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

AVIATION INVESTIGATION REPORT A17W0024

Loss of control and collision with terrain

Mount Royal University
Tecnam P2006T, C-GRDV
Calgary/Springbank Airport, Alberta, 32 nm NW
13 February 2017

Canada

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Le présent rapport est également disponible en français.

The Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

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Summary

On 13 February 2017, a Tecnam P2006T aircraft (registration C-GRDV, serial number 088) operated by Mount Royal University was conducting a day visual flight rules instructional flight originating out of Calgary/Springbank Airport, Alberta, with a flight instructor and a pilot who was undergoing multi-engine training on board. Approximately 30 minutes into the flight, at 1704 Mountain Standard Time, the aircraft departed from controlled flight and collided with terrain 32 nautical miles northwest of the airport. The emergency locator transmitter emitted a signal for a short time. There was a post-impact fire and the aircraft was destroyed. Both occupants were fatally injured.

Le présent rapport est également disponible en français.

Factual information

History of the flight

On 13 February 2017 at 1634,[1] the Mount Royal University Tecnam P2006T aircraft (registration C-GRDV, serial number 088) departed from Calgary/Springbank Airport (CYBW), Alberta, with a pilot undergoing multi-engine training (the trainee) and a flight instructor on board, for the trainee's first training flight toward obtaining a multi-engine rating. The aircraft proceeded to the northwest and climbed to 8000 feet above sea level (ASL), an altitude that equated to 2500 to 3000 feet above ground level (AGL), given the terrain in the area.

The training flight was to consist of 2 segments: the first was to be conducted at higher speeds, and the second at lower speeds (Appendix A). Once the desired altitude had been reached, the first flight segment was conducted over a period of 9 minutes, at airspeeds ranging from 100 to 120 knots calibrated airspeed (KCAS).[2] It included a sequence of turns, which were carried out from 1648 to 1650, and consisted of a 360° right turn, a 180° right turn, and a 180° left turn. The turns were flown at approximately 95 to 115 KCAS, with an angle of bank of approximately 45° and vertical acceleration of up to 1.3*g*.[3] The higher-speed segment of the flight concluded at 1653 with a 90° left-to-right turn sequence with bank angles of about 30°.

The aircraft then slowed. The remainder of the segment was conducted at lower airspeeds and included a series of alternating 90° turns at bank angles of 20° to 30° and speeds ranging from 65 to 80 KCAS. Both segments of the flight were conducted at 8000 feet ASL, with very little variation in altitude.

At 1701, the aircraft accelerated to about 100 KCAS. At 1702, its airspeed decreased to 65 KCAS before increasing again to 80 KCAS, and its altitude decreased by about 300 feet, constituting the largest reduction in altitude at that point in the flight. The aircraft climbed back to its original altitude at 80 KCAS; then, at 1703, it slowed to 70 to 75 KCAS. This was the aircraft's last secondary-surveillance radar position, at 2800 feet AGL, directly above the accident site.

There were 2 primary-surveillance radar returns over the next 10 to 15 seconds before all radar data were lost. The aircraft's altitude loss from the time of the last radar return to impact equated to a descent rate of between 11 200 and 14 000 feet per minute.

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[1] All times are Mountain Standard Time (Coordinated Universal Time minus 7 hours).

[2] All airspeed estimates are in knots calibrated airspeed (KCAS). For this aircraft, and given that the airspeeds are estimates only, KCAS can be considered the same as knots indicated airspeed (KIAS).

[3] *g* is the unit of measure for vertical acceleration forces.

At 1712, the Joint Rescue Coordination Centre (JRCC) Trenton, in Ontario, contacted Mount Royal University and NAV CANADA to advise that an emergency locator transmitter (ELT) signal from C-GRDV had been detected by Cospas-Sarsat.[4] The signal had been detected only momentarily, and a position could therefore not be determined. Mount Royal University initiated a radio and telephone search.

At 1732, NAV CANADA air traffic services contacted another Mount Royal University aircraft to request that its crew contact the CYBW tower and assist in the search. A radio search was conducted by air traffic services in an attempt to contact C-GRDV.

At 1750, C-GRDV was located by the other Mount Royal University aircraft; it was substantially damaged and on fire. A helicopter air ambulance reached the accident site at 1850. At 1900, the Royal Canadian Mounted Police and the Ghost River Fire Department arrived at the accident site and confirmed that there were no survivors.

Wreckage and impact information

The wreckage was situated near a road, at the foot of an embankment, at an elevation of 4850 feet ASL. The aircraft had been almost entirely consumed by fire. Ground scars and damage to the aircraft were consistent with a high-speed collision with the slope while the aircraft was in a near-vertical attitude. The top of the aircraft had struck the embankment first, and the aircraft had continued down the slope for 50 feet before coming to rest at the foot of the escarpment, where a post-impact fire ignited (Figure 1).

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4 Cospas-Sarsat is an international satellite-based monitoring system that detects distress signals from emergency locator beacons on aircraft or vessels within Canada's search-and-rescue area of responsibility.

Figure 1. Accident site as viewed from the embankment above, showing the left side of the aircraft and looking south (Source: Alberta Occupational Health and Safety)

All of C-GRDV's major components were accounted for at the accident site. An examination of the wreckage determined that the flaps had been in the up position and the landing gear had been retracted. The remains of the flight control systems were inspected and no indication of malfunction was found.

The post-impact fire had completely destroyed the aircraft's avionics and engine instrumentation. There was substantial fire damage to the majority of the aircraft, with the exception of the empennage and the left wingtip.

Both of the propellers and the attached gearboxes were located at the initial impact point; they had not sustained fire damage. The propeller hubs were analyzed at an overhaul facility with Transportation Safety Board of Canada (TSB) personnel in attendance, and it was determined that both propellers had been in the low-pitch setting at the time of impact.

An examination of both engines at the TSB facility in Edmonton, Alberta, was completed with the engine manufacturer in attendance. Rotational damage and distortion was noted in both engine crank cases, indicating that the engines were producing power at the time of impact.

Meteorological information

At the time of the accident, there was a high-pressure system centred over Cranbrook, British Columbia, that also affected the southern portion of Alberta. The graphical area forecast (GFA) issued at 1631 and valid at 1700 called for visibilities greater than 6 statute miles and scattered clouds at 9000 feet ASL. No significant turbulence or icing conditions were forecasted for the Springbank area.

