Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION OCCURRENCE REPORT

A98A0184

COLLISION WITH TERRAIN

CESSNA 172M C-GDTK
LIVERPOOL, NOVA SCOTIA 2 nm West
15 DECEMBER 1998

Canada

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Synopsis

The pilot and passenger departed the Shearwater airport in a Cessna 172M aircraft, on a night visual flight rules (VFR) flight to the Liverpool airport. The flight was to include a touch-and-go at Liverpool before a return to Shearwater. About 2 ½ hours after flight departure, the Moncton Area Control Centre (ACC) was advised that an emergency locator transmitter (ELT) signal was being received by other aircraft. A search was initiated and the wreckage site was found early the next morning. The aircraft had crashed in heavily wooded terrain two nautical miles (nm) west of the Liverpool airport. The two occupants were fatally injured, and the aircraft was destroyed.

The Board determined that, during the overshoot from the approach to the airport, the pilot probably lost situational awareness as a result of spatial disorientation, and unintentionally flew the aircraft into the ground.

Ce rapport est également disponible en français.

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1.0 Factual Information

1.1 History of the Flight

At 1843 Atlantic standard time (AST)[1] the 25-year-old pilot and his 19-year-old brother departed the Shearwater airport on a time-building flight in preparation for the pilot's upcoming commercial flight test. The flight was to include a touch-and-go at the Liverpool airport before returning to Shearwater.

At 2112, the Moncton ACC received pilot reports of an ELT signal. A search was initiated that included the Canadian Forces, the Rescue Coordination Centre (RCC) Halifax, the Royal Canadian Mounted Police (RCMP), and the Halifax flight service station (FSS), as well as personnel from the Queens County volunteer ground search and rescue unit. The geographic location of the ELT signal was confirmed at 2235. The terrain was heavily wooded, and flares were dropped to aid in locating the aircraft. The ground search team reached the wreckage site about 0625 the next morning. The pilot and passenger had been fatally injured, and the aircraft was destroyed.

The aircraft was equipped with an altitude reporting transponder. A review of the radar data indicated that the aircraft approached the Liverpool airport from the east, turned south across runway 25/07 and joined the circuit left-hand downwind for runway 25. The aircraft disappeared from radar at 1100 feet above sea level (asl) while on final to runway 25 and reappeared on radar at the same altitude just west of the airport one minute and 27 seconds later; radar coverage continued for another 47 seconds. During this phase it climbed to 1300 feet, levelled off, and then descended to 1100 feet asl before disappearing from radar.

1.2 Injuries to Persons

	Crew	Passengers	Others	Total
Fatal	1	1	—	2
Serious	—	—	—	—
Minor/None	—	—	—	—
Total	1	1	—	2

1.3 Damage to Aircraft

The aircraft was destroyed.

1.4 Other Damage

Ground damage was restricted to mature trees in an unpopulated area.

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[1] All times are AST (coordinated universal time minus four hours) unless otherwise stated.

1.5 Personnel Information

1.5.1 General

	Captain
Age	25
Pilot Licence	PPL
Medical Expiry Date	March 1999
Total Flying Hours	187
Hours on Type	45
Hours Last 90 Days	39.4
Hours on Type Last 90 Days	39.4
Hours on Duty Prior to Occurrence	2.5
Hours Off Duty Prior to Work Period	5.5

1.5.2 Pilot Experience and Training

The pilot enrolled in the aviation flight training program with the Career Academy School of Aviation (CASA) in February 1997. He completed his private pilot training, received his licence in April 1998, and continued towards a commercial pilot licence rating until CASA closed their operation in August 1998. The Nova Scotia Department of Education facilitated the continuation of flight training for the CASA students in October 1998 through a Nova Scotia Community College aviation diploma program, with the Shearwater Flying Club providing the required flight training portion of the syllabus.

