Transport Canada Transports Canada

ISSUE 1/2021

AVIATION SAFETY LETTER

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TP 185E

Cover photo: iStock

Canada

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Letters with comments and suggestions are invited. All correspondence should include the author's name, address and telephone number. The editor reserves the right to edit all published articles. The author's name and address will be withheld from publication upon request.

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Electronic distribution:

To subscribe to the *Aviation Safety Letter* e-Bulletin notification service, visit: www.tc.gc.ca/ASL.

Print-on-Demand:

To purchase a Print-on-Demand (POD) version (black and white), please contact:

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Toll-free number (North America): 1-888-830-4911
Local number: 613-991-4071
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Sécurité aérienne — Nouvelles est la version française de cette publication.

ISSN: 0709-8103
TP 185E

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Aviation Safety Letter survey: We want to hear from you!

Transport Canada (TC) created the *Aviation Safety Letter* (ASL) to serve the aviation community as a safety and awareness educational tool. We are looking for your feedback as a reader about whether the content is relevant, useful, and meets safety awareness expectations.

Your input is important to us so that we can continue to improve the ASL.

All responses are anonymous, and data is aggregated for reporting purposes. The survey will take 5 minutes to complete. △

ASL instructor's corner

The purpose of the ASL instructor's corner is for instructors to share past instructing/teaching experience with the ASL readership.

Submitted articles can be addressed to a variety of readers, instructors, student pilots, private pilots, and glider, ultra-light or commercial pilots. In fact, this issues's article is for any type of student that an instructor may encounter in the course of their career, whether it be for a licence or a rating. The most important thing is that, at the end of the article, a lesson has been learned.

Your submissions can be as basic as attitude and movement for private pilot training, to night rating, multi-IFR or seaplane rating, teaching tips for instructors. It can also be tips to increase aviation safety or to be better prepared for a flight.

It's up to you, as long as you have your instructor's hat when you're writing your piece.

If you would like to submit an article or would like more information, please send an email to the following address: jim.mulligan@tc.gc.ca

Thanks to Michael Schuster for the first article of this series. —Ed. △

The supervisory process

by Michael Schuster, Chief Instructor, Aviation Solutions

At one of our recent Flight Instructor Refresher Courses, we had an unusually large number of Class 1 and Class 2 flight instructors in attendance. We put their collective efforts together as part of a special assignment. We asked them a question, and their responses were near unanimous—whether the instructor worked at a small school, or a large one.

Photo credit: iStock

We asked them:

"What would you like new flight instructors to know about their role in supporting the instructor supervision program?"

Here are their answers:

- Follow the instructions laid out by your chief flight instructor (CFI) or supervisor. Whether in an Operations Manual or verbal, they are there for a reason you may not be aware of yet.
- Conduct training in accordance with the school's syllabus, policies, handouts, and procedures. There is a reason those were developed the way they were. If you have an idea to improve them, please share with your CFI so that it can be evaluated by experienced eyes. If it's a good idea it will be incorporated for everyone. If there is a problem with it, the CFI will explain why the change can't happen.
- Whether a CARs requirement or a company requirement, both are equally important. Company requirements are there to address CARs requirements or other issues that have come up in the past. If you are unsure why you are required to do something, just ask.
- The CFI and supervisors are there as mentors and it's normal to have questions. Please ask as soon as you run into concerns with a student; don't think you have to fix it on your own—it can result in unnecessary stress and cost.
- Supervision isn't just about a supervisory flight. It's about briefings, preparatory ground instructions (PGIs), groundschool, planning training, paperwork, and everything else in the flight school environment—supervisors support all aspects of this.

- Supervision should be an ongoing dialogue, not a single top-down event. Take initiative, ask questions, and work as a team with your supervisor. Then when a need for an additional supervisory event comes up, it doesn't have to be a big issue.
- Standard 426.22 (5) (b) requires supervision of ALL flight instructors, of any class, working at an FTU. Two supervisory flights for Class 4 instructors is simply a minimum floor. The CFI determines how and to what extent supervision will take place, based on a variety of factors. Best practice in industry for newer instructors is that each student gets a supervisory flight every 10 hours. During this flight the supervising instructor samples a variety of exercises and may teach a new topic as well.
- Paperwork is a required part of the job. PTRs, logbooks, and licence applications need your constant attention to ensure compliance with the CARs. It also provides a customer-service-driven training experience.

All of the above are indicators of your professionalism as a flight instructor. There is a lot to instructing, and no one expects everyone to know everything. But there is an expectation that instructors know and follow the foundational regulatory and company requirements, which create a safe and effective training environment.

Be sure to keep an on-going and open dialogue with your supervisor; they are there to be a mentor. And if you find that your supervisor isn't providing the guidance described above, take the time to ask.

A version of this article originally appeared on aviationsolutions.net. *Michael Schuster is an experienced Class 1 flight instructor who has taught at all levels, from ab initio to airline. He is the Chief Instructor at Aviation Solutions, which is an authorized Flight Instructor Refresher Course provider for rating renewal.* △

The vertical challenge

By Anthony MacKay, Director, Operational Safety, NAV CANADA

When I started flying in 1986, the definition pertaining to precision and non-precision approaches was very simple. Precision was ILS and everything else was non-precision where dive and drive was the way you managed the vertical. Today, with the advent of RNAV, the precision/non-precision line is very blurry. Let us consider the following approaches:

Conventional Approaches	RNAV Approaches
• ILS • LOC • NDB • VOR	• LPV • RNP • L/V • LNAV/VNAV • LP • LNAV

Now let's list them by their ability to provide electronic vertical guidance and pilot derived vertical guidance via vertical speed or flight path angle:

Approaches with vertical guidance	Approaches without vertical guidance
• ILS • LPV • RNP • L/V • LNAV/VNAV	• LOC • NDB • VOR • LP • LNAV*

*may have advisory BARO VNAV

The approaches with vertical guidance can be further broken down to those that provide geometric vertical guidance and those that provide barometric vertical guidance:

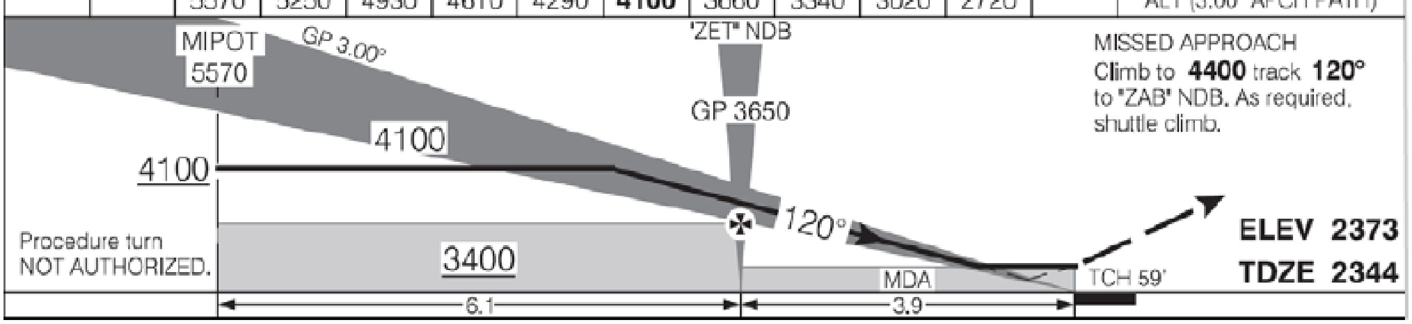
Geometric vertical guidance	Barometric vertical guidance
• ILS • LPV • L/V	• RNP • LNAV/VNAV • LNAV*

*if advisory BARO VNAV is used

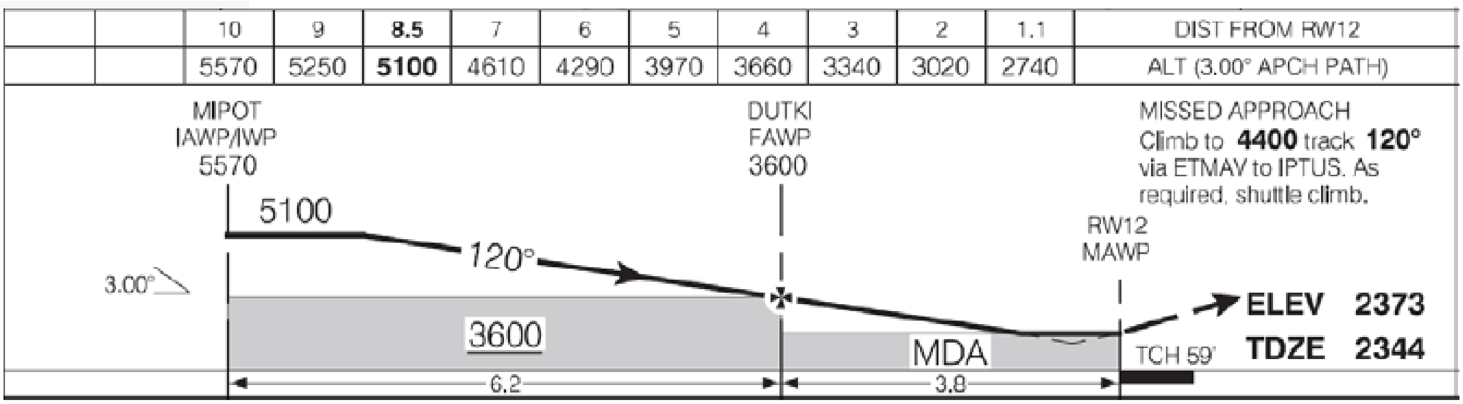
Geometric vertical guidance maintains a constant angle relative to the runway regardless of altimeter errors due to non-ISA temperatures, mountain wave effect or altimeter setting errors. As an example, during the winter at -35°C when flying the ILS or LPV to runway 12 in Edmonton, the aircraft, when on the glide path, will cross the FAF at the correct true altitude, but the indicated altitude will be higher than normal. During the summer at 35°C when flying the ILS or LPV to runway 12 in Edmonton, the aircraft, when on the glide path, will cross the FAF at the correct true altitude, but the indicated altitude will be lower than normal. If temperature corrections have been completed, this will be expected.