The aviation routine weather report (METAR) from CYBW at 1600 indicated the following:

- winds at 270° true (T) at 10 knots

- visibility greater than 9 statute miles
- sky clear
- temperature 6 °C, dew point −1 °C
- altimeter setting 30.15 inches of mercury

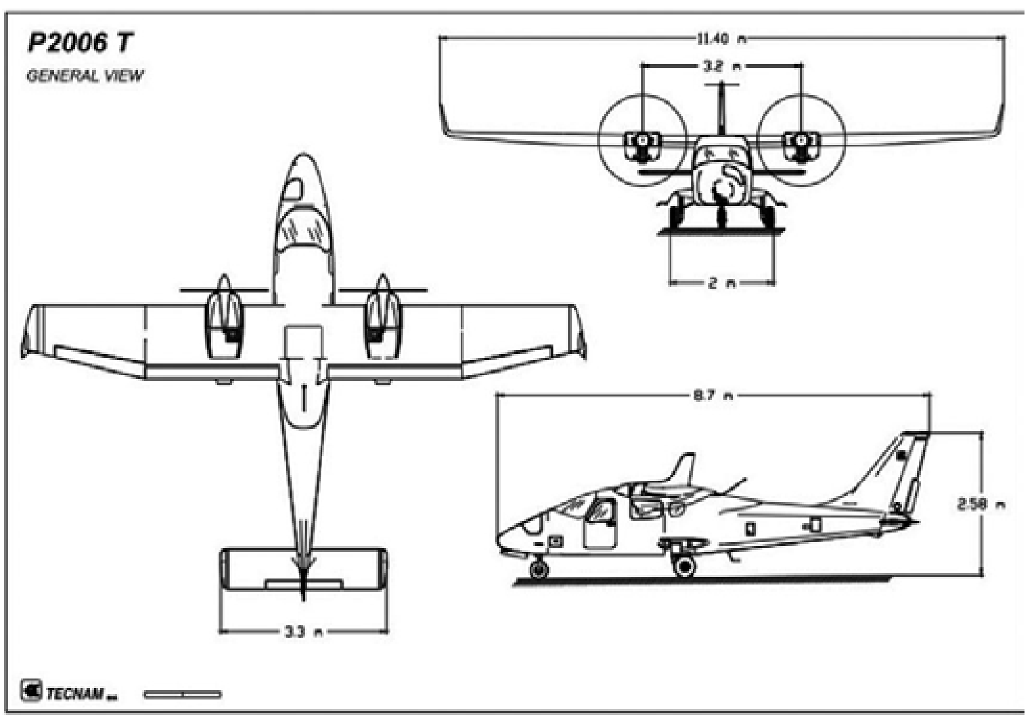
The METAR issued at 1700 was identical to that of 1600, with the exception of wind conditions, which were 290°T at 4 knots.

Sunset was at 1750, and official night began at 1824.

Aircraft information

The Tecnam P2006T is a high-wing, all-aluminum, light, twin-engine training aircraft (Figure 2). It is equipped with 2 Rotax 912S3 engines and retractable landing gear. Mount Royal University had purchased 3 Tecnam P2006T aircraft, the first of which entered into service in April 2012. At the time of the accident, the 3 aircraft owned by Mount Royal University were the only Tecnam P2006T aircraft registered in Canada; approximately 100 were in service globally.

Figure 2. Dimensions of Tecnam P2006T (Source: Construzioni Aeronautiche, *Aircraft Maintenance Manual—TECNAM P2006T*, Doc. No. 2006/045, 2nd Edition, Revision 2 (29 September 2012), Chapter 6-00: Dimensions and Areas, p. 2)



Records indicate that the aircraft was certified, equipped, and maintained in accordance with existing regulations and approved procedures. The most recent 100-hour-interval inspection of C-GRDV had been completed on 26 January 2017.

C-GRDV had operated within the approved weight-and-balance envelope for the entire flight.

Personnel information

Records indicated that the instructor and the trainee were certified and qualified for the flight in accordance with existing regulations.

Instructor

The instructor was a retired airline pilot and had accumulated over 20 000 flying hours. He had previously held a Class I instructor rating and had been the chief flight instructor at a flight training unit from 1985 to 1988.

After being hired by Mount Royal University in August 2016, the instructor began training to renew the Class II instructor rating and to undergo proficiency checks on the Cessna 172 and Tecnam P2006T aircraft. At the time of the accident, he possessed a valid airline transport pilot licence, a Category I medical certificate, and a Class II instructor rating. He had acquired 61 flying hours on the Tecnam P2006T and 48 hours on the Cessna 172 during his employment at the university.

Based on a review of the instructor’s work and rest schedules, fatigue was not considered to be a factor in the accident.

Trainee

The trainee was a retired Royal Canadian Air Force training pilot, and had been hired by Mount Royal University for a flight instructor position in December 2016. He possessed a commercial pilot licence with a valid Class I medical certificate, and had experience in both rotary-wing aircraft (830 flying hours) and single-engine fixed-wing aircraft (1070 flying hours) operation. On 24 January 2017, the trainee had completed a Class III instructor rating. At the time of the accident, he had acquired 25 flying hours in the Cessna 172 and was a line instructor for Mount Royal University.

The trainee had been undergoing training to obtain a multi-engine rating as a condition of employment. Because he lacked multi-engine experience on fixed-wing aircraft, the training followed the same syllabus used for students in the university program (see Section 1.6.1.1). He had completed two ground-briefing sessions prior to the accident flight, which was his first flight in the Tecnam P2006T aircraft.

Organizational and management information

Mount Royal University

Mount Royal University is a mid-sized university; its primary campus is located in Calgary, Alberta. In addition to a variety of bachelor degree programs and certificates, the university offers a 2-year aviation diploma program through the Faculty of Business and

Communications Studies. On fulfillment of the program, students obtain a commercial pilot licence, a night rating, a multi-engine rating, and a multi-engine instrument rating. The program's flying component is conducted at CYBW using both Cessna 172 and Tecnam P2006T aircraft.

Multi-engine flight training program

Students of Mount Royal University's multi-engine flight training program must undergo 11 missions involving a cumulative 10.2 hours of dual flight in the Tecnam P2006T, 2 hours of flight simulation, 10.2 hours of ground briefings, and 1.5 hours of flight time (during which the multi-engine flight test is completed).[5]

Prior to the first flight, 2 ground-briefing sessions (missions 1 and 2) are completed. In Mission 3, the first in-flight training session, the following exercises must be demonstrated by the flight instructor and/or the student[6]:

- Engine start
- Takeoff
- Steep turn[7]
- manoeuvring at reduced airspeed (MARA)[8]
- Approach to stall
- Clean stall[9]
- Engine failure

Mission 3 would be expected to take 1.7 hours, approximately 1 hour of which is allocated for in-air time. C-GRDV had flown approximately 30 minutes of that 1 hour when the accident occurred.