The pilot was issued his night endorsement in July 1998 and, at the time of the occurrence, had about 187 hours total flight time. His pilot logbook showed 13.5 hours dual night instruction, 12.9 hours (night) pilot-in-command, 10.1 hours instrument (hood) training, and 3.3 hours flight simulator time. He had flown to the Liverpool airport on four previous occasions within the past six weeks. Three of the flights were conducted at night with either an instructor or another licensed pilot on board; the accident flight was the first night flight without another pilot on board. The pilot had about 45 hours total flight time in the Cessna 172 aircraft and all of this time was within the five months preceding the accident. The *Canadian Aviation Regulations* (421.42) require, in part, a minimum of 10 hours dual instrument time for a night endorsement.

The pilot flew with his instructor on the morning of the occurrence, booked the aircraft for the night flight to Liverpool, and returned home early in the afternoon. He slept several hours before having supper and departing for the Shearwater airport. The pilot was reported to have been well rested and in good spirits when he left home. Interviews with his instructors did not identify the presence of any attitude, judgement, or piloting deficiencies other than those expected as part of the student-pilot training environment. The pilot was considered conscientious and one who took a keen interest in all flying-related subjects.

1.6 Aircraft Information

Manufacturer	Cessna Aircraft Company
Type and Model	C172M
Year of Manufacture	1976
Serial Number	172 - 66720
Certificate of Airworthiness (Flight Permit)	28 April 1977
Total Airframe Time	1820.1
Engine Type (number of)	Lycoming O 320 -E2D (1)
Propeller/Rotor Type (number of)	McCauley 1C160 DTM - 7553 (1)
Maximum Allowable Take-off Weight	2300 lbs
Recommended Fuel Type(s)	80/87, 100LL
Fuel Type Used	100LL

The aircraft's last maintenance inspection was a 200-hour scheduled inspection carried out on 13 November 1998. A 50-hour inspection was due following the completion of the occurrence flight. There had been no aircraft unserviceabilities or unscheduled maintenance action recorded in the aircraft journey log or aircraft technical log since completion of the 200-hour inspection. The aircraft had 1820 hours total time since new, and the engine had 504 hours time since overhaul in 1996. The aircraft had been flown by the occurrence pilot and his instructor earlier on the day of the occurrence, and there were no deficiencies identified at that time. A review of the aircraft's technical records indicated that the aircraft was certified, equipped, and maintained in accordance with existing regulations and approved procedures. The computed aircraft weight at the time of the occurrence was 2049 pounds, and the centre of gravity was within limits.

1.7 Meteorological Information

1.7.1 Weather Observation Stations

There are two aviation weather observation stations near the Liverpool airport: Greenwood, 42 nm north, and Yarmouth, 60 nm southwest. There is also a marine automatic weather station at Western Head, 17 nm to the southeast, and a provincial highway weather station at Bridgewater, 22 nm to the east.

On 15 December 1998, the weather observations for 2000 were as follows:

> Greenwood—reported surface winds 230 degrees true at 9 knots, visibility 15 statute miles (sm), temperature 4 degrees Celsius, dew point 0 degrees Celsius, and altimeter setting of 29.82.
>
> Yarmouth—reported surface winds 240 degrees true at 14 knots gusting to 23 knots, visibility 12 sm, sky clear, temperature 6 degrees Celsius, dew point 3 degrees Celsius, and altimeter setting 29.92.

Western Head—reported winds 240 degrees true at 13 knots, temperature 4.5 degrees Celsius, dew point minus 1 degree Celsius.

Bridgewater—reported surface winds 292 degrees magnetic at 9 knots gusting to 12 knots, temperature 4 degrees Celsius, dew point 3 degrees Celsius.

1.7.2 Weather Interpretation

An interpretation of available weather information shows that, at the time of the occurrence, the Liverpool area was under clear skies with no restrictions to visibility. The surface temperature was 5 degrees Celsius and the winds were 15 knots with gusts to 25 knots. The freezing level was at 10 000 feet with no possibility of icing at lower levels. The presence of moderate mechanical turbulence was expected from the surface to 4000 feet above ground level (agl); this was supported by several pilot reports (PIREP) of weather conditions in flight, which indicated low-level turbulence that day. There was no indication of windshear.