ILS 12

		10	9	8	7	6	**5.4**	4	3	2	1.1		DIST FROM RW12
		5570	5250	4930	4610	4290	**4100**	3660	3340	3020	2720		ALT (3.00° APCH PATH)



RNAV 12 (LPV)

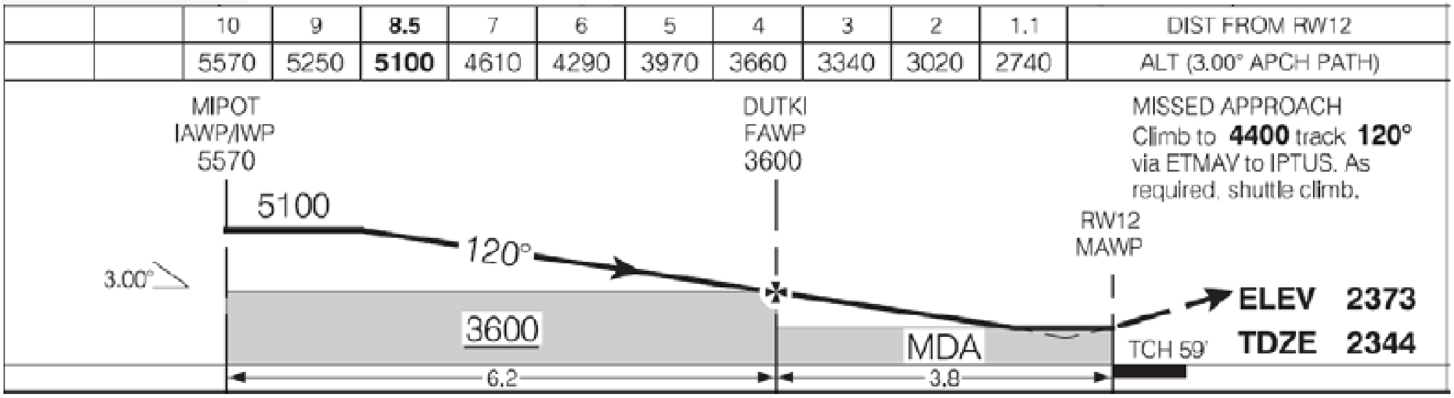


ISA FAF Altitude and Approach Angle	Indicated Altitude -35°C & Approach Angle	Indicated Altitude 35°C & Approach Angle
ILS 3650’ & 3°	3893’ & 3°	3548’ & 3°
LPV 3600’ & 3°	3833’ & 3°	3502’ & 3°
L/V[1] 3600’ & 3°	3833’ & 3°	3502’ & 3°

1 L/V approaches use GNSS lateral and WAAS vertical for approach guidance

Barometric vertical guidance will shallow (cold) or steepen (warm) the approach angle relative to the runway due to altimeter errors like non-ISA temperatures, mountain wave effect or altimeter setting errors. As an example, during the winter at -35°C when flying the LNAV/VNAV or LNAV (*with advisory BARO VNAV) to runway 12 in Edmonton, the aircraft, when on the barometric vertical path, will cross the FAF at the correct indicated altitude, but the true altitude will be lower than designed. During the summer at 35°C when flying the LNAV/VNAV or LNAV (*with Advisory BARO VNAV) to runway 12 in Edmonton, the aircraft, when on the barometric vertical path, will cross the FAF at the correct indicated altitude, but the true altitude will be higher than designed. RNP procedures use barometric vertical paths and are subject to the same errors. The examples below show the effect <u>without temperature compensation applied</u>.

RNAV 12 (LNAV/VNAV or LNAV (*with advisory BARO VNAV)



ISA FAF indicated altitude and approach angle	True altitude -35°C & approach angle	True altitude 35°C & approach angle
LNAV/VNAV 3600' & 3°	3367' & 2.5°	3698' & 3.2°
LNAV* 3600' & 3°	3367' & 2.5°	3698' & 3.2°

*with advisory BARO VNAV

The good news is that if your flight management system (FMS) has a temperature compensation function, and you use it, the FMS will correct the aircraft vertical path for non-standard temperatures back to the correct true altitude and approach angle. Currently, aircraft procedures are developed for temperature compensation and cold temperatures, but very little guidance exists regarding higher than ISA temperatures on approach. For aircraft operators using FMS that do not have temperature compensation, cold temperature limits are included on the approach plate limiting the use of the approach to temperatures warmer than the published limit.

CATEGORY	A	B	C	D
LPV	**2600** (256) 1 RVR 50			
LNAV/VNAV (min.-34°C)	**2740** (396) 1 RVR 50			
LNAV	**2740** (396) 1 RVR 50			
CIRCLING	**2880** (507) 1½		**2880** (507) 2	**2980** (607) 2

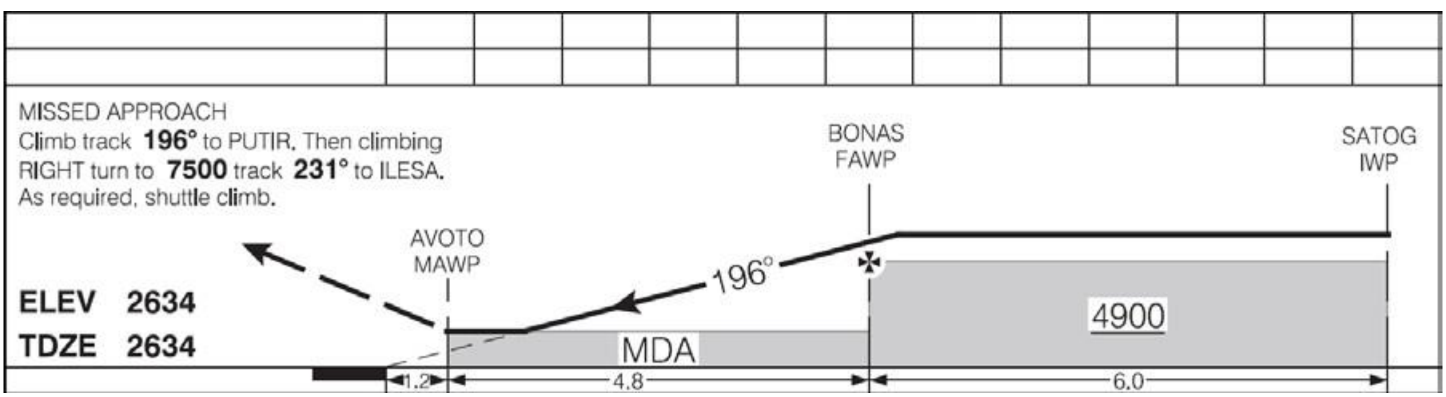
Additional good news is that Transport Canada is requiring that all new aircraft with FMS BARO VNAV have temperature compensation. *"New or updated FMS designs shall provide a means for an aircraft to fly the true vertical path angle for final approach segment, as defined in the resident navigation database, in below ISA temperature conditions."* Transport Canada AC 500-020 provides additional information.

ISA FAF Indicated Altitude and Approach Angle	True Altitude -35°C & Approach Angle & PAPI	True Altitude 35°C & Approach Angle & PAPI
LNAV/VNAV 3600' & 3°	3367' & 2.5° &	3698' & 3.2° &
LNAV* 3600' & 3°	3367' & 2.5° &	3698' & 3.2° &

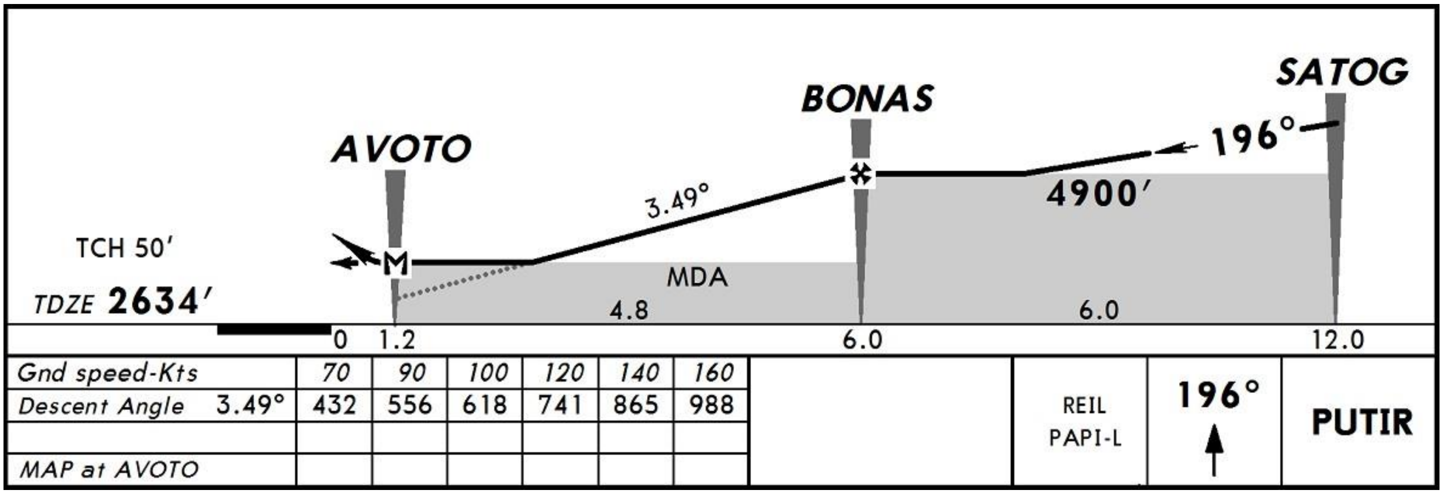
If you are flying a BARO VNAV path (RNP, LNAV/VNAV) with a FMS that does not use temperature compensation, you may expect the following PAPI indications when entering the visual segment of the approach. An additional caution must be observed when flying LNAV *with advisory BARO VNAV. The advisory BARO VNAV is derived from the runway threshold altitude +50 ft and projected back up the approach slope at 3° or the steeper angle required to provide a descent path above all step-down altitudes in the final approach segment. This provides the aircraft with a path to follow in the instrument segment of the approach that will clear all step-down altitudes and obstacles to LNAV minimums. The visual segment of the non-precision approach may require a different descent angle based on the PAPI. Dease Lake, BC, is a good example of this. The FMS has generated a path of 3.49° from BONAS to AVOTO to RWY20.

FMS screen

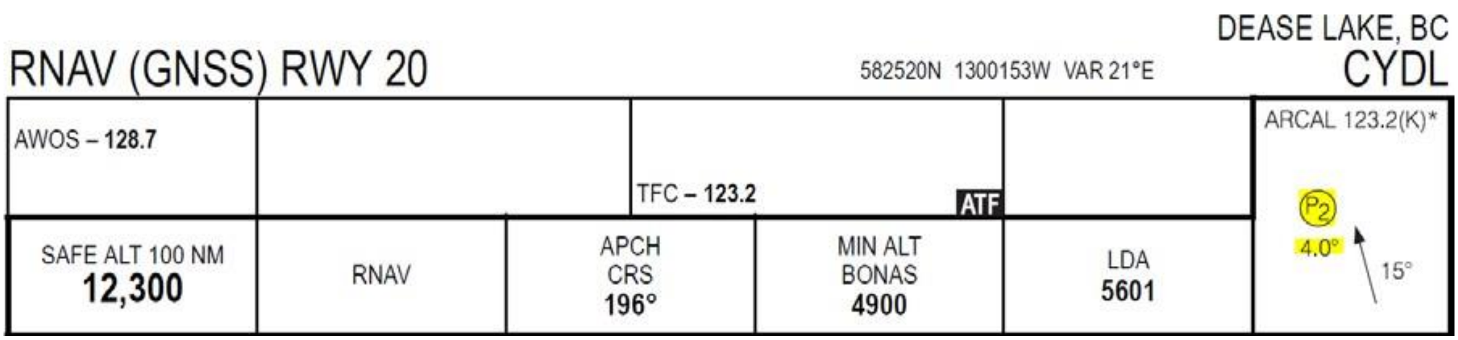
The CAP plate shows no vertical information.