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5 Mount Royal University, *Flight Training – FLTR1105 – Multi-Engine Training (Instructor Notes – January 2017)*.

6 Ibid., "Mission 2: Dual 1.7 / 1.0."

7 I.e., a 45° angle of bank.

8 I.e., medium-banked turns with gear down and full flaps, at a minimum speed of 72 knots indicated airspeed (KIAS).

9 The stall speed with power at idle, landing gear down, full flaps, gross take-off weight, wings level and forwardmost centre of gravity is 54 KIAS (55 KCAS). Under the same conditions but with flaps up, it is 66 KIAS (65 KCAS). (Source: Costruzioni Aeronautiche TECNAM srl, *Aircraft Flight Manual – TECNAM P2006T*, Doc. No. 2006/044, 3rd Edition, Revision 1 (15 October 2012), Section 5, page SW5-5.)

Stall-recovery training in the Tecnam P2006T

The multi-engine flight training program at Mount Royal University uses 2 scenarios to instruct students in stall recovery:

- An approach to stall, in which the aircraft nears the speed at which it will stall, but is not allowed to enter a stall
- A clean stall, in which the aircraft is allowed to enter a stall

The approach to stall is entered with gear down, full flaps, and throttles at idle; altitude is held with steady application of back pressure on the control column. The university flight training syllabus provides the following guidance for recovery:

> **Recovery**: FIRST SIGN OF A STALL (stall warning, in the red arc of airspeed tape, buffeting). Recover as per Balked Landing procedure in AFM [aircraft flight manual][10]

The procedures for a balked landing in the Tecnam P2006T AFM are as follows:

1	LH and RH Propeller Lever	*FULL FORWARD*
2	LH and RH Throttle Lever	*FULL POWER*
CAUTION: *Propeller Lever increase to max RPM should be attained before engine Throttle Levers are advanced to max take off power. Max take off power must be limited to 5 minutes.*		
3	Flaps	*T/O [takeoff]*
4	Speed	*Keep over 62 KIAS, climb to V_Y or V_X as applicable.*
5	Landing gear	*UP as positive climb is achieved*
6	Flaps	*UP*[11]

The clean stall is entered with flaps and landing gear up and power on idle; altitude is maintained using steady application of back pressure on the control column until the aircraft stalls. Recovery is described in the Mount Royal University syllabus as follows:

> **Recovery**: […]
>
> - Control wing drop with GENTLE rudder inputs (entering rudder too aggressively will cause an opposite wing drop)
> - Break the stall by releasing back pressure or pushing forward enough to break the stall
> - Add power smoothly while pulling the aircraft to a level or climbing attitude. WARNING: DO NOT ADD POWER UNTIL THE AIRCRAFT

[10] Mount Royal University, *Flight Training – FLTR1105 – Multi-Engine Training (Instructor Notes – January 2017)*, "Mission 2: Dual 1.7 / 1.0."

[11] Costruzioni Aeronautiche TECNAM srl, *Aircraft Flight Manual – TECNAM P2006T*, Doc. No. 2006/044, 3rd Edition, Revision 1 (15 October 2012), Section 4.10, p. S4-24.

IS OUT OF THE STALL to avoid asymmetric thrust causing an incipient spin[12]

The investigation determined that some of the flight instructors at Mount Royal University had developed a non-standard training practice wherein they would induce yaw using either flight control inputs or abrupt power inputs before the aircraft was recovered from the stall. The practice was intended to demonstrate the reaction of the Tecnam P2006T if excessive yaw were introduced during a stall.

The non-standard training practice had been in use since the university began operating Tecnam P2006T aircraft; it had been passed along by word of mouth and demonstrated to new instructors, but was neither documented nor approved by the manufacturer. Mount Royal University supervisory staff was aware of the non-standard practice, but was not aware that aircraft limitations were exceeded by its use.

It could not be determined whether the instructor or the trainee involved in the occurrence had been exposed to the non-standard practice in use for stall-recovery training or whether the instructor had used it on the accident flight or on previous flights.

Mount Royal University Tecnam P2006T flight data

Mount Royal University had begun operating its Tecnam P2006T aircraft in the spring of 2012; all 3 aircraft were equipped with the Garmin 950 avionics suite. The Secure Digital (SD) memory cards from the avionics system of C-GRDV were destroyed in the post-impact fire. Those from the 2 other aircraft were obtained by the TSB for analysis.

Because the SD memory cards were sometimes swapped between aircraft by the university in the course of updating the flight deck system, each included flight data files from all 3 Tecnam P2006T aircraft. One memory card contained 565 files of recorded flights dating back to 30 April 2015. The 2nd card contained 79 files covering flights dating back to 13 November 2016. Each file contained a unique system identification number that helped to determine the individual aircraft to which it belonged. To confirm the aircraft and to identify the mission that was being flown when a given recording was produced, the data files were also cross-referenced with the university's daily flight records.

Each data file contained a variety of flight parameters that were recorded approximately every second. Those of greatest interest to the investigation were

- date and time;
- latitudinal and longitudinal positions;
- barometric and global positioning system (GPS) altitudes;
- altimeter setting;
- barometric and GPS vertical speeds;

[12] Mount Royal University, *Flight Training – FLTR1105 – Multi-Engine Training (Instructor Notes – January 2017)*, "Mission 2: Dual 1.7 / 1.0."

- pitch and roll attitudes;
- magnetic heading and variation;
- ground track;
- indicated and true airspeeds;
- vertical and lateral acceleration; and
- outside air temperature.

Numerous stall recoveries had been recorded. Generally, in those recoveries, there had been a gradual reduction in airspeed toward stall speed, and then the aircraft nose had been lowered for recovery. The wings had remained level throughout the recoveries, and the degree of altitude loss had been limited to approximately 300 feet. It could not be determined, based on the available data, whether the actions taken to initiate recovery in each case were in response to the stall warning system or to stall buffet on the airframe.

To identify events that fell outside of normal operational parameters, the data were searched for events wherein a given aircraft's bank angle had exceeded 55°.[13] Twenty-two such events were identified, and all but 1 were associated with stall-recovery training.