The moon was positioned 50 degrees below the horizon at the time of the accident, and pilot reports indicated that dark sky conditions existed; there would have been fewer visual cues than would have been present during his previous flights to Liverpool.

1.8 Aids to Navigation

The Liverpool airport has a non-directional beacon.

1.9 Communications

The pilot had contacted the Halifax FSS at 1852 to confirm that the aircraft's flight plan had been activated. At that time the pilot was provided with the Yarmouth and Greenwood altimeter settings, 29.92 and 29.82 respectively, and the Yarmouth surface winds of 240 degrees magnetic at 17 knots gusting to 24 knots.

Several local residents, who had frequency scanning equipment for recreational purposes, had been listening on their scanners about the time of the accident. They reported hearing a pilot transmit his intentions to fly across the active runway and join the circuit downwind for a touch-and-go on runway 25 at the Liverpool airport. One of the listeners had been a commercially licensed pilot and, as an avid scanner user, recognized the pilot's voice as a previous visitor to the Liverpool airport. The listener remarked that the occurrence flight was the only air traffic that had broadcast to land at Liverpool that night. The listener also remarked that there was no inflection in the pilot's voice to suggest the pilot was experiencing difficulty with the flight. There was no known other communication from the pilot.

1.10 Aerodrome Information

The Liverpool airport (CYAU) is a regional, certified aerodrome operated by Queens Municipality, is 314 feet asl, and has a paved runway 3937 feet long and 75 feet wide oriented 250/070 degrees magnetic. The runway lighting system was Aircraft Radio Control of Aerodrome Lighting (ARCAL) type J, and could be remotely activated on the Liverpool UNICOM frequency by keying the microphone five times within five seconds; once activated, the lights remain on for 15 minutes unless keyed again by the pilot.

1.11 Flight Recorders

The aircraft was not equipped with a flight data recorder or a cockpit voice recorder, nor was either required by regulation.

1.12 Wreckage and Impact Information

1.12.1 General

The aircraft descended into mature trees about 2 nm beyond the departure end of runway 25 at Liverpool, on a magnetic heading of 270 degrees. The aircraft was 44 feet above the ground in a wings-level, 30-degree descent angle when the right wing struck trees, leaving wing structure and a partial section of aileron lodged in the trees. Further tree impact displaced the left wing aft along the fuselage, and the aircraft came to rest in a nose-down, 45-degree right-bank attitude. The impact ruptured both wing fuel tanks, spilling the contents onto the ground. There were several propeller strike marks on trees along the wreckage trail; the marks were consistent with the propeller being powered at impact.

The fuselage was extensively damaged, which compromised the cabin integrity. The floor structure, including the seat tracks, had buckled, and the rudder pedals and surrounding floor/firewall structure were crush damaged. The engine separated from the fuselage, and the propeller and propeller flange separated from the engine crankshaft. The engine and propeller came to rest several feet forward of the fuselage. The wing flaps were retracted at the time of impact.

The cockpit controls were positioned as follows: engine mixture control full rich; throttle control displaced at a near idle position; carburetor heat full cold; engine primer in and locked; magnetos on both; and, fuel selector on both. No reliable information could be derived from the electrical switch positions due to the nature of the impact damage. The elevator trim tab position was consistent with a slight nose-down trim setting, normal for final approach for a touch-and-go landing. An aircraft established in the climb phase would normally have the elevator trim reset to a slightly nose-up trim position; however, this trim position would not have affected the aircraft’s controllability and, therefore, was not considered a factor in the occurrence.

1.12.2 Engine and Propeller

The engine was examined at the TSB regional wreckage examination facility in Dartmouth, NS, with personnel from the TSB, the engine manufacturer, the aircraft manufacturer, and the Shearwater Flying Club in attendance. The engine had substantial impact damage to all of the accessories; however, continuity of the accessory gear drives and engine internal components was confirmed. There was no indication of pre-impact, mechanical failure.