The Jeppesen Plate shows 3.49° which matches the FMS coding.



But to clear obstacles in the visual segment of the approach to RWY 20 in Dease Lake, you have to fly the 4.0° PAPI in the visual segment of the approach.



ADDITIONAL RUNWAY INFORMATION

RWY		USABLE LENGTHS LANDING BEYOND Threshold	Glide Slope	TAKE-OFF	WIDTH
02 ❶	❷MIRL ❷REIL ❷❸PAPI-R (angle 4.0°)				100′
20	❷MIRL ❷REIL ❷❸PAPI-L (angle 4.0°)	5601′			

If an LNAV procedure is collocated with an ILS, LPV, RNP or LNAV/VNAV procedure, the visual segment of the approach will be protected on the BARO VNAV path. If the LNAV procedure is stand-alone such as the Dease Lake example, the PAPI will provide the visual segment obstacle protection.

Finally, if using an SCDA technique (VS or FPA) on LP, LNAV, LOC, NDB or VOR procedures, the requirements of Transport Canada AC 700-028 must be adhered to. △

RECENTLY RELEASED TSB REPORTS

The following summaries are extracted from final reports issued by the Transportation Safety Board of Canada (TSB). They have been de-identified. Unless otherwise specified, all photos and illustrations were provided by the TSB. For the benefit of our readers, all the occurrence titles are hyperlinked to the full report on the TSB Web site. —Ed.

TSB Final Report A19P0187—Collision with terrain

Background

The occurrence flight was conducted on behalf of the United States Department of Commerce National Oceanic and Atmospheric Administration (NOAA) as part of the Global Greenhouse Gas Reference Network's aircraft program. The program collects air samples at specified altitudes and locations across North America and stores them for later analysis.

History of the flight

On 21 December 2019, the privately registered Cessna 172H aircraft was conducting a visual flight rules (VFR) flight from Courtenay Airpark (CAH3), BC, with only the pilot on board. Shortly after departing CAH3, the aircraft appeared on radar at 11:32 climbing through 1 900 feet ASL. At 12:03, the aircraft levelled off at 17 400 feet ASL. For the next 15 minutes, it followed the planned flight path for the air-sampling mission with a pattern of flight consistent with previous air-sampling flights, including a transponder code change at 12:14.

When the aircraft reached 9 500 feet ASL at 12:17, it did not level off to conduct a sampling as planned. Instead, it descended through 9 500 feet ASL on a steady track heading southwest and continued its descent for 4 minutes at 80 to 100 knots groundspeed and an average rate of 1 800 fpm, until it was no longer visible on radar. The last radar return was at 2 800 feet ASL. There was no record of any radio communications from the aircraft.

The on-board NOAA sampling equipment's GPS (global positioning system) indicated that the aircraft came to rest at 12:22 (Figure 1). It had struck trees and collided with the ground near Stewardson Inlet, BC. The pilot was fatally injured. The aircraft was destroyed. There was no post-impact fire.

Figure 1. Flight paths of the occurrence flight and the previous sampling flight, based on NAV CANADA radar and National Oceanic and Atmospheric Administration GPS data (Source: Google Earth, with TSB annotations)

Note: Flight data for the 27 November flight comes from the NOAA GPS, which only captures data from the first to the last sample.

When the pilot did not return to his home at the expected time, a ground and air search was initiated. The local police were contacted just less than 4 hours after the accident, and approximately 5½ hours elapsed between the time of the accident and the time that the Joint Rescue Coordination Centre in Victoria was notified of a possible missing aircraft. The aircraft's 121.5 MHz emergency locator transmitter (ELT) emitted a signal, which assisted the search-and-rescue (SAR) aircraft in finding the occurrence location at approximately 20:00. Due to poor visibility, cloud, and heavy rain, SAR personnel could not get to the scene until the following morning.

Pilot information

The pilot held a recreational pilot permit with a valid Category 4 medical certificate. The permit was valid for single-engine, land- and seaplanes, in daytime VFR conditions. Additionally, the pilot held a glider licence originally issued in 1995.

Wreckage and impact information

The wreckage was found at approximately 2 600 feet ASL on a steep, densely wooded mountainside, 31 nautical miles (NM) northwest of Tofino/Long Beach Airport (CYAZ), BC. (Figure 2). Few tree tops and tree limbs were broken. The average height of the trees at the occurrence site was approximately 150 feet and those nearest the aircraft had bark scarring on the lower 60 feet, primarily on the sides facing east-southeast; the aircraft's flight path to the occurrence site from CAH3 was from the east-northeast. The scarring is consistent with the NOAA GPS track, which showed the aircraft made a right turn in the last 20 seconds of flight.

Figure 2. Occurrence site on 12 February 2020, looking west (Source: TSB)

The fuel tank caps on both wing tanks were secured; both wing tanks were damaged, and no fuel was found in the tanks. The odour that remained in the fuel tanks was consistent with automotive gasoline. The fuel selector was set to BOTH. A note found on the pilot's kneeboard at the occurrence site indicated the aircraft had departed CAH3 with 87 litres (23 US gallons) of fuel. A typical air sampling flight would consume about 50 litres (13 US gallons) of fuel.

The aluminum fixed-pitch propeller remained attached to the engine crankshaft. Both propeller blades exhibited S–shaped bending and 1 blade had significant leading edge damage. The spinner was crushed. These indications are consistent with the propeller turning and the engine producing power at impact.

The aircraft had an oxygen tank installed with an attached nasal cannula. The oxygen tank valve was in the OFF position and there was approximately 500 psi remaining. Both the left and right control yoke tubes were broken 6 inches from their respective control yoke, which is consistent with them being fully out, or in nose-up, elevator position.

The wing flaps were found fully retracted and the elevator trim was found in the neutral position. Because the engine had partially pulled away from the airframe, the positions of the engine controls, carburetor heat, throttle, and mixture at the time of impact could not be determined. The aircraft was equipped with a pitot heat system; however, due to the nature of the impact, the position of the switch prior to the accident could not be determined.

Aircraft information

The occurrence aircraft was a Cessna 172H manufactured by the Cessna Aircraft Corporation in 1967. It had originally been equipped with a 145-hp engine. The engine was upgraded in February 2006 to a 180-hp Lycoming O-360-A4M in accordance with supplemental type certificate (STC) SA4428SW. The aircraft was not certified for flight in instrument meteorological conditions nor in known icing conditions.

The fuel used in the aircraft was a mixture of 100LL aviation fuel and automotive gasoline. The investigation determined that this fuel mixture had been used by the pilot for many years. There is an available STC for automotive gasoline for this airframe and engine; however, the aircraft's technical records did not indicate that this STC had been completed.

Records indicate that the aircraft was equipped and maintained in accordance with existing regulations. Nothing was found to indicate that an airframe failure or system malfunction had occurred before or during the flight.

Meteorological information

The closest aviation weather reporting station to the occurrence site is located at CYAZ, 31 NM to the southeast. An aerodrome special meteorological report (SPECI) was issued at 12:25 and indicated the following:

- winds calm;
- visibility 10 statute miles (SM) in rain showers;
- scattered clouds at 2 500 feet above ground level (AGL), a broken ceiling at 3 000 feet AGL including cumulonimbus clouds, and an overcast layer at 4 700 feet AGL;
- temperature 6 °C, dew point 5 °C;
- altimeter setting 29.75 inHg.

The local graphic forecast (LGF) issued on 21 December at 09:46 and valid at 10:00 depicted, in the area of the occurrence, broken ceilings of cumulus clouds based at 2 000 to 4 000 feet ASL, with tops at 12 000 feet ASL and visibility expected to be greater than 6 SM. The forecast included an expectation of occasional towering cumulus clouds with tops at 22 000 feet ASL and visibilities from 4 to greater than 6 SM in light rain showers and mist. Patchy ceilings were expected from 800 to 1 500 feet AGL with local visibility of 2 SM in light rain showers and mist. In addition, the LGF for the occurrence area included towering cumulus clouds with frequent isolated cumulonimbus clouds with tops at 26 000 feet ASL and visibility of 2 SM in thunderstorms and rain with wind gusts up to 30 knots. The freezing level was forecast to be at 2 500 feet ASL.

Lightning strikes were recorded near the occurrence site between 10:00 and 13:00 and clouds of vertical development were observed on satellite weather imagery just south of the accident site. The hazards associated with towering cumulus and cumulonimbus clouds are: tornadoes, turbulence, squall lines, microbursts, heavy updrafts and downdrafts, icing, hail, lightning, precipitation static, heavy precipitation, low ceilings and visibilities.

The *Transport Canada Aeronautical Information Manual* (TC AIM) describes several performance decrements when ice builds up on various areas of the aircraft. Ice on the wings can reduce lift, increase drag and reduce the angle at which the wing stalls. Ice on the propeller can reduce efficiency and create vibrations due to an imbalance. Ice on the windshield can reduce or completely block forward vision.

Safety messages

In this occurrence, the aircraft was flying in an area of forecasted convective cloud activity, icing, and instrument meteorological conditions. While the investigation could not determine if any of these affected the occurrence flight, it is important that pilots assess all available weather information before departure, plan alternate routes, and operate within the limitations of their aircraft and the privileges of their licences or permits.

TSB Final Report A19Q0128—Loss of control and collision with terrain

History of the flight

At 15:55 Eastern Daylight Time (EDT) on 29 July 2019, the Beechcraft Bonanza V35B aircraft departed Wittman Regional Airport (KOSH), Wisconsin, U.S., for a daytime visual flight rules (VFR) flight to Danbury Municipal Airport (KDXR), Connecticut, U.S., with only the pilot on board. Within minutes, the aircraft turned approximately 15° north of a direct flight path to KDXR. At 16:10, the aircraft climbed through 10 000 feet above sea level (ASL) and levelled off at approximately 11 500 feet ASL. As the flight progressed, the aircraft deviated toward the north and never regained a track or heading toward the original destination (Figure 1). At 17:27, just before entering Canadian airspace, the pilot contacted the Toronto Area Control Centre (ACC) and informed the controller that, in 20 nautical miles (NM), he would be turning 90° to the right to regain his track to KDXR. The Toronto ACC controller replied that a solid line of thunderstorms and lightning was visible on the radar and that he could not provide any indication of the best route to take. The pilot acknowledged the weather information and stated that he was "painting the weather." After having reached the northern shore of Lake Huron, Ontario, the aircraft turned north-northeast and flew between 2 Canadian airports: Sudbury Airport (CYSB), Ontario, approximately 20 NM to his left, and North Bay Airport (CYYB), Ontario, approximately 30 NM to his right.