In contrast with normal stall recoveries, these instances ranged from roll events that were recovered to wings level, to incipient spins that inverted the aircraft, to full spins[14] of up to 1.5 rotations. They generally shared key characteristics (appendices B, C, and D) that had initiated the upsets:

- The aircraft involved had been flown to stall conditions in a nose-high attitude and held there upon encountering stall conditions.
- The aircraft nose had not been lowered to initiate stall recovery.
- The airspeed had continued to decline until the aircraft had eventually rolled and yawed in either direction in an aggravated stall or incipient spin.

Although flight control input and engine power data were not available, it was evident from the motion of the aircraft involved that yaw/roll or engine power control inputs were sometimes being made by pilots during the stalled conditions. The resulting uncoordinated condition in each of these cases had led to an asymmetric aggravated stall and a relatively rapid roll/yaw departure toward an incipient spin.

Among the recorded events was one in which an aircraft exited a spin of 1.5 rotations, became inverted, and was pulled into a steeper dive through a descending half-loop

13 The multi-engine flight training program requires training in turns with bank angles up to 45° (steep turns) with a tolerance of +/-10°. With 55° selected as the minimum bank angle, the data set would most likely exclude the steep turn exercises.

14 "Full spin" refers to a spin of at least 1 full rotation of heading (360° or greater). It is not intended to signify a "fully developed spin," which is a spin of multiple rotations wherein spin rate and attitude have stabilized to relatively steady values.

(Appendix C). This event had the highest descent rate (12 500 feet per minute) and load factor (3.1*g*) of the upsets that were examined, and the second highest loss of altitude (1400 feet).

In the events sampled, airspeeds were recorded up to 153 KIAS. The design manoeuvring speed (V_A)[15] published in the aircraft flight manual (AFM)[16] is 122 KIAS, the maximum structural cruising speed (V_{NO})[17] is 138 KIAS, and the never-exceed speed (V_{NE})[18] is 171 KIAS. Although V_{NE} was not exceeded in any of the recorded events, V_{NO} was met or exceeded 5 times, and V_A 11 times.

The altitude losses in the examined events ranged from 525 feet to 1500 feet, with an average loss of 960 feet.[19] All of the flights had been conducted at an altitude of just under 8000 feet ASL. The combination of that altitude and the elevations of the underlying terrain significantly reduced the margins for recovery in the event of a spin. The terrain elevations over which the flights had been flown varied greatly; in some cases, local peaks exceeded 5000 feet ASL, leaving as little as 2500 feet in which to recover from an upset.

Appendix D shows the comparative flight-path shapes and altitude losses of the aircraft involved in the upset events; a normal stall recovery is also shown. Among the events examined, the lowest recovery height above surrounding terrain was 700 feet, in an event that also involved the largest altitude loss (1500 feet).

Flight training operations at Mount Royal University are guided by the *Company Operating Procedures Manual*. Section 9.18, Safety Checks (HASEL[20] Check), stipulates, in part, "Pilots will not perform stalls, spins, slow flight or any other aerobatic maneuver unless the aircraft will recover by 2000 [feet] AGL."[21] This altitude is also consistent with Transport Canada's multi-engine class rating flight test guide.[22]

The Emergency Procedures section of the Tecnam P2006T AFM advises that "spin behaviour has not been demonstrated"[23] on the aircraft because its demonstration is not a prerequisite

15 V_A is the maximum speed where full and/or abrupt control inputs are allowed.

16 Costruzioni Aeronautiche TECNAM srl, *Aircraft Flight Manual – TECNAM P2006T*, Doc. No. 2006/044, 3rd Edition, Revision 1 (15 October 2012), Section 2.2, p. SW2-5.

17 V_{NO} is the speed that should not be exceeded, except in smooth air, and only with caution.

18 V_{NE} is the speed that may not be exceeded at any time.

19 For comparison, aircraft typically lose 300 feet in normal stalls with recovery.

20 HASEL is an acronym meaning height, area, security, engine, look out.

21 Mount Royal University, *Company Operating Procedures Manual (COPs)*, Edition 6, Revision 2 (April 2016), p. 25.

22 Transport Canada, TP 219E, *Flight Test Guide: Multi-Engine Class Rating – Aeroplane*, Ninth Edition (April 2017), EX. 8B: Approach to Stall, p. 26.

23 Costruzioni Aeronautiche TECNAM srl, *Aircraft Flight Manual – TECNAM P2006T*, Doc. No. 2006/044, 3rd Edition, Revision 1 (15 October 2012), Section 3, p. S3-59.

for certification of this category of aircraft. The manual also stipulates that "[i]ntentional spin is forbidden."[24]

Management of safety

The Mount Royal University flight training unit consisted of the chair of the Department of General Management, Human Resources and Aviation; a chief flight instructor (CFI); and 12 staff flight instructors. One of the staff flight instructors held the designation of assistant CFI, and another was the person responsible for maintenance (PRM). Standard operating procedures, ground briefing material, and flight training material were approved and managed by the chair and the CFI.

Safety at Mount Royal University was managed through its *Company Operating Procedures Manual* and *Safety Management System Manual* (SMS manual). Although not required by regulation to have an SMS, Mount Royal University had developed a safety program in the spirit of a TC-approved SMS. The program included several of the key elements of a formal SMS, such as a non-punitive reporting system and an accountable executive. Its oversight was delegated to the CFI; the SMS manager reported to the CFI, but also had access to the accountable executive. In January 2017, a dedicated SMS manager was hired on a part-time basis. Prior to that time, the SMS manager position was a secondary duty of one of the flight instructors.

Additionally, a standing committee, the Mount Royal University Aviation Safety Board (ASB), was established with a mandate to meet monthly "to review all incidents and hazards that occur and to make recommendations to the SMS Manager."[25] The ASB held 12 meetings from February 2015 to February 2017.

Safety reporting in the university's aviation program was accomplished through a dedicated web-based electronic reporting system. From November 2013 until the accident on 13 February 2017, there were 77 reported incidents related to Tecnam P2006T operation. Of those, 38 had been assessed as low risk, 25 as medium risk, and 10 as high risk; 4 incidents had not yet been assessed. The majority of the high-risk incidents had involved issues related to aircraft engine problems, all of which occurred prior to May 2015. None of the reported incidents related to stall-recovery training, flight dynamics, or roll upset events.

Although the avionics suite of Tecnam P2006T aircraft collects significant flight data, Mount Royal University did not have a flight data-monitoring program, and was not required by regulation to have one.

On 06 June 2016, Tecnam issued a service bulletin regarding operational limitations pertaining to all Tecnam aircraft. Stating that its purpose was to address issues involving loss

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24 Ibid.