Spalling was observed on the intake tappet bodies of cylinders number 3 and 4 as well as on the corresponding cam lobes that action both these tappet bodies. It could not be determined to what extent, if any, this wear affected engine performance. There were no pilot reports of degraded engine performance during any of the preceding flights.

The carburettor was disassembled and the only anomaly observed was that the metal floats were compressed from the nominal dimension. This anomaly is frequently associated with a fuel system rupture during impact where a brief increase in static pressure is often sufficient to compress the metal floats.

Propeller blade damage and twist were consistent with considerable power being produced at the time of impact.

1.12.3 Exhaust Stacks

The engine exhaust stacks were sent to the TSB Engineering Branch for metallurgical testing and analysis. The metallurgical analysis determined that the exhaust stack material was crushed while above the 600 to 800 degree Fahrenheit temperature range, an indication that the engine was operating at impact.

1.12.4 Instruments and Light Bulbs

The aircraft flight and engine instruments and all undamaged light bulbs were examined by the TSB Engineering Branch. The engine tachometer showed a needle impact mark at 1200 revolutions per minute (rpm). The indicated airspeed (IAS) indicator needle left a witness mark on the glass face, indicating 125 miles per hour (mph). There was insufficient damage to the vacuum-driven horizon gyro to give any valid information concerning its operation at impact. The aircraft overhead instrument flood light, cabin dome light, compass light, and the tail navigation light bulbs were retrieved from the wreckage. With the exception of the dome light, the remaining bulbs would normally be illuminated during a night flight. The analysis determined that the instrument flood light bulb was illuminated at impact. The remaining lamps were either off at impact or had not received sufficient force to distort the filament.

1.12.5 Navigation Equipment

The aircraft was equipped with a Trimble model TNL 1000 global positioning system (GPS), which was sent to the component manufacturer for flight data retrieval. The last two seconds of GPS data identified that the aircraft was descending at about 4000 feet per minute (fpm) at 111 knots. The GPS recorded geographic coordinates corresponding to the occurrence site, about 2 nm west of the Liverpool airport. The last time recorded by the GPS was 15 seconds after the aircraft had disappeared from radar.

1.13 Medical Information

The pilot received an aviation medical (Category 3) in February 1997, and, as a private pilot, was due for his next medical in March 1999. In preparation for the Category 1 medical requirements for a commercial pilot licence, the pilot had received a medical examination on December 14, the day before the occurrence, and no health concerns were identified at that time. The pilot's autopsy results did not identify the presence of any pre-existing medical condition, and toxicology tests for alcohol/drugs were negative for both individuals. Blood analysis identified the presence of a low level of carbon monoxide (less than 10 per cent saturation). Both the pilot and passenger were smokers, and the carbon monoxide levels were consistent with levels observed in smokers.

1.14 Fire

There was no evidence of fire either before or after the occurrence.

1.15 Survival Aspects

The pilot and passenger were wearing their seat-belts and associated shoulder harnesses. They had received multiple injuries due to the high "g" force at impact, which compromised the cabin integrity and rendered the accident non-survivable.

1.16 Tests and Research

The TSB conducted a representative night flight to the Liverpool airport in a rented Cessna 172 at a time when light and sky conditions were similar to those of the occurrence night. The purpose of the flight was to identify the visual references available to a pilot when flying a runway 25 approach and departure/go-around.

The airport is located in a sparsely populated area where there is little peripheral lighting. The runway lights were observed clearly on approach and during the go-around phase, and the aircraft passed over a road about 1.5 miles west of the airport, where there was some street lighting in an area of houses. Beyond the road there were few external visual cues, and the horizon was not easily discernable.