At 18:24, the pilot initiated a descent from 11 500 feet ASL and 4 minutes later, the aircraft had descended below 10 000 feet ASL. At 18:37 and as the aircraft was flying over the province of Quebec, the Toronto ACC controller informed the pilot that radar services were terminated and instructed him to contact the Montreal ACC.

At 18:42, the aircraft had descended to 7 500 feet ASL and the pilot contacted the Montreal ACC. Because other aircraft were flying in the area, the controller asked the pilot if he was familiar with the Rouyn-Noranda Airport (CYUY), Quebec, or the Val d'Or Airport (CYVO), Quebec, which were nearby. The pilot replied that he was not.

Radio communications between the pilot and the Montreal ACC controller were limited and did not reveal any indication that the pilot was in distress. Due to the limitations in radar coverage below 8 000 feet ASL in the area, the controller was unable to maintain radar contact with the occurrence aircraft. As a result, at 18:44, the Montreal ACC controller provided the altimeter setting for CYVO and then cleared the pilot to switch to an en-route frequency. The pilot replied by repeating the CYVO altimeter setting. There were no further transmissions from the pilot.

At approximately 19:06, the aircraft flew past Senneterre, Quebec, level at 7 000 feet ASL. Approximately 3 minutes later, the aircraft was in a gradual climb through 7 500 feet ASL. At that point, the aircraft was flying at 160 knots calibrated airspeed (KCAS), on an easterly heading. The aircraft then entered a slow turn to the left at 1.45° per second for approximately 75 seconds, which then increased to 4.36° per second for another 33 seconds. At 19:10 the left turn continued into a descent, and the descending left turn continued until the aircraft reached 7 200 feet ASL.

After turning approximately 250° to the left, the aircraft then immediately entered a climbing right turn and its speed decreased to approximately 100 KCAS while it climbed back to approximately 7 900 feet ASL.

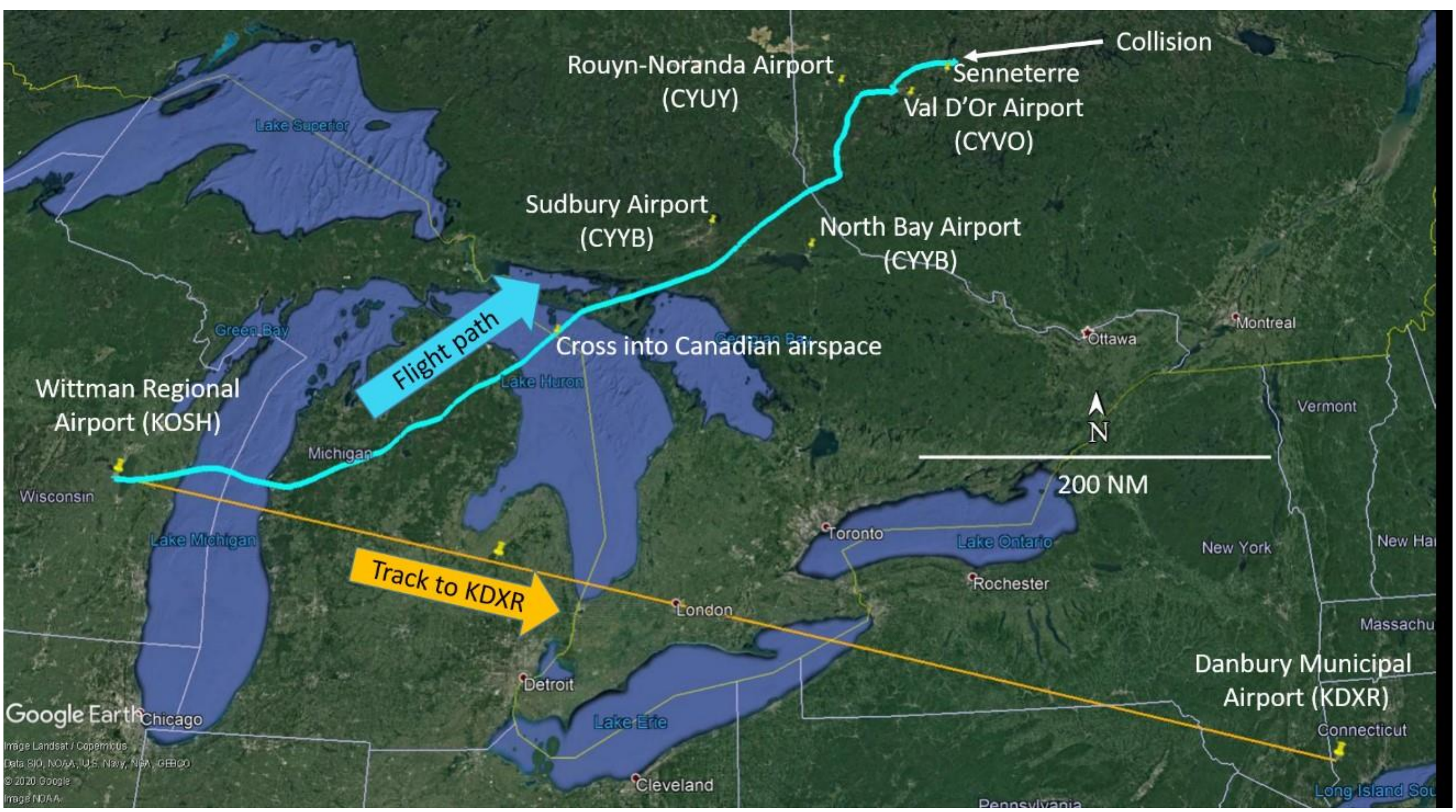


Figure 1. The occurrence aircraft's flight path (green line) and direct track from Wittman Regional Airport to Danbury Municipal Airport (orange line) (Source: Google Earth, with TSB annotations)

As the right turn continued, the aircraft began to descend, the right turn steepened and its airspeed and descent rate increased rapidly. At 19:12, the aircraft collided with terrain in a heavily wooded area approximately 7 NM northeast of Senneterre, 452 NM from KDXR.

Later that night, shortly after the aircraft's planned arrival time at KDXR, the pilot's family notified the U.S. authorities of the missing aircraft. The U.S. authorities then contacted Canadian air traffic control (ATC) services. At 23:31, the Joint Rescue Coordination Centre (JRCC) in Trenton, Ontario, was notified of the missing aircraft and initiated a search and rescue (SAR) operation. The accident site was located 4 days later, on 02 August 2019.

Personnel information

The pilot was certified and qualified for the flight in accordance with existing U.S. Federal Aviation Administration (FAA) regulations. The pilot had 20 years of experience as a general aviation pilot and flew approximately 100 to 150 hours per year.

Aircraft information

General

The model 35 Bonanza is a single-engine, low-wing monoplane with retractable landing gear. A distinguishing feature is its combined elevator and rudder, called a ruddervator, or V-tail. The occurrence aircraft (Figure 2) was a Bonanza V35B model, manufactured in 1980. The occurrence pilot purchased the aircraft in 2001.

Records indicate that the aircraft was certified, equipped and maintained in accordance with existing regulations and approved procedures.

Figure 2. Occurrence aircraft
(Source: TSB, with permission from third party)

Beechcraft Bonanza spiral-dive characteristics

A spiral dive is a steep descending turn with the aircraft in an excessively nose-down attitude. A spiral dive may be recognized by an excessive angle of bank, rapidly increasing airspeed, rapidly increasing rate of descent, and increasing load factors.

The Beechcraft Pilot Proficiency Program, Inc. Approved Bonanza Recurrent Course includes a demonstration of the airplane's spiraling characteristics, the technique for recovery, and the student's practice of that technique. The spiral demonstration is explained in a handout and provides the following information:

The spiral demonstration shows the likely outcome if the airplane enters a steep bank but the pilot does not maintain altitude and airspeed. Spirals usually result from disorientation, attitude instrument failure, severe turbulence or thunderstorm encounters, or inattention, especially in instrument conditions. They are the natural result of an airplane that is stable in pitch but neutrally stable or unstable in roll. Beech piston airplanes have this characteristic. […]

> *Now, roll into a steep bank and let go of the controls. The airplane will immediately begin accelerating and descending downward, with rapidly increasing airspeed and vertical speed. It has no tendency to recover, but instead tries to return to its trimmed airspeed by pitching up relative to the airplane. This simply tightens the spiral and increases the load factor.*

Meteorological information

General

The investigation was unable to determine what, if any, weather information the pilot obtained before departure. However, at the time of departure, the weather at KOSH showed VFR conditions.

A weather analysis for the area and day of the accident determined that a broken line of showers and thunderstorms extended from Michigan into central Ontario and western Quebec, and was moving eastward at around 25 to 30 knots. The analysis concluded that near the thunderstorms and heavy showers, visibilities dropped to as low as 1½ statute miles (SM) and ceilings dropped to as low as 700 feet above ground level (AGL). The aircraft flew along the line of weather (Figure 3).