25 Mount Royal University, *Safety Management System Manual (SMS Manual)*, Edition 9 (29 September 2016), Section 1.3.5: MRU Aviation Safety Board (ASB), p. 4.

of aircraft control during slow-flight and stall-recovery training, the bulletin stresses the following safety considerations:

> - stall speed depends upon several factors, amongst which power setting at stall and deceleration rate: the highest the power setting (RPM) at stall together with the rate of speed deceleration (pitch attitude), the lower will be the stall speed;
> - stall characteristics also depend upon variations of weight and CG [centre of gravity];
> - extreme nose up attitudes at stall (high deceleration rates) will result in extremely low stall speeds;
> - at high RPM and very low speeds, the control authority available to counteract the propeller effect (or mild airplane longitudinal or lateral tendencies) is naturally reduced;
> - stall should always be performed with ball centered (zero sideslip) using rudder authority (rudder pedals);
> - stalls poorly executed may lead into a departure from controlled flight;
> - before performing stalls, always review the spin recovery procedure;
> - stalls should be performed at a safe altitude, taking into account the event of an unwanted departure from controlled flight.[26]

Mount Royal University circulated the service bulletin together with an attached sign-off sheet listing the names of its flight instructors and the students in the program at that time. Beside each name were lines where the individual was to sign and indicate the date of reading. A note at the top of the sheet stated that all students and instructors must read and sign off on the bulletin before being permitted to undertake their next missions in the Tecnam P2006T aircraft. The Mount Royal University *Company Operating Procedures Manual* made no reference to, and provided no guidance on, use of the bulletin and attached sheet, and the flight authorization form[27] did not refer to these documents.

All instructors were made aware of the service bulletin on 04 October 2016. The sign-off sheet that was circulated with the bulletin listed 13 instructors; 11 had signed, including the instructor involved in the accident. The name of the trainee involved in the accident was not among those listed on the sheet.

Transport Canada oversight

Since 2012, TC has conducted 3 program validation inspections (PVIs) of Mount Royal University's flight training program. The first, carried out from 11 to 15 June 2012, generated 3 findings of risk that were classified as moderate. One of those findings pertained to the

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26 Costruzioni Aeronautiche TECNAM srl, Service Bulletin No. SB244-CS-ED1, Revision 0 (06 June 2016), p. 1.

27 Prior to each training flight, the pilot-in-command must complete a flight authorization checklist as part of the flight authorization form.

availability of emergency checklists in the aircraft, while the other 2 were related to the program's maintenance quality assurance (QA) program. The university's corrective action plan (CAP) was accepted, follow-up was completed, and TC closed the PVI file on 10 October 2013.

The second PVI was conducted from 31 August to 04 September 2015, and generated 10 findings:

- 2 minor findings on operational control record keeping
- 1 minor finding on CFI responsibilities in relation to training files
- 1 major finding on CFI responsibilities in relation to training syllabus requirements
- 6 major findings related to the company's maintenance control system and QA program

As a result of the systemic findings of the second PVI, Mount Royal University was placed under enhanced monitoring (EM) surveillance by TC on 05 October 2015. On 09 December 2015, the university's CAP was accepted by the regulator. The EM period was to continue until an EM-terminating PVI was conducted; the latter was carried out from 28 to 30 March 2017 and evaluated Mount Royal University's QA program, CFI responsibilities, and operational control. On 16 May 2017, the EM-terminating PVI file was closed and the EM was terminated.

Additional information

Stall recognition and recovery training

Multi-engine aircraft certification standards (normal category)

The Tecnam P2006T was certified in the normal category[28] by the European Aviation Safety Agency (EASA) and the United States Federal Aviation Administration (FAA) in 2010, and by TC in September 2011. The *Canadian Aviation Regulations* (CARs) set out the certification requirements[29] for multi-engine aircraft. Sections 523.201 to 523.207 of the CARs Airworthiness Manual detail the requirements that must be met with respect to flight characteristics and warning systems approaching a stall and during recovery from a stall. CARs Airworthiness Manual section 523.221, Spinning, stipulates that "a single-engine normal, category aeroplane must be able to recover from a one-turn spin or a three-second

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28 The normal category is limited to aeroplanes that have a seating configuration, excluding pilot seats, of 9 or fewer and a maximum certificated take-off weight of 5700 kg (12 566 pounds) or less, and that are intended for non-aerobatic operation. (Source: Transport Canada, SOR/96-433, *Canadian Aviation Regulations* (last amended 15 September 2017), Part V: Airworthiness, Chapter 523: Normal, Utility, Aerobatic and Commuter Category Aeroplanes.)

29 Ibid.

spin, whichever takes longer […].”[30] There are no certification requirements to demonstrate spins in a multi-engine aircraft.

Multi-engine class rating – aeroplane

The TC multi-engine class rating flight test guide requires that 2 stall exercises be performed: a stall and an approach to stall. For the approach to stall exercise, the aim is

> [t]o determine that the candidate can recognize and safely recover smoothly and correctly from an approach to a stall in a landing configuration with a minimum loss of altitude.[31]

The TC multi-engine class rating instructor guide provides the following objectives for the stall exercises:

> To teach:
>
> - recognition of the symptoms of an approaching stall
> - recognition of power-off stalls in both the landing and cruise configurations
> - positive and smooth recovery, while maintaining directional control, with a minimum loss of altitude[32]

The instructor guide states the following:

> All stalls must be entered from power-off straight and level flight with slow deceleration, in accordance with the POH [Pilot Operating Handbook]/AFM. Power-on stalls are to be avoided. Using power on the entry can lead to an inadvertent spin entry, from which recovery may be difficult and result in substantial loss of altitude.[33]

Transport Canada advisory circular

In November 2013, TC issued an advisory circular (AC) addressing prevention of and recovery from aeroplane stalls. The AC was applicable to

> all Transport Canada Civil Aviation (TCCA) employees, operators, manufacturers, training providers, pilots, flight crews, and to individuals or organizations exercising privileges granted to them under an External Ministerial Delegation of Authority.[34]

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30 Ibid., section 523.221.

31 Transport Canada, TP 219E, *Flight Test Guide: Multi-Engine Class Rating – Aeroplane*, Ninth Edition (April 2017), EX. 8B: Approach to Stall, p. 26.

32 Transport Canada, TP 11575E, *Instructor Guide: Multi-Engine Class Rating*, Second Edition (October 2010), EX. 8: Stall, p. 32.