The TSB flight was recorded on radar, allowing a comparison between the occurrence flight and TSB flight radar data. The TSB flight included four approaches to runway 25, with two touch-and-go landings and two go-arounds. The aircraft's altitude when passing over the road was between 1100 and 1300 feet asl, depending on whether the climb phase had followed a touch-and-go or a go-around, respectively. A comparison of elapsed time during a touch-and-go versus a go-around indicated that the pilot of the occurrence flight had conducted a go-around. Time and distance information was used to estimate that the occurrence aircraft had averaged a ground speed of 78 knots during the last 47 seconds of flight. The reported winds from the west would have provided a headwind component during the approach and go-around phase of flight, resulting in the air speed being greater than 78 knots. The estimated airspeed during the go-around was consistent with a speed at which the aircraft was controllable.

1.17 Organizational and Management Information

The Shearwater Flying Club has been in operation since 1967 and is located at Canadian Forces Base Shearwater. A general manager oversees the club's operations and reports to a Board of Directors who are elected and serve a two-year term of appointment. The club has a good working relationship, but is not affiliated, with the military base.

1.18 Additional Information

1.18.1 Witness Observations at Liverpool

The Liverpool airport was not staffed at the time of the occurrence, and no one had observed an aircraft land. An individual who was working near the airport reported having seen an aircraft descending towards the airport and had driven there with his son to observe it land, but they were too late. He reported that the runway lights were illuminated and that he observed a flashing red light in the sky, to the west of the airport.

1.18.2 Spatial Disorientation

The most accurate sensory information available to a pilot about aircraft attitude and motion are the visual cues provided by the earth's horizon, the aircraft's flight instruments, or both. When this information is not available, such as when the horizon is obscured by darkness or weather, or when the pilot's attention is distracted from the attitude instruments for a short time, the pilot's sense of orientation may be taken over by the inner ear, a very inaccurate source of sensory information during flight. Spatial disorientation occurs when a pilot's sense or "orientation percept" of the position, motion, or attitude of his aircraft or himself with respect to the earth's surface and the gravitational vertical is based on incorrect or misinterpreted sensory information. Pilots with limited instrument flight time are most susceptible to spatial disorientation.

One form of spatial disorientation is the false climb illusion. This illusion can occur during acceleration when a pilot loses or is uncertain of visual references and relies on the inner ear rather than on the instruments. Because the inner ear cannot distinguish between gravity and horizontal acceleration, forward acceleration can generate the same perception as backward tilt (i.e., a climbing aircraft). This illusion can be experienced by pilots operating low- or high-performance aircraft.

In low visibility a pilot may attempt to counteract a perceived climb by lowering the aircraft's nose until the downward pitch of the aircraft counterbalances the apparent backward tilt caused by the acceleration, often resulting in flight into terrain. Furthermore, if the false climb illusion is reinforced by the presence of a false visual horizon (such as a shoreline or other extended cluster of lights with ocean or unlighted terrain beyond) receding under the aircraft, the pilot's compulsion to push the nose down can become overwhelming.

Knowledge and experience are the key determinants of a pilot's susceptibility to disorientation. Pilots with little instrument time are particularly susceptible to spatial disorientation when they are confronted with limited external visual attitude references. A pilot's only defence against spatial disorientation is to develop the ability to suppress natural vestibular responses through training and practice (vestibular suppression), and to always use visual information from the instruments to maintain spatial orientation (instrument discipline) and, consequently, his or her situational awareness.

2.0 *Analysis*

When the pilot broadcast his intentions to conduct a touch-and-go on runway 25 there was no indication of any in-flight mechanical difficulty. The radar data time comparisons showed that following the last approach the pilot conducted a go-around rather than the planned touch-and-go. The decision to go-around normally is taken if a pilot assesses that a safe landing cannot be accomplished. Analysis of the radar data during the aircraft's climb phase on the go-around also indicated that the flight path and estimated airspeed were consistent with a normally operating aircraft in controlled flight. The aircraft was at 1100 feet asl (about 800 feet agl) when it disappeared off radar. About 15 seconds later, following a 4000 fpm rate of descent, the aircraft struck the terrain. There was no indication of a mechanical failure or pilot incapacitation.