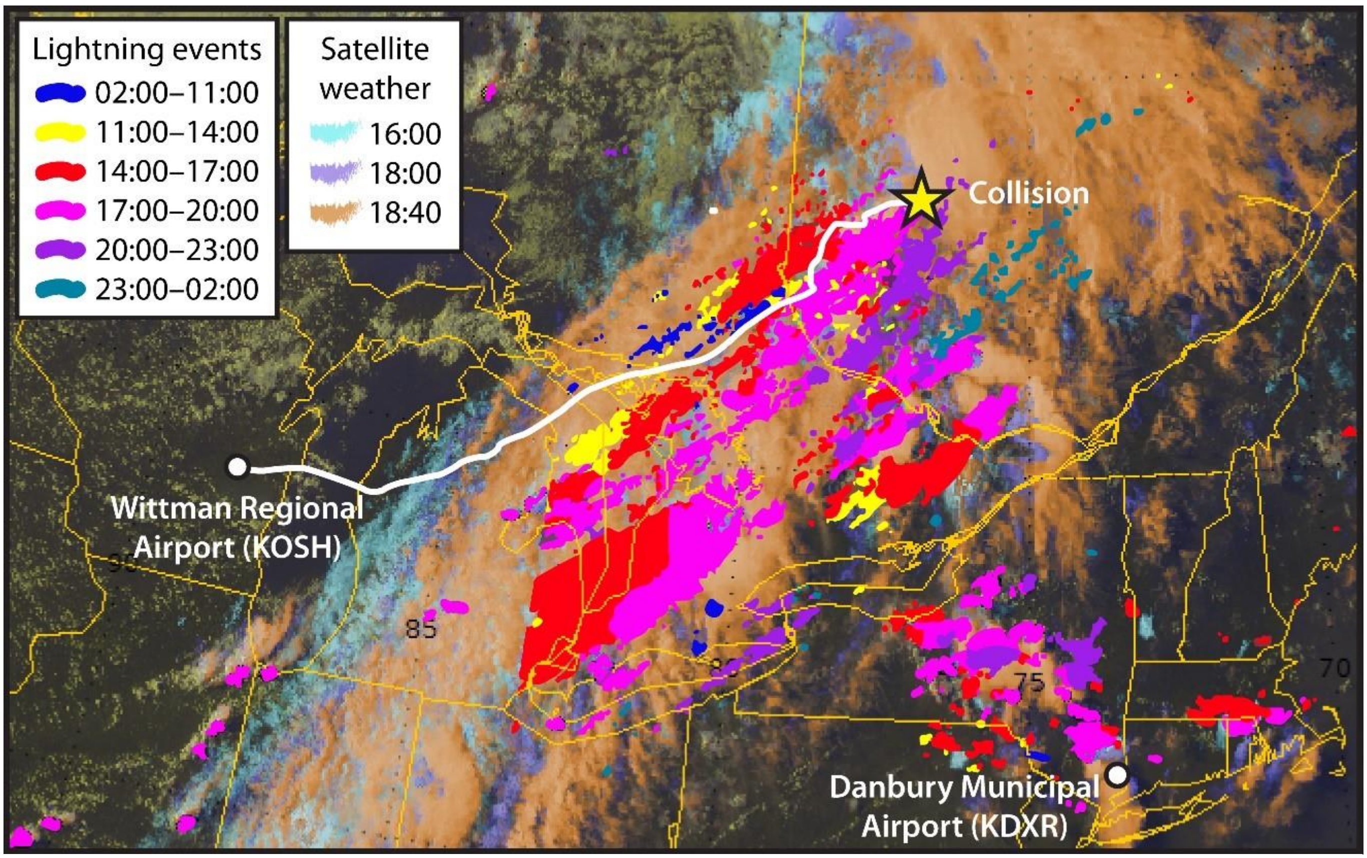


Figure 3. Flight path superimposed on multispectral visible satellite images around the time of the event, on 29 July 2019. Lightning strikes in the past 24 hours are indicated by a color code. The location of departure (KOSH), the intended destination (KDXR), and the location of the collision with the terrain are also indicated. (Source: Environment and Climate Change Canada)

Weather near the accident site

Thunderstorms reached CYUY at around 16:00 and CYVO at around 17:45. By 18:45, the aircraft was east of CYUY and flying toward CYVO at 7 500 feet ASL. Thunderstorms reached the accident site at around 18:50. At 19:00, the aircraft was approximately 20 NM north of CYVO, the nearest reporting facility to the accident site; the accident occurred at 19:12. Sunset was at 19:56. The investigation could not determine the exact weather that the pilot encountered. However, due to its proximity, it is likely that the pilot encountered weather similar to that reported at CYVO.

Aids to navigation

According to NAV CANADA records, there were no reported anomalies or planned maintenance outages to navigation aids for the region encompassing the flight path within the Toronto and Montreal flight information regions.

Wreckage and impact information

The occurrence site was located in a heavily wooded area at 48°28'19"N, 077° 02'52"W, more than 350 NM north of the intended track from KOSH to KDXR, and 452 NM from KDXR. The aircraft impacted trees at high velocity 32 feet before the collision with terrain and at an angle of approximately 30° below the horizon. The wreckage distribution extended approximately 85 feet.

Most parts of the aircraft, including the wings and the ruddervator, were located at the occurrence site. The engine was found in a crater approximately 6 to 10 feet deep. The engine, aircraft fuel system, flight controls, instrument panel, cockpit seats and seat belts were all found heavily damaged and highly fragmented. As a result, flight control continuity and engine control continuity could not be established. As well, no instrument switch positions could be determined. The propeller hub was fractured into pieces.

Examination of the site and wreckage showed that there was no in-flight breakup or separation of the wing or ruddervator. The investigation did not identify any pre-impact material failures or component malfunctions.

Emergency locator transmitters

The occurrence aircraft was equipped with an ELT capable of transmitting on 121.5 MHz and 243 MHz that was destroyed on impact. No functional testing could be completed on the unit due to the extent of damage.

Additional information

Visual flight rules flight into instrument meteorological conditions

TSB accident data shows that continued VFR flight into adverse weather or instrument meteorological conditions (IMC) represents a significant threat to aviation safety. Aircraft operating under VFR that continue into IMC are at risk of controlled flight into terrain and loss of control accidents.

The TSB examined its data to identify accidents involving pilots who were flying under VFR and proceeded into IMC. From 1992 to 2019, 168 accidents and 205 fatalities were identified.

Spatial disorientation

Spatial disorientation (SD) is defined as a pilot’s inability “to correctly interpret the aircraft’s attitude, altitude, or airspeed in relation to the Earth or other points of reference.”

All humans require and receive sensory information from the visual system (the eyes), the vestibular system (the balance organs within the inner ears), and the proprioceptive system (known as "seat of the pants"–the pressure receptors throughout the body that help contribute to the overall sense of orientation). Humans will process information from these systems to determine their position in time and space, and in relation to the surface of the Earth. Unfortunately, humans are susceptible to visual or vestibular illusions, which can affect how a person interprets the information received, seen or felt, that can result in SD. The visual or vestibular illusions relevant to this investigation include the leans, the Coriolis illusion and the graveyard spiral (spiral dive).

- The leans is a common illusion where, after a prolonged roll or turn, and upon returning to straight and level flight, the pilot may sense a turn in the opposite direction. SD "can occur when movement is below the sensory threshold for the semicircular canal (0.2-8.0 degrees per second), especially during slow rotational movement."
- The Coriolis illusion is caused when the aircraft is in a prolonged roll or turn and the pilot abruptly moves his or her head out of the plane of rotation (e.g., down or back). The combination of the lengthy rolling or turning motion (stabilizing the fluid in the inner ear) and the sudden head motion (causing an opposite reaction within the inner ear) stimulates the vestibular system, creating a tumbling sensation.
- The graveyard spiral (spiral dive) is an insidious illusion where a pilot will initially not notice a wing drop (increase in bank) and the resultant lowering of the aircraft pitch attitude (increase in airspeed). This can result in a slow gradual descending turn with increasing airspeed. "As the aircraft spirals downward and its rate of descent accelerates, the pilot senses the descent but not the turn. With the bank angle having gradually increased, any control input only tightens the turn and increases the descent rate."

In a degraded visual environment (such as intentionally or inadvertently flying into IMC) where a pilot is unable to maintain visual reference with the ground, these illusions can lead to improper flight control inputs and result in a loss of control. The strength of these illusions can be so intense that even a conscious cross-reference to flight instruments may be insufficient to prompt the pilot to apply the appropriate corrective input to the flight controls.

Situation awareness

Situation awareness (SA) is defined as "the perception of elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future."

Maintaining SA is therefore a result of 3 separate processes. A pilot must first perceive information from the environment; second, establish the relevance of this information to the ability to achieve operational goals; and finally, use this information to project future states and events. In this way, a pilot maintains SA, allowing him or her to "plan ahead and prepare for contingencies," which leads to more effective decision making. All 3 processes involve information-processing stages at which shortcomings may occur and that may result in incomplete or inadequate SA.

A pilot's training, knowledge, experience, and preconceptions are some of the individual factors that influence his or her understanding of a situation. Other issues facing pilots when flying—such as workload, distraction, time pressure, equipment malfunctions, changes in weather conditions, unfamiliarity with a geographical area and flying at night—can also affect SA.

Pilot decision making

Pilot decision making (PDM) is a cognitive process to select a course of action between alternatives. Many decisions are made on the ground, and a well-informed pre-flight choice avoids the need for a much more difficult in-flight decision. An important component of PDM is good SA.

Other factors can affect PDM, such as family or work pressure to arrive at the destination by a certain time; financial implications when landing at an alternate airport, such as requiring aircraft services, transportation, meals or accommodations; or administrative issues such as clearing customs when landing in another country.

Plan continuation bias

Plan continuation bias is best described as “the unconscious cognitive bias to continue with the original plan in spite of changing conditions,” or “a deep-rooted tendency of individuals to continue their original plan of action even when changing circumstances require a new plan.” Once a plan is made and committed to, it becomes increasingly difficult for stimuli or conditions in the environment to be recognized as necessitating a change to the plan. Often, the stimuli or conditions will appear obvious to people external to the situation; however, as workload increases, it can be very difficult for a pilot caught up in the plan to recognize the saliency of the cues and the need to alter the plan.

Hypoxia

In this occurrence, the pilot flew above 10 000 feet ASL, but no higher than 11 500 feet, for 2 hours 18 minutes. The pilot subsequently descended below 10 000 feet ASL and was operating below that altitude for 44 minutes before the accident. Although an oxygen bottle was found at the crash site, it could not be determined if it was used for the portion of the flight flown above 10 000 feet ASL. With the FAA regulation only requiring the use of supplemental oxygen above 12 500 feet ASL, and the pilot having selected and flown at a cruising altitude of 11 500 feet ASL, it is possible that the pilot elected not to use supplemental oxygen.

The investigation concluded that hypoxia was unlikely to have played a role in this accident.

Analysis

The pilot was certified and qualified for the flight in accordance with existing U.S. Federal Aviation Administration regulations. Records indicate that the aircraft was certified, equipped and maintained in accordance with existing regulations and approved procedures. The investigation determined that there was no in-flight breakup or separation of the wing or ruddervator.

The flight profile and weather data suggest that the pilot was deviating around the weather in an attempt to bypass or outrun a moving line of thunderstorms and lightning. It is likely that the aircraft subsequently entered instrument meteorological conditions (IMC) and the pilot became spatially disoriented. The aircraft entered a spiral dive and collided with terrain.

The analysis will identify factors that could have played a role in the occurrence and accident sequence. Factors affecting the search and rescue will also be discussed.

Plan continuation bias affecting situation awareness and pilot decision making

The numerous northerly heading deviations were all followed by gradual corrections to regain an easterly heading. These heading corrections all proved unsuccessful in either crossing the line of weather or regaining a suitable track toward the original destination of Danbury Municipal Airport (KDXR), Connecticut, U.S.

