in the pilot's urine, but not in the blood, had affected the pilot's performance.

23. Somatogravic illusion may have adversely affected the pilot's performance during the acceleration stages of the take-off and initial climb.

24. Contrary to the chief pilot's recommendation, the company president decided to allow additional training on the C-310 aircraft to be conducted in Prince Albert, under the guidance and control of the general manager.

25. The Transport Canada licensing authority did not apply any restrictions to this pilot's licence as referred to in the guidelines of the Transport Canada *Licensing Manual*, Volume 3, section 2.0.

3.2 Causes

The pilot established, and the aircraft remained in, a very shallow climb after take-off and struck trees during the initial departure, while in controlled flight prior to reaching cruise climb speed.

Other factors that may have contributed to the accident were the poor ground and sky illumination, the absence of illumination from the landing lights, and the deviation from the recommended night departure profile.

4.0 Safety Action

4.1 Action Taken

4.1.1 Accidents Involving Controlled Flight into Terrain

This occurrence is classified as a Controlled Flight into Terrain (CFIT) accident. CFIT occurrences are those in which an aircraft, under the control of the crew, is flown into terrain (or water) with no prior awareness on the part of the crew of the impending disaster. The Board notes with concern that, over the 11-year period from 01 January 1984 to 31 December 1994, 68 commercially operated aircraft (not including those conducting low-level special operations) were involved in CFIT accidents. In view of the frequency and severity of such accidents, the Board is conducting a study of CFIT accidents to identify related systemic deficiencies. The study includes, *inter alia*, an examination of CFIT data on VFR operations at night and on contributing factors such as somatogravic illusions.

4.2 Action Required

4.2.1 Pilot Licence Restrictions - Practical Flight Tests

The pilot's vision had been considered by an Aviation Medical Review Board (AMRB). Following a practical flight test, the pilot had been issued a commercial licence in accordance with medical standards allowing the option of flexibility for vision; his licence indicated that he was required to wear prescription bifocal glasses while flying. The practical flight test had been conducted during daylight hours in visual meteorological conditions (VMC); the pilot's duties at the time of the occurrence required that he fly at night and in instrument meteorological conditions (IMC). The flight test environment was not typical of the most difficult conditions in which the pilot was expected to fly.

In the spring of 1990, the TSB investigated another occurrence in which the validity of an AMRB-requested practical flight test was also brought into question (TSB A90Q0090). In this accident, the TSB determined that, because the pilot had only limited use of his right leg, he was unable to recover from a spin in the ultralight he was flying. The flight test was conducted in a category of aircraft different from that which the pilot was licensed to fly, and the in-flight exercises apparently did not include manoeuvres which typically would have placed the greatest demands on the pilot's right leg.

Neither the content of the flight tests nor the environment in which they were conducted was representative of the challenges that these pilots might encounter while exercising the privileges of their respective licences; nor had the pilots' actual licences been annotated to indicate limitations to any operational aspects of flying associated with their category of licence.

The Board accepts the principle of issuing licences with a flexibility for various medical conditions. It is also recognized that it may be impractical on AMRB flight tests to cover all aspects of the flying environment. However, based on these two occurrences, there appear to be inconsistencies between the flying abilities actually being verified on the flight tests and the follow-on restrictions being placed on licence privileges. Consequently, pilots with licences issued under the medical flexibility option may be flying in aircraft or environments beyond their demonstrated abilities. In this occurrence, fare-paying passengers were relying on a pilot to safely fly in conditions in which his vision may have hampered his ability to maintain adequate visual reference with the ground and avoid obstacles.

To reduce the likelihood of other pilots with licences issued under the medical flexibility option inadvertently operating aircraft in conditions beyond their demonstrated ability, the Board recommends that:

> The Department of Transport review all pilot licences issued under the medical flexibility option to ensure compatibility of verified pilot abilities and licence privileges.
>
> A95-13

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson, John W. Stants, and members Gerald E. Bennett, Zita Brunet, the Hon. Wilfred R. DuPont and Hugh MacNeil, authorized the release of this report on 17 February 1995.

Appendix A - Glossary

AES	Atmospheric Environmental Service
agl	above ground level
AIP	Aeronautical Information Publication
AMRB	Aviation Medical Review Board
ARCAL	aircraft radio control of aerodrome lighting
asl	above sea level
ATF	aerodrome traffic frequency
C of G	centre of gravity
CAR	Civil Airworthiness Regulation
CFIT	controlled flight into terrain
CFS	Canada Flight Supplement
CST	central standard time
ELT	emergency locator transmitter
FAR	Federal Aviation Regulation
fpm	feet per minute
hp	horsepower
IFR	instrument flight rules
IMC	instrument meteorological conditions
KIAS	knots indicated airspeed
lb	pound(s)
M	magnetic
MHz	megahertz
mi	statute mile(s)
nm	nautical mile(s)
PPC	pilot proficiency check
RAMO	Regional Aviation Medical Officer
RCMP	Royal Canadian Mounted Police
rpm	revolutions per minute
TSB	Transportation Safety Board of Canada
VFR	visual flight rules
VMC	visual meteorological conditions