33 Ibid.

34 Transport Canada, Advisory Circular 700-031, Prevention and Recovery from Aeroplane Stalls (08 November 2013), p. 3.

Developed partly in response to a recognition that in-flight loss-of-control events were the leading cause of fatalities in aircraft accidents worldwide, the circular focused on the following:

> (a) Prevention of stall events through effective recognition, avoidance, and recovery should they be encountered;
>
> (b) Reduction of Angle of Attack (AOA) is the most important response when confronted with a stall event;
>
> (c) Evaluation criteria for a recovery from a stall or approach-to-stall does not mandate a predetermined value for altitude loss and should consider the multitude of external and internal variables which affect the recovery altitude;
>
> (d) Realistic scenarios that could be encountered in operational conditions including stalls encountered with the autopilot engaged;
>
> (e) Pilot training which emphasizes treating an "approach-to-stall" the same as a "full stall," and execute the stall recovery at the first indication of a stall;
>
> (f) Incorporation of stick pusher training into flight training scenarios, if installed on the aircraft.[35]

Federal Aviation Administration advisory circular

Two years after the release of TC's AC, in November 2015, the FAA issued a similar AC regarding stall prevention and recovery. The core principles communicated by the FAA advisory were as follows:

> - Reducing angle of attack (AOA) is the most important pilot action in recovering from an impending or full stall.
> - Pilot training should emphasize teaching the same recovery technique for impending stalls and full stalls.
> - Evaluation criteria for a recovery from an impending stall should not include a predetermined value for altitude loss. Instead, criteria should consider the multitude of external and internal variables that affect the recovery altitude.
> - Once the stall recovery procedure is mastered by maneuver-based training, stall prevention training should include realistic scenarios that could be encountered in operational conditions, including impending stalls with the autopilot engaged at high altitudes.

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35 Ibid., p. 7.

- Full stall training is an instructor-guided, hands-on experience of applying the stall recovery procedure and will allow the pilot to experience the associated flight dynamics from stall onset through the recovery.[36]

Previous TSB recommendations

During the investigation of the March 2011 in-flight breakup of a DHC-3T,[37] the TSB issued a safety recommendation[38] regarding lightweight flight recorders and flight data monitoring programs. The preamble to the recommendation stated that routine monitoring of normal operations can help operators both improve the efficiency of their operations and identify safety deficiencies before they result in an accident. In the event that an accident does occur, recordings from lightweight flight-recording systems will provide useful information to enhance the identification of safety deficiencies in the investigation.

The Board acknowledged that there were issues that would need to be resolved to facilitate the effective use of recordings from lightweight flight-recording systems, including questions about the integration of this equipment in an aircraft, human resource management, and legal issues such as the restriction on the use of cockpit voice and video recordings. Nevertheless, given the potential of this technology, when combined with flight data monitoring to significantly improve safety, the Board believed that no effort should be spared to overcome these obstacles.

Therefore, the Board recommended that

> the Department of Transport work with industry to remove obstacles to and develop recommended practices for the implementation of flight data monitoring and the installation of lightweight flight recording systems by commercial operators not currently required to carry these systems.
>
> **TSB Recommendation A13-01**

TC has acknowledged that flight data monitoring programs would enhance safety. Since 2013, attempts by TC to assemble a focus group with industry stakeholders to address this recommendation have been unsuccessful. In its January 2017 response, TC indicated its renewed proposal to conduct a focus group during 2017, which it had been planning to do since 2013. In the fall of 2017, TC informed the TSB that it would be organizing a focus group with industry stakeholders in February 2018 to address this recommendation.

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36 Federal Aviation Administration, Advisory Circular No. 120-109A, Stall Prevention and Recovery Training (24 November 2015).

37 TSB Aviation Investigation Report A11W0048.

38 TSB Recommendation A13-01.

TSB laboratory reports

The TSB completed the following laboratory reports in support of this investigation:

- LP032/2017 – Flight Path Analysis
- LP056/2017 – Data recovery from GPS and AHRS [attitude and heading reference system]

Analysis

Given that the aircraft was almost entirely destroyed by the crash and subsequent post-impact fire, it could not be determined whether any pre-impact system failure or malfunction contributed to the accident; however, the components that were examined showed no signs of malfunction.

The analysis will focus on the loss of control, the stall-recovery training and safety management processes at Mount Royal University, Transport Canada (TC) guidance material, and the multi-engine certification and flight test standard.

Loss of control

It is likely that aircraft control was lost during a practice stall or an approach to stall, given

- the locations and timing of the final radar returns from the flight;
- the inclusion of approach-to-stalls and clean stalls in the mission; and
- the consistency between the time at which the loss of control occurred and the sequence of flight exercises that were to be carried out.

The initial event leading to a loss of control was likely an approach-to-stall or clean-stall exercise during which the aircraft entered a spin at approximately 2800 feet above ground level. Insufficient information was available to determine what had induced the yaw that caused the stall to develop into a spin.

During the loss of altitude, the pilot recovered from the spin, resulting in a dive, which was consistent with evidence of a high-energy impact and with the relatively short lateral distance between the last radar location and the accident site.

When compared with rate-of-descent data from the 2 other aircraft operated by Mount Royal University, C-GRDV's descent rate was very similar to that of flights during which the aircraft involved had entered a spin and recovered to a dive.

The instructor and trainee were unable to recover the aircraft from the dive. In previous aircraft spins that were recorded on the flight data memory cards, most—if not all—had been anticipated and involved an average altitude loss of 960 feet, with a maximum loss of 1500 feet.

For unknown reasons, the aircraft entered a spin from a stall exercise. The instructor and trainee recovered the aircraft from the spin, but insufficient altitude remained to recover from the ensuing dive.

Stall-recovery training

Mount Royal University

Training in stall recovery emphasizes the importance of keeping altitude losses to a minimum. This precaution is reinforced in the flight test guide and in instructor guides produced by the regulator. In its approach-to-stall exercise, Mount Royal University uses the balked landing recovery rather than a stall recovery with an emphasis on zero altitude loss.

The flight training material at Mount Royal University identifies 2 types of stall recoveries: one to be used when an aircraft approaches a stall and the other to be employed when an aircraft has stalled. However, advisory circulars issued by both TC and the United States Federal Aviation Administration indicate that only one stall-recovery technique should be used, because flight crew may not know whether they are near a stall or have fully stalled. If flight training units do not emphasize that the most important reaction to a stall or approach to stall is a reduction in the angle of attack, a loss of aircraft control may occur.