These continued unsuccessful attempts and the surrounding adverse weather conditions were cues that should have suggested a change to the pilot's original plan, such as deviating to one of the several suitable alternate airports along the route, or continuing the flight under instrument flight rules (IFR). Once he was in Canadian airspace over the province of Quebec, reaching his intended destination of KDXR—more than 450 nautical miles away—would not have been possible. The commitment to the original plan indicates that the pilot's decision making was likely affected by plan continuation bias. Consequently, he continued the flight, likely until he no longer could maintain flight in visual meteorological conditions.

The pilot's decision making was likely affected by plan continuation bias, which led him to continue a visual flight rules (VFR) flight in adverse weather conditions.

Visual flight rules flight into instrument meteorological conditions

VFR flight into IMC represents a significant threat to aviation safety. Aircraft operating under VFR that continue into IMC are at risk of controlled flight into terrain and loss of control accidents.

In addition to deviating around the weather to bypass or outrun the moving line of thunderstorms and lightning, the aircraft may also have been flying above or between cloud layers. The multiple course alterations indicate that the pilot was likely attempting to remain flying under VFR and avoid entering IMC.

If the pilot inadvertently entered cloud or IMC, flight with visual reference to the ground would no longer have been possible, and a transition to flying solely by reference to instruments would have been required.

Flying safely in IMC requires training and regular practice. While the pilot did have an instrument rating, the investigation could not determine whether or not he had recent experience flying in these conditions or that he attempted to transition to IFR.

If pilots do not have recent experience flying in IMC, they may not possess the skills and proficiency required to do so, increasing the risk of loss of control and accident.

Spatial disorientation

Spatial disorientation (SD) is a common hazard in aviation that can lead to a loss of control. Flying in a degraded visual environment, such as in IMC, without reference to the ground increases a pilot's susceptibility to SD.

In the slow left turn prior to the spiral dive, if the occurrence pilot was experiencing a visual or vestibular illusion, his flight control input to stop the turn or correct the aircraft back to straight and level flight could have led to the right turn and descent in the opposite direction. The slow gradual right turn that followed would have led to a spiral dive if the pilot increased the pitch to address the rate of descent without recognizing the increasing angle of bank.

The automatic dependent surveillance–broadcast (ADS-B) data shows that the aircraft descended in a spiral with an increasing rate of descent indicative of a spiral dive. The flight path suggests that the pilot likely experienced SD from a visual or vestibular illusion and, as a result, the aircraft entered a spiral dive and collided with terrain.

Findings

Findings as to causes and contributing factors

These are conditions, acts or safety deficiencies that were found to have caused or contributed to this occurrence.

1. The pilot’s decision making was likely affected by plan continuation bias, which led him to continue a visual flight rules flight in adverse weather conditions.
2. The flight path suggests that the pilot likely experienced spatial disorientation from a visual or vestibular illusion and, as a result, the aircraft entered a spiral dive and collided with terrain.

Findings as to risk

These are conditions, unsafe acts or safety deficiencies that were found not to be a factor in this occurrence but could have adverse consequences in future occurrences.

1. If pilots do not have recent experience flying in instrument meteorological conditions, they may not possess the skills and proficiency required to do so, increasing the risk of loss of control and accident.
2. If search and rescue authorities do not access or use data from emerging technologies, such as space-based automatic dependent surveillance–broadcast, in a timely manner, there is a risk that following an accident, potentially life-saving search and rescue services will be delayed.

TSB Final Report A19C0070—DC-3 power loss of both engines on initial climb

History of the flight

On 20 June 2019, Douglas DC-3C Basler Turbo Conversions TP67 (DC3-TP67) aircraft was conducting a series of visual flight rules flights between Pickle Lake Airport (CYPL), Ontario, and Fort Hope Airport (CYFH), Ontario.

The purpose of the flights was to deliver 5940 L of diesel fuel per trip to the Eabametoong First Nation community, also known as Fort Hope. The aircraft was equipped with one 6815 L flexible bladder secured to the floor.

Figure 1. Map showing the location of the occurrence (Source: Google Earth, with TSB annotations)

Before departing CYFH on the occurrence flight, the crew conducted the before-takeoff checklist, which requires the propeller automatic feathering system to be armed for takeoff; however, the crew did not arm this system.

At approximately 0140, the aircraft departed CYFH with the first officer acting as the pilot flying (PF), seated in the right seat, and the captain acting as the pilot not flying (PNF), seated in the left seat. Shortly after takeoff, the PF called for the landing gear to be retracted. The PNF then selected the gear up at approximately 200 ft above ground level (AGL). Both engines subsequently lost power simultaneously, and the flight crew executed a forced landing on Eabamet Lake, Ontario, in total darkness (Figure 1).

The aircraft fuselage remained intact and immediately began to fill with water. The flight crew retrieved the survival kit, evacuated the aircraft via the main cabin door, and swam to shore.

Once on shore, the flight crew started a fire to warm up. The fire was noticed by a patrolling officer of the Nishnawbe Aski Police Service, who responded and transported the flight crew to the nursing station at the Eabametoong First Nation Band Office for a medical assessment. Neither flight crew member was injured.

Pilot information

The captain had joined the company as a captain in April 2017 and had completed his initial training on 3 July 2017.

The first officer had joined the company as a first officer in May 2018 and had completed his initial training on 25 June 2018.

Throttle quadrant

The throttle quadrant consists of power levers, propeller levers, fuel condition levers, and rotary friction locks (Figure 2).

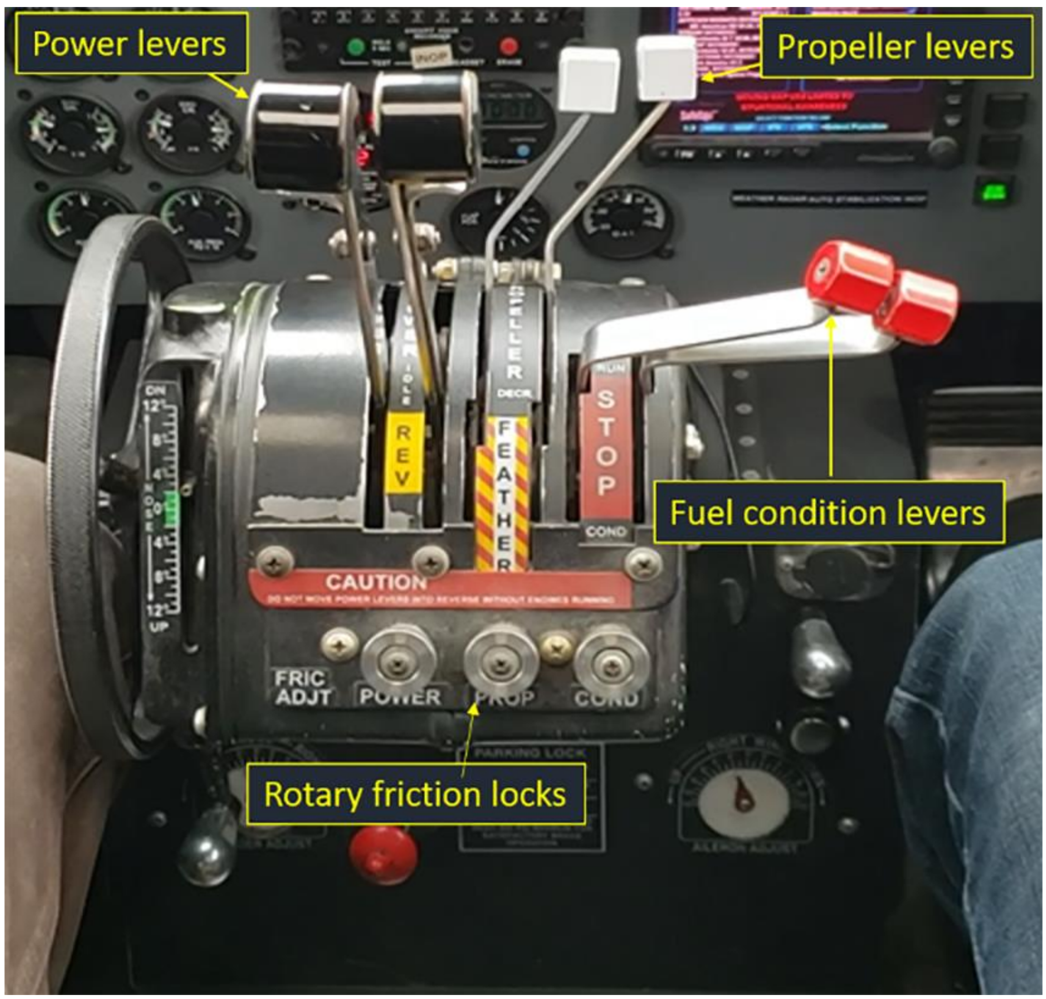


Figure 2. Picture of the throttle quadrant showing the power levers, propeller levers, fuel condition levers and rotary friction locks (Source: TSB)

There is one set of levers for each engine and associated propeller. Both pilots have functional reach to all sets of levers. The design uses varied colours, sizes, and shapes to facilitate visual and tactile identification.

The fuel condition levers in this aircraft are offset to the right of the quadrant and angled toward the right seat. The fuel condition levers stop fuel flow to the engines when they are moved into the down position (STOP). To allow fuel feed to the engines, the fuel condition levers are placed in the up position (RUN) and are secured in that position by means of a gate.

On the occurrence aircraft, the fuel flow to the engines is cut when the levers are moved down past the "O" of the word "STOP" (this position can vary from one aircraft to another).

Rotary friction locks, also shown in Figure 2, are located below each lever and allow the flight crew to apply resistance to the levers.

Relighting engines in flight

An engine that has flamed out in flight due to a momentary disruption of airflow or fuel to the engine should be automatically relighted if the ignition system switches are in the CONT position.

The company's SOPs also provide flight crews with 2 different emergency procedures for relighting engines in flight: a propeller windmilling procedure and a starter assist procedure. These procedures are based on the AFMS.

The procedure for relighting with the propeller windmilling procedure requires an aircraft speed greater than 160 knots indicated airspeed (KIAS). This allows the engine to obtain sufficient Ng speed (minimum 10%), but, to do so, the aircraft may need to descend. This procedure is completed without starter assist.

Main landing gear

A hydraulic pump is installed on each engine to provide hydraulic system pressure. As long as one engine is operating, hydraulic pressure to operate the main landing-gear system is available. The main landing gear is actuated by means of a 3-position landing gear control handle located behind and to the left of the right seat. A mechanical safety latch control handle provides a backup system to keep the landing gear in the down position if there is a hydraulic failure, and this handle is located on the cockpit floor to the right of the left seat (Figure 3).