The environmental conditions on the night of the occurrence and the limited outside visual ground references in the vicinity of the Liverpool airport were elements conducive to spatial disorientation. During the go-around, false horizon and false climb illusions were both possible. A pilot's response to a false horizon illusion can result in incorrect flight control inputs for the real situation; false climb illusion can result in forward pressure on the control column and subsequent aircraft nose-down pitch attitude. At low altitude there is minimal time for a pilot to recognize an illusion and take the appropriate corrective action. The impact angle of the aircraft appeared to be more consistent with the nose-down pitch attitude associated with the false climb illusion.

The complex skill set that a pilot requires to recognize and counter the effects of spatial disorientation are developed through flight instrument training, experience, and practice. The occurrence pilot, although appropriately licensed, had minimal instrument experience; consequently, he did not have the opportunity to fully develop the skills necessary to deal with the onset of spatial disorientation. Therefore, it is probable that the pilot experienced spatial disorientation that he could not overcome, lost situational awareness, and flew the aircraft into the ground.

3.0 Conclusions

3.1 Findings

1. The pilot was appropriately licensed to conduct the night VFR flight and was apparently medically fit.

2. There was no indication of pilot incapacitation, and toxicology tests for drugs and alcohol were negative for both individuals.

3. Blood analysis identified the presence of a low level of carbon monoxide (less than 10 per cent saturation) in both individuals; these values were consistent with levels observed in smokers.

4. Records indicate that the aircraft had been maintained in accordance with existing regulations.

5. The pilot transmitted his intentions to carry out a touch-and-go on runway 25 at the Liverpool airport.

6. From a comparative analysis of radar data from the occurrence flight and the TSB representative flight, it was determined that the pilot conducted a go-around rather than a touch-and-go landing

7. The aircraft's engine and flight control configuration at impact were consistent with settings used during a go-around phase of flight.

8. Metallurgical analysis of the engine exhaust stacks indicated that the engine was operating at impact.

9. The propeller blade damage and propeller cuts observed on trees along the wreckage trail indicate that the engine was developing power at impact.

10. There was no mechanical anomaly identified that would account for the descent into the terrain.

11. Conditions necessary for visual and vestibular illusions were present at the time of the occurrence.

12. Spatial disorientation can lead to a loss of situational awareness, which in turn can result in an inappropriate control input.

13. The pilot had minimal instrument experience.

14. The impact angle of the aircraft was consistent with the nose-down pitch attitude associated with the false climb illusion.

3.2 Causes

During the overshoot from the approach to the airport, the pilot probably lost situational awareness as a result of spatial disorientation, and unintentionally flew the aircraft into the ground.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson Benoît Bouchard, and members Jonathan Seymour, Charles Simpson, W.A. Tadros and Henry Wright, authorized the release of this report on 14 January 2000.

Appendix A—List of Supporting Reports

The following TSB Engineering Report was completed:

LP 12/99—Exhaust Stack Analysis Temperature Determination

This report is available upon request from the Transportation Safety Board of Canada.

Appendix B—Glossary

ACC	Area Control Centre
agl	above ground level
ARCAL	aircraft radio control of aerodrome lighting
asl	above sea level
AST	Atlantic standard time
CASA	Career Academy School of Aviation
ELT	emergency locator transmitter
fpm	feet per minute
FSS	flight service station
g	G load factor
GPS	global positioning system
IAS	indicated airspeed
lbs	pounds
mph	miles per hour
nm	nautical miles
PIREP	pilot report of weather conditions in flight
PPL	Private Pilot Licence
RCC	Rescue Coordination Centre
RCMP	Royal Canadian Mounted Police
rpm	revolutions per minute
sm	statute mile(s)
TSB	Transportation Safety Board of Canada
UNICOM	a private advisory station located at an uncontrolled aerodrome
VFR	visual flight rules