Although steps had been taken to ensure that instructors and students were aware of the handling characteristics of the Tecnam P2006T, a non-standard training practice had been developed by some of the flight instructors at Mount Royal University. Although, at times, that practice resulted in manoeuvres (i.e., aerobatic movements and spins) that exceeded aircraft limitations, the practice continued. The avionics suite of Tecnam P2006T aircraft collects significant flight data, but Mount Royal University did not have a flight data-monitoring program. As well, although the university had safety-reporting processes in place, no incidents reported since 2013 related to stall recovery training, flight dynamics, or roll upset events.

If organizational safety processes do not identify and mitigate non-standard practices, manoeuvres that are outside of the aircraft limitations defined in the aircraft flight manual may be conducted, increasing the risk of aircraft accidents.

Transport Canada guidance material

TC issued an advisory to emphasize the importance of ensuring that an aircraft's angle of attack be reduced prior to any other actions, regardless of the training exercise (i.e., whether it involves an approach to stall or a stall). The information contained in Advisory Circular 700-031 was not incorporated into TP 11575, *Instructor Guide – Multi-Engine Class Rating*.

Multi-engine certification and flight test standard

When a single-engine aircraft is being certified, it undergoes a process that requires spin testing. The aircraft may also be certified for intentional spins if the manufacturer requires it. This testing serves as a defence to ensure prompt recovery of aircraft control should a spin develop from a stall exercise. Multi-engine aircraft do not undergo spin testing in the certification process.

When a full stall must be demonstrated, a hazard is introduced into multi-engine flight training. However, given that multi-engine aircraft do not undergo spin testing during the certification process, there is no defence against that hazard. The spin qualities of twin-engine aircraft are therefore unknown, and the effectiveness of recovery techniques in use are assumed.

If full-stall demonstrations are required as part of a multi-engine rating test, there is an increased risk that, due to unknown spin characteristics, pilots may not be able to regain aircraft control if the stall progresses into a spin.

Findings

Findings as to causes and contributing factors

These are findings related to the unsafe acts, unsafe conditions, or safety deficiencies that are associated with the safety significant events that played a role in causing and/or contributing to the occurrence.

1. For unknown reasons, the aircraft entered a spin from a stall exercise.

2. The instructor and trainee recovered the aircraft from the spin, but insufficient altitude remained to recover from the ensuing dive.

Findings as to risk

These findings are not causal or contributory to the occurrence. They identify a risk that was found during the investigation that has the potential to degrade safety. They may describe a condition that is systemic in nature that applies to an audience beyond those involved in the immediate occurrence.

1. If flight training units do not emphasize that the most important reaction to a stall or approach to stall is a reduction in the angle of attack, a loss of aircraft control may occur.

2. If organizational safety processes do not identify and mitigate non-standard practices, manoeuvres that are outside of the aircraft limitations defined in the aircraft flight manual may be conducted, increasing the risk of aircraft accidents.

3. If full-stall demonstrations are required as part of a multi-engine rating test, there is an increased risk that, due to unknown spin characteristics, pilots may not be able to regain aircraft control if the stall progresses into a spin.

Other findings

These findings are not causal or contributory to the occurrence and are not systemic in nature. They identify an element or contain a message that has the potential to enhance safety. They can resolve an issue of controversy or provide a data point for future safety studies or analyses.

1. It could not be determined whether the instructor or the trainee involved in the occurrence had been exposed to the non-standard practice in use for stall-recovery training or whether the instructor had used it on the accident flight or on previous flights.

2. Given that the aircraft was almost entirely destroyed by the crash and subsequent post-impact fire, it could not be determined whether any pre-impact system failure or malfunction contributed to the accident; however, the components that were examined showed no signs of malfunction.

3. The information contained in Advisory Circular 700-031, Prevention and Recovery from Aeroplane Stalls, was not incorporated into TP 11575, *Instructor Guide – Multi-Engine Class Rating.*

Safety action

Safety action taken

Mount Royal University

Immediately following the accident, Mount Royal University suspended all flight training activities and inspected its 2 remaining Tecnam P2006T aircraft for evidence of overstress damage. None was found.

On 22 February 2017, the flying program was reactivated in stages. Each instructor conducted 4 flights in the Cessna 172: 2 in the left seat and 2 in the right seat. Students then conducted 2 flights, each in the Cessna 172. Once those reactivation flights had been completed, the normal program was restarted using the Cessna 172 aircraft.

On 03 March 2017, Mount Royal University issued a change to section 9.18 (Safety Checks [HASEL[39] checks]) of its *Company Operating Procedures Manual*. The amendment increased the minimum altitude at which aircraft should be recovered, from 2000 feet above ground level to 4000 feet above ground level.

On 10 March 2017, a memo was issued to all instructional staff, clarifying the roles of the designated instructor and the designated student when 2 instructors are conducting staff training flights together.

In late March 2017, Mount Royal University flight instructors were trained on twin-engine Piper PA 34 Seneca aircraft operated by another flight school, located at Calgary/Springbank Airport (CYBW), Alberta. Once its staff were qualified, Mount Royal University reactivated its multi-engine syllabus with an agreement to use the other flight school's aircraft. The arrangement was a transitional measure while the university completed a review of its multi-engine program.

At the beginning of August 2017, Mount Royal University decided to acquire 2 Piper PA 34 Seneca aircraft and began operating them as its designated multi-engine training aircraft. The disposition of the university's 2 remaining Tecnam P2006T aircraft had not yet been decided.

In September 2017, the Mount Royal University multi-engine standard operating procedures were amended to reflect that the first action in recovery to an approach-to-stall exercise is to lower the nose.