Figure 3. Main landing gear control handle and mechanical safety latch control handle (Source: TSB)

The position of the handles can present ergonomic challenges, as some pilots may need to bend over and/or rotate sideways to reach the handles. When the left-seat pilot is tasked with raising the landing gear, they unlatch the mechanical safety latch control handle by pressing down on the handle with their right hand and pushing the safety latch forward with a finger. Next, the left-seat pilot pulls the handle up. He then rotates inboard at the waist to reach back and lift the landing gear control handle with one hand (the right hand).

The left-seat pilot could use their left hand to steady themselves; however, there is no dedicated handle or recommended position for the left hand to grasp while reaching back with the right hand to lift the landing gear control handle. The pilot may therefore place their left hand near or on the throttle quadrant.

The same process occurs when the right-seat pilot is tasked with raising the gear, except with opposite hands.

Propeller automatic feathering system

The primary role of the propeller automatic feathering system is to quickly reduce the drag associated with a failed engine, with no action required by the flight crew.

The DC3-TP67 is certified under Title 14 of the *Code of Federal Regulations* (CFR), Part 25: Airworthiness Standards: Transport Category Airplanes, which requires that 2-engine aircraft maintain a climb gradient of 1.2% at the maximum certified take-off weight following an engine failure on takeoff.

The regulations also state that

> *[t]he airplane configuration may not be changed, except for gear retraction and automatic propeller feathering, and no change in power or thrust that requires action by the pilot may be made until the airplane is 400 ft above the takeoff surface.*

The propeller automatic feathering system allows the aircraft to meet obstacle clearance requirements in case an engine fails on takeoff.

A 3-position toggle switch, located on the pilot’s overhead panel, controls the propeller automatic feathering system. The system is also controlled by two secondary arming switches located in the throttle quadrant. The secondary arming switches are installed in such a way that they are actuated when the power lever position for each engine corresponds to a power lever angle at which 92% to 94% Ng should be produced.

When the 3-position toggle switch is moved to the ARM position, dual indicator lights on each side of the switch indicate ARMED. The indicator lights indicate READY when each respective system is activated.

When the power levers are set for takeoff power or torque and the two secondary arming switches are actuated by power lever position, the READY light illuminates after approximately 5 seconds, indicating that the propeller automatic feathering system is activated.

A torque sensor switch mounted on each engine monitors engine power. When the propeller automatic feathering system is ARMED and indicating READY, the engine-mounted torque sensor will close if engine power decreases below approximately 25% torque. When the torque sensor closes, the activation circuit is completed, which will cause the propeller overspeed governor solenoid to activate, allowing for a drop in oil pressure in the propeller hub. This, in turn, will allow the propeller feathering spring to drive the propeller to the feathered position.

The investigation found that, in colder temperatures, the engines might reach their maximum take-off torque setting before the power levers reach the secondary arming switches in the throttle quadrant. As a result, the READY light never illuminates. This is why some pilots, including the flight crew in this occurrence, do not set the automatic feathering system to ARM. At 16°C (the temperature at the time of the occurrence flight), the power levers would have reached the secondary arming switches, thus arming the automatic feathering system, if it had been selected to the ARM position.

Meteorological information

The accident occurred during hours of darkness. Weather information available from the limited weather information system at CYPL at 0100 on 21 June was as follows:

- Winds 100° true (T) at 7 knots
- Temperature 16°C
- Dew point 6°C
- Altimeter setting 29.96 inches of mercury

The meteorological conditions at the time of the occurrence were not considered to have been a contributing factor in this occurrence.

Aerodrome information

The elevation of CYFH is 899 ft above sea level. It has one lighted east/west gravel-surfaced runway, Runway 09/27, which is 3497 ft in length. Eabamet Lake is approximately 250 ft to the west of the departure end of Runway 27.

Flight recorders

The aircraft was equipped with a cockpit voice recorder (CVR) and a flight data recorder (FDR), although neither was required by regulation. At the time of the occurrence, the FDR's circuit breaker was collared and placarded as unserviceable and had not been operable for more than 2 years.

Cockpit voice recorder

The aircraft was equipped with an L3 CVR model FA 2100, which is capable of recording 120 minutes of high-quality 4-channel audio data. The CVR records the cockpit area microphone, captain's microphone, first officer's microphone, and all received transmissions on the aircraft's selected communication radio, including the intercom.

The data from the CVR were recovered successfully, and the quality of the recording was excellent.

Acoustic signature data

A comprehensive analysis was conducted to determine whether information could be derived from the CVR to permit a better understanding of the occurrence flight. The CVR cockpit area microphone channel contained pertinent acoustic data that were essential to conduct a comprehensive analysis.

Five individual flights were captured on the CVR; four of those flights, including the occurrence flight, were captured in their entirety. The occurrence flight was approximately 50 seconds, including the moment of impact on the water.

The acoustic environment in the flight deck was evaluated in order to assess whether specific acoustic signatures that were common between the occurrence flight and the previous flights could be identified. These included the isolation and calculation of propeller speeds, the transcription of crew conversation, and the identification of aural alerts and various clicks caused by the movement of engine-related levers and other controls on the flight deck.

The Basler Turbo Conversions STC indicates the nominal take-off propeller speed as 1700 rpm. The four recorded takeoffs all showed take-off propeller speeds of approximately 1692 rpm, which confirmed that the propeller speed approximation derived from the audio data was reasonable.

The events of the occurrence flight were examined in detail to compare them with an uneventful departure.

During the three normal takeoffs, the same two clicks could be detected, followed by the acoustic signature related to the retracting landing gear. The full gear swing time lasted 16.6 seconds and was consistent for each normal takeoff. In each of these three flights, no other distinct acoustic events were heard from the point after the gear was commanded up until the crew made the 400-ft call (see Section 1.17.1). The 400-ft call included turning off the automatic propeller feathering system and setting climb power. On the occurrence flight, as the aircraft had not reached 400 ft AGL, no 400-ft call was made.

During the occurrence flight, the acoustic environment of the takeoff commenced in a similar fashion to the previous three flights. Once the power was set, the two clicks associated with the movement of the landing gear handle were heard. These were followed shortly afterward by the sound related to the landing gear retracting. However, the gear operation was interrupted approximately 1 second after it began. This interruption coincided with two additional clicks and a rapid reduction in propeller speed. Impact sounds were heard approximately 17 seconds after the propeller speeds began to decrease.

The source of the clicks heard as the engines were spooling down was investigated, and it was hypothesized that they were a result of the fuel condition levers making contact with the bottom of their slots in the control pedestal as they were moved toward the STOP position.

The acoustic analysis also confirmed that no power or propeller lever adjustments were made before the reduction in engine power on any of the analyzed flights.

A rapid reduction in propeller speed shortly after liftoff was noted in the occurrence flight. No split in propeller speeds between engines was observed as the propeller speed decreased, suggesting a simultaneous loss of propeller speed on both engines.

The audio recording was also reviewed to determine whether the condition levers were advanced back to the RUN position after the sudden power loss. Although a number of clicks were heard following the abrupt loss in propeller speed, it was not possible to assign these acoustic events to a particular source because there was no reference for comparison.

Wreckage and impact information

The aircraft struck the surface of Eabamet Lake in a level pitch, left-wing-low attitude. The aircraft propeller blades were bent but still attached to their respective hubs and to the engines. The wings and tail surfaces remained attached to the fuselage.

Investigators attended the scene while the aircraft was partially submerged and conducted an examination of the aircraft (Figure 5). The leading edge of the left wingtip had crush damage consistent with the left wing striking the water (Figure 6).

A visual inspection of the cockpit, cabin, and engines was limited to areas above the waterline. The cockpit inspection revealed that the inertial separators were in the icing position for takeoff, and that the aircraft ignition and the propeller automatic feathering systems were turned off.

Initial examination of the throttle quadrant (Figure 7) indicated the following:

- The left power lever was in the forward position.
- The right power lever was in the IDLE position.
- The propeller levers were fully forward.
- The left and right engine fuel condition levers were bent and fully forward, but not in the gates.
- Quadrant control friction locks were applied to the engine controls and were in a serviceable condition.

Figure 5. Occurrence aircraft on Eabamet Lake during recovery (Source: Pratt & Whitney Canada)

A continuity check of the throttle quadrant controls to their applicable engine control accessories was completed, with no defects found.

The aircraft was recovered from the water on 9 July 2019. On 11 July 2019, investigators returned to CYFH, where the aircraft was parked on the airport ramp. Investigators examined the aircraft, found that all components were accounted for, and were able to confirm flight control continuity.

The engine cowlings were free from debris and did not show signs of air blockage; no intake plugs had been installed.

A visual inspection of the aircraft's main fuel tanks found that all fuel caps were on. Fuel was found in the main tanks only. Fuel samples were taken from the main tanks and the in-line main fuel filters.

Approximately 545 L of fuel was drained from the left main tank and approximately 550 L from the right main tank. The main fuel tanks did contain a small amount of water; however, no water was found in the in-line main fuel filters.

The left and right fuel shutoff valves were found in the open position, the fuel bypass indicators were not activated, and the fuel cross feed valve was closed.

Figure 6. Occurrence aircraft's left wingtip, with crush damage (Source: TSB)

The engines were removed from the aircraft and sent to Pratt & Whitney Canada. On 16 September 2019, the engines were dismantled to determine whether any mechanical failure had occurred.

The investigation determined that there were no signs of an airframe, engine, or system failure during the occurrence flight.

The operator's maintenance personnel subsequently replaced the propellers and engines and carried out airframe repairs. The aircraft was then flown to a maintenance repair facility.

Organizational and management information

Standard operating procedures

The company operations manual details the policies and procedures to be followed by all its operations personnel in the conduct of their duties. The company also issues SOPs to guide its pilots in the operation of company aircraft. The SOPs are specific to each aircraft type and are based on the aircraft's AFMS. At the time of the occurrence, the SOPs included procedures based on

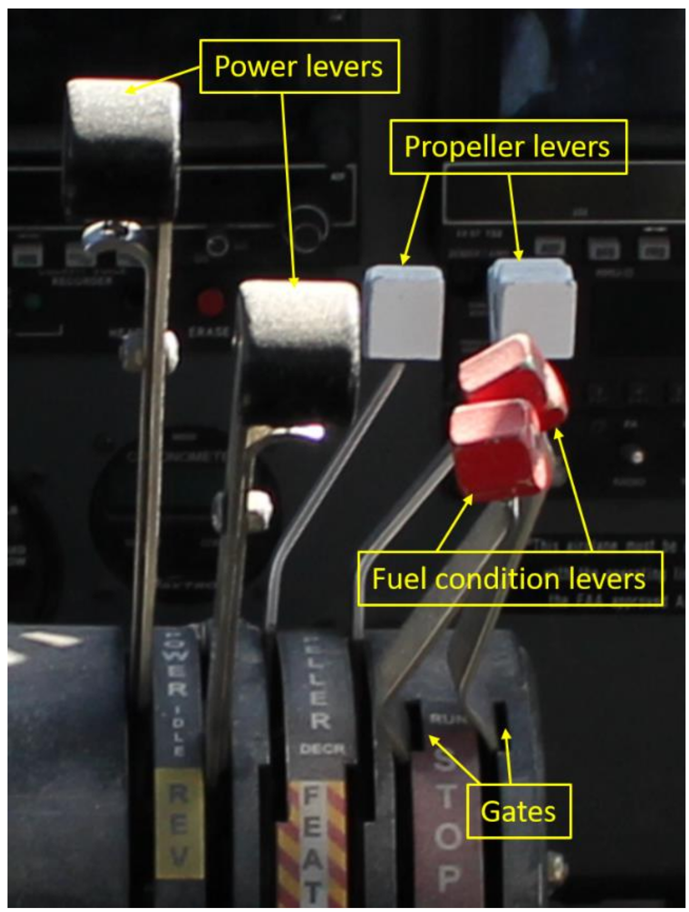


Figure 7. Throttle quadrant with the levers and gates labelled (Source: TSB)

Revision 12 of the AFMS, dated 3 March 2014. However, they did not incorporate changes from the newest revision of the AFMS, Revision 13, dated 10 January 2018.

The SOPs are designed to enhance crew coordination, avoid misunderstandings in flight crew communications, and provide a division of responsibility between the captain and the first officer, and the PNF and the PF.

Analysis

General

The investigation determined that there were no signs of an airframe, engine, or system failure during the occurrence flight.

The simultaneous engine shutdown led investigators to consider inadvertent engine control inputs as a possible cause. The analysis will therefore focus on the acoustic signatures from the occurrence flight and the four previous flights, the location of the landing gear handles, and the operator’s procedures for updating checklists.

The analysis will also examine the possibility of engine relights, the design and ergonomics of the throttle quadrant, and the use of the propeller automatic feathering system.

Acoustic signature analysis

The cockpit voice recorder (CVR) recorded the four flights before the occurrence flight. The sound of a rapid reduction in propeller speeds shortly after takeoff was heard only on the occurrence flight. Propeller speed was reduced at the same time and at the same rate on both engines. A power loss on two engines can occur; however, the shutdown is usually staggered in sequence, with one engine reducing power before the 2nd engine. Clicks were heard immediately before the reduction in propeller speed, which likely indicated that the fuel condition levers made contact with the control pedestal as they were moved toward the down position (STOP).

The analysis of the acoustic signatures found that the timing of the clicks heard during the normal engine shutdowns corresponded to an immediate reduction in propeller speed. This phenomenon was also observed in a video of a shutdown filmed on another DC3-TP67 operated by the company.

During the uneventful departures, the acoustic signatures did not include clicks between when the gear was commanded UP and when the 400-foot call was completed.

On the occurrence flight, acoustic signatures related to the movement of gear handles and the activation of the hydraulic system indicate the gear was selected UP. However, the gear operation was interrupted approximately one second after it began due to a loss of hydraulic pressure. This interruption coincided with two clicks and a rapid reduction in propeller speed.

The rapid reduction in propeller speeds and the sound of the two clicks suggest that the fuel condition levers were likely accidentally moved, cutting the fuel to both engines simultaneously. However, the investigation could not find an acoustic signature to indicate conclusively whether the levers had been returned to the RUN position. There were no power or propeller lever adjustments made before the reduction in engine power.

Landing gear handles

The location of the landing gear controls on the DC3-TP67 can present ergonomic challenges for some pilots. In the occurrence aircraft type, the pilot raising the landing gear needs to bend over and/or rotate sideways to reach the mechanical safety latch control and landing gear control handles, and then must lift the landing gear control handle with one hand. Because there is no dedicated position or handle for pilots to place the opposite hand to steady themselves if necessary, such as during the initial climb out, there is an increased likelihood that the pilot will place that hand on the throttle quadrant and will move a control by accident.

Throttle quadrant design and ergonomics

Controls and displays are designed and laid out with the aim of balancing functionality, effectiveness, usability, and safety. The layout of the controls in the cockpit takes into account importance, frequency and sequence of use, and grouping by function.

There are ways to protect controls from being moved unintentionally, such as gates, friction locks, or locking mechanisms. On the occurrence aircraft, gates are used to secure the fuel condition levers in the RUN position. The gates are narrow and the fuel condition levers are long, making it possible to snag or bump the fuel condition levers out to the left and down. The levers travel out of the gates in the same direction, making it possible to move both fuel condition levers with one hand.

There are trade-offs between measures to prevent unintentional movement and usability, because such measures may make controls more difficult to operate.

Cockpit discipline and procedures also reduce the risk of unintentional movement. Cockpit design uses varied colours, sizes, and shapes to facilitate visual and tactile identification. A colour and shape coding and grouping for these levers is common in the industry.

The acoustic signature analysis indicated the simultaneous loss of power to both engines, suggesting that the fuel condition levers were accidentally moved to the STOP position shortly after the gear selection.

During the climb out, both of the pilot flying's (PF's) hands were likely on the yoke, in accordance with standard operating procedures (SOPs). The pilot not flying (PNF) had his right hand on the landing gear control handle, and his left hand and arm may have rotated toward the throttle quadrant. After the PNF raised the landing gear control handle with his right hand, he may have accidentally moved the fuel condition levers while rotating back into position and steadying or bracing himself with his left hand. Therefore, after lifting the landing gear control handle, with his left hand on or near the throttle quadrant, the PNF may have inadvertently moved the fuel condition levers, cutting the fuel to both engines simultaneously.

The design of the levers in the throttle quadrant of the occurrence aircraft is consistent with ergonomic guidelines to prevent accidental movement: the design provides tactile and visual cues, movement resistance, and dual-axis motion, which are safeguards against accidental movement. However, the fuel condition levers are still usable in the case of an emergency when an engine shutdown is necessary.

Checklist updates

The crew followed the before-takeoff checklist, which did not include setting the ignition switches to CONT (continuous mode) for takeoff, although this step was required by the latest revision of the airplane flight manual supplement (AFMS), dated 10 January 2018.

The company received a notification of the updated AFMS on 16 March 2018. The notification included instructions on which sections of the manual to remove and replace. The investigation did not determine why the updated procedure was not incorporated into the company.

If operators do not follow manufacturers’ directions to amend procedures, operators will use incorrect operating procedures, increasing the risk of compromising safety margins.

Relighting engines in flight

Relighting an engine that has flamed out in flight, due to a momentary disruption of airflow or fuel to the engine, should be automatic when the ignition system switches are in the CONT position. If the ignition system switches are not set to CONT, as was the case in the occurrence flight, the flight crew are required to complete an in-flight engine relighting procedure.

In-flight engine relighting procedures are approved emergency procedures published in the North Star Air SOPs. These procedures (propeller windmilling and starter assisted) require flight crews to follow a checklist.

In the propeller windmilling procedure, a minimum airspeed of 160 kt is required to successfully relight an engine in flight. The SOPs state that the initial climb after takeoff and up to 400 ft above ground level should be conducted at an airspeed of V_2 (approximately 90 kt), which is lower than the 160 kt required for the propeller windmilling procedure. The crew would have needed to increase airspeed by descending, but the aircraft had insufficient altitude to attain the required airspeed at the time of the engine power loss. Therefore, the starter-assisted relight procedure was the only option available to restore engine power at this altitude and airspeed.

The SOPs indicate that, when following the starter-assisted relight procedure, the engine should normally relight within 10 seconds from when the fuel condition lever is moved to the RUN position, and that the relighting would be evident from a rise in gas generator speed (Ng). Only 17 seconds elapsed from the time the engines lost power until impact. Therefore, the flight crew did not have enough time to attempt this engine relight procedure before the aircraft collided with the water surface.

In this occurrence, it could not be determined whether a successful relight would have occurred if the ignition system switches had been set to CONT and if the fuel conditions levers had been returned to the RUN position when the crew recognized the engine power loss. Engine relights with ignition system set to CONT may be possible if the Ng is above 10%. The Ng percentage when the crew recognized the engine power loss could not be determined, but it was likely below 10%, which would have prevented engine restart.

Due to insufficient altitude and time available to the crew, none of the three engine relight options were available to the flight crew before the aircraft collided with the water surface.

Propeller automatic feathering system

The before-takeoff checklist requires that the automatic feathering system be armed for takeoff; however, there were times when the engines would reach the torque setting before the power levers reached the arming switches.

The primary role of the propeller automatic feathering system is to quickly reduce the drag associated with a failed engine, without requiring flight crew action. When the aircraft was certified, it had to meet the minimum climb gradient on departure, following an engine failure, to ensure obstacle clearance requirements. The DC3-TP67 certification was done with the automatic feathering system activated for takeoff. In this occurrence, the crew did not arm the automatic feathering system; therefore, it would not have been available if it had been required.

If the propeller automatic feathering system is not armed, there is a risk that, in the event of an engine failure, the aircraft would not be able to maintain the required climb gradient and obstacle clearance would not be guaranteed.

Safety belts

The use of inertia reel shoulder harnesses ensures a more equal distribution of the impact forces. Wearing a lap belt and a shoulder harness is known to reduce the severity of injuries to the upper body in the event of an accident, compared with wearing only the lap belt. The shoulder harness should allow for some freedom of movement, to reduce the likelihood that pilots will unfasten it during flight.

However, on this aircraft type, the layout of the cockpit instrument panel switches and the location of controls (such as the landing gear handle) can make it difficult for pilots to reach them while wearing a shoulder harness. Nevertheless, if pilots do not use available shoulder harnesses, there is an increased risk of injury in the event of an accident.

Findings

Findings as to causes and contributing factors

These are conditions, acts or safety deficiencies that were found to have caused or contributed to this occurrence.

1. After lifting the landing gear control handle, with his left hand on or near the throttle quadrant, the pilot not flying may have inadvertently moved the fuel condition levers, cutting the fuel to both engines simultaneously.

Findings as to risk

These are conditions, unsafe acts or safety deficiencies that were found not to be a factor in this occurrence but could have adverse consequences in future occurrences.

1. If the propeller automatic feathering system is not armed, there is a risk that, in the event of an engine failure, the aircraft would not be able to maintain the required climb gradient and obstacle clearance would not be guaranteed.
2. If operators do not follow manufacturers’ directions to amend procedures, operators will use incorrect operating procedures, increasing the risk of compromising safety margins.
3. If pilots do not use available shoulder harnesses, there is an increased risk of injury in the event of an accident.

Other findings

This item could enhance safety, resolve an issue of controversy, or provide a data point for future safety studies.

1. Due to insufficient altitude and time available to the crew, none of the three engine relight options were available to the flight crew before the aircraft collided with the water surface.

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