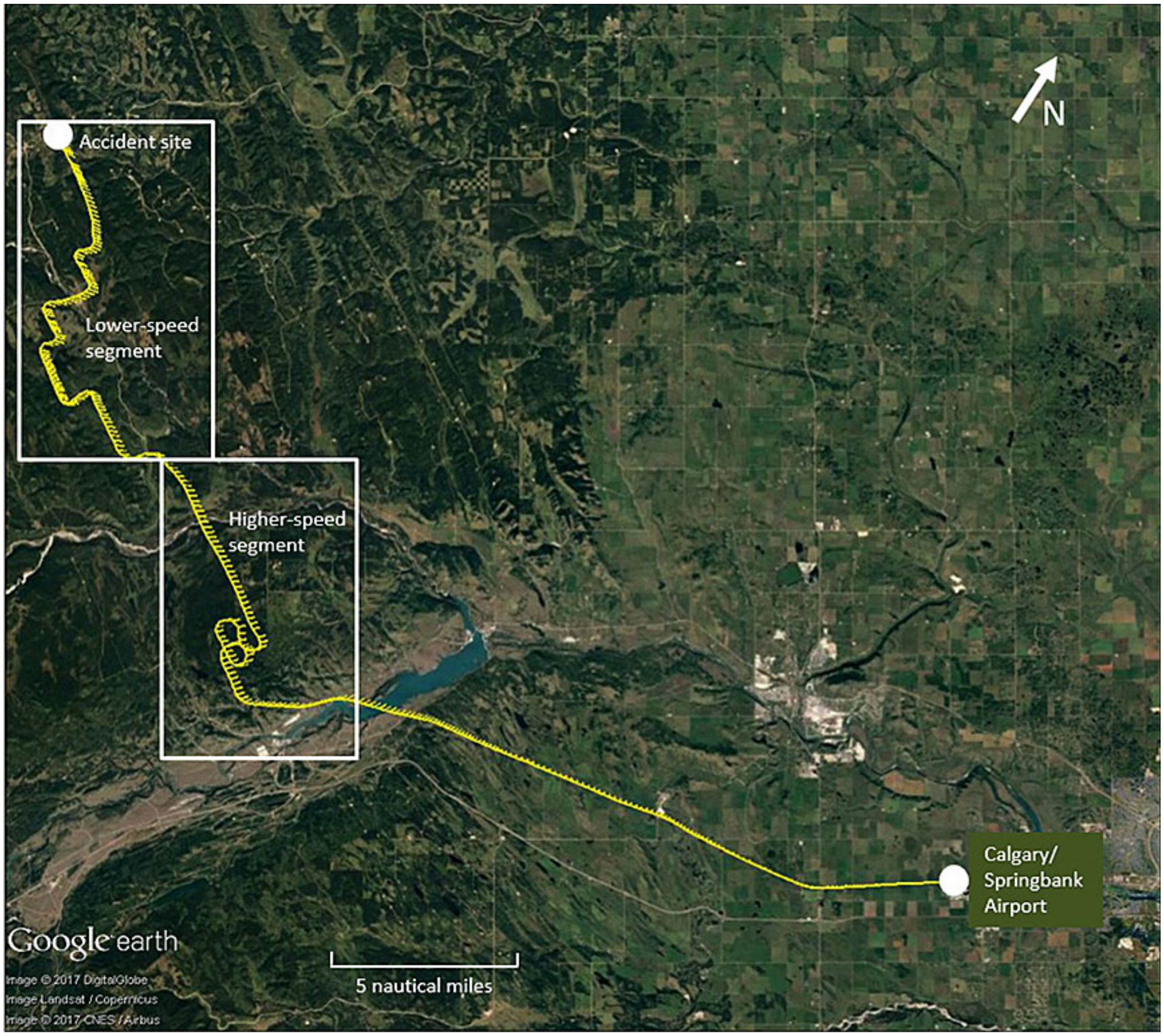
This report concludes the Transportation Safety Board of Canada's investigation into this occurrence. The Board authorized the release of this report on 17 January 2018. It was officially released on 22 February 2018.

[39] HASEL is an acronym meaning height, area, security, engine, look out.

Visit the Transportation Safety Board of Canada's website (www.tsb.gc.ca) for information about the TSB and its products and services. You will also find the Watchlist, which identifies the key safety issues that need to be addressed to make Canada's transportation system even safer. In each case, the TSB has found that actions taken to date are inadequate, and that industry and regulators need to take additional concrete measures to eliminate the risks.

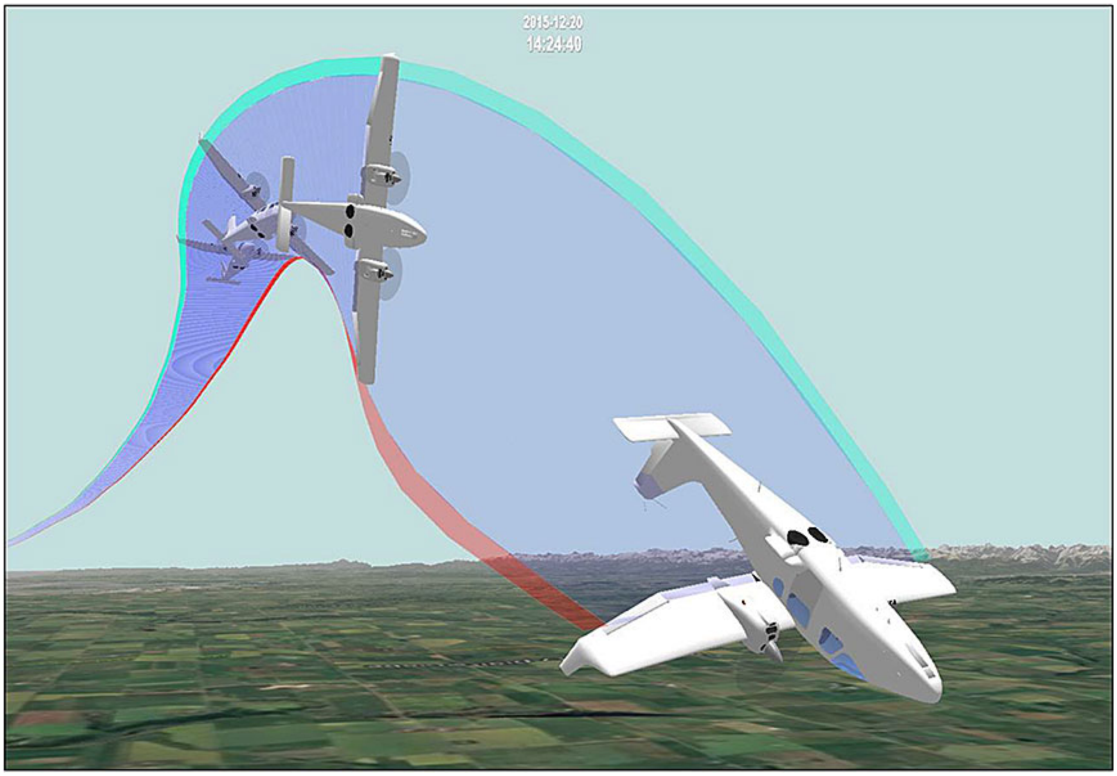
Appendices

Appendix A – Occurrence flight path



Source: Google Earth, with TSB annotations

Appendix B – Flight data analysis: Spin entry sequence of previous training flights



Terrain imagery sources: Google; DigitalGlobe

Appendix C – Flight data analysis: Spin entry and dive recovery of previous training flights

Terrain imagery sources: Google; DigitalGlobe

Appendix D – Flight data analysis: Comparison of flight-path shapes and altitude losses in aircraft upsets during stall-recovery training