Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

# AVIATION INVESTIGATION REPORT
# A12O0138

## COLLISION WITH TERRAIN

## WATERLOO-WELLINGTON FLYING CLUB
## CESSNA 172S, C-FNET
## MOOREFIELD, ONTARIO
## 24 AUGUST 2012

Canada

# Aviation Investigation Report A12O0138

# Collision with terrain

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# Cessna 172S, C-FNET
# Moorefield, Ontario
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## *Summary*

The Cessna 172S (registration C FNET, serial number 172S8544), owned by the Waterloo Wellington Flying Club, departed the Kitchener/Waterloo Airport, Ontario, at 1815 Eastern Daylight Time, under visual meteorological conditions. The aircraft flew to Niagara Falls, Ontario, then to the city of Toronto, Ontario, and back to a practice area north of Kitchener-Waterloo. At approximately 2016 Eastern Daylight Time, the aircraft crashed into a field, 25 nautical miles north of the Kitchener/Waterloo Airport. The aircraft was destroyed; the pilot and 3 passengers were fatally injured. There was no post-impact fire. The emergency locator transmitter activated upon impact.

*Ce rapport est également disponible en français.*

# *Factual information*

## *History of the flight*

The aircraft was rented by the pilot, who filed a visual flight rules (VFR) flight plan with London flight information center (FIC). The flight plan route was from the Kitchener/Waterloo Airport (CYKF), Ontario, to Niagara Falls, Ontario, followed by a tour of the city of Toronto, Ontario, along the shoreline of Lake Ontario, and to an area north of CYKF before returning to CYKF.

The aircraft departed CYKF at 1815 [1] and proceeded on the flight plan route at an altitude of 2500 feet above sea level (asl) for the Niagara Falls and Toronto portions of the flight. It then climbed to 6900 feet asl enroute to the area north of CYKF. The investigation determined that, during the flight, the passengers exchanged seat positions so that each one had a turn in the front right seat. Current regulations do not prohibit occupants of an aircraft from switching seats in flight. All of the occupants were found properly seated, wearing seat belts and shoulder harnesses.

When the aircraft proceeded northwest of CYKF, the pilot broadcast 2 traffic advisory transmissions for the practice area of the Waterloo-Wellington Flying Club (WWFC) indicating that the pilot was going to perform upper airwork. [2] Recorded radar data indicated that the aircraft was manoeuvering in various directions and ground speeds, as low as 50 knots. The last radar data indicated that the aircraft was at 6900 feet and that it slowed to a ground speed of 70 knots before descending rapidly to 2400 feet in approximately 33 seconds (a descent rate of approximately 8200 feet per minute [fpm]), at which point radar contact was lost.

In the final moments of the flight, the aircraft was in a nose-down attitude, spinning and descending rapidly.

## *Wreckage*

The aircraft crashed into a cornfield at an elevation of 1360 feet asl. The impact angle was approximately 50° nose-down; damage was consistent with a left spin at impact. All flight control surfaces were accounted for, and all damage to the aircraft was attributable to the severe impact forces.

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1 All times are Eastern Daylight Time (Coordinated Universal Time minus 4 hours).

2 Generally, the term upper airwork refers to the following manoeuvers: slow flight, spins, stalls and steep turns.

## *Stall warning system and examination*

The stall warning system includes a stall warning horn and a scoop assembly. The stall warning horn is found on the inside of the cabin, behind the doorpost moulding and to the outboard side of the pilot on the fuselage rib. The scoop assembly is installed on the leading edge of the left wing at wing station (WS) 91.25. The scoop is operated by airflow over the surface of the wing. An internal reed in the stall warning horn sounds when the airspeed is approximately 8 to 15 knots greater than the airplane stall speed. 3 The scoop is attached to the wing leading edge by 4 fasteners. Cracks were found in the scoop flange at all fastener locations. The pipe at the back of the scoop was fractured from the scoop at its base (Photo 1).

During subsequent examination at its regional facility, the Transportation Safety Board (TSB) found that the scoop of the stall warning system was cracked. The system was sent to the TSB Laboratory for further examination. Examination of the fracture under a microscope revealed an area that had been previously cracked; this was made evident by the discoloration of the fractured surfaces. Another area of the fracture showed a more recent break (Photo 2), which was determined to be the result of impact forces. According to the manufacturer's maintenance procedures, inspection of the stall warning system, including its operation, is performed during every 'A' check (50-hour inspection). The previous inspection had been performed 40 hours prior to the occurrence; the stall warning system was serviceable at that time.

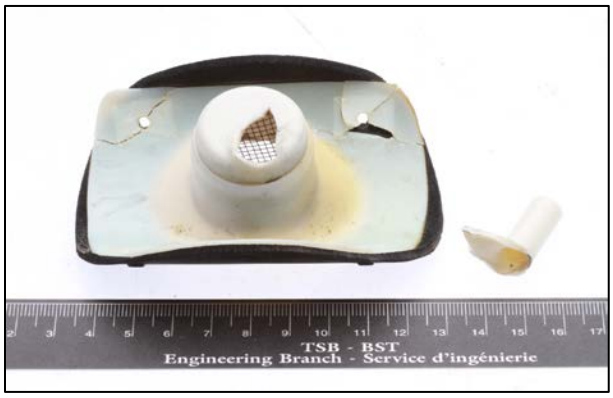


**Photo 1.** Rear view of scoop, fractured at its base

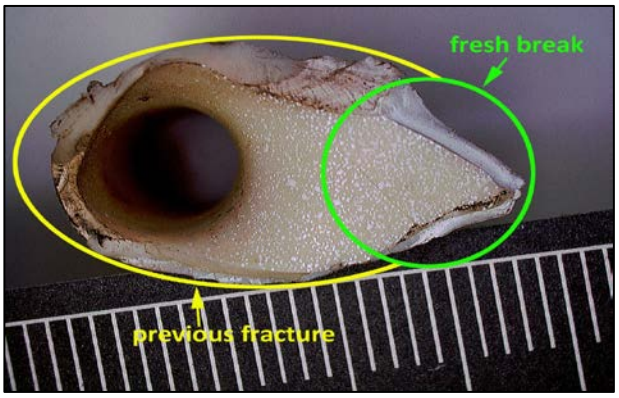


**Photo 2.** Fractured surfaces of the pipe

The scoop was made of acrylonitrile-butadiene-styrene (ABS) plastic. It failed in a brittle, progressive mode, consistent with environmental stress cracking, [4] weathering [5] and thermal

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3 172R/172S (1997 & On) Maintenance Manual, Part Number 172RMM20

4 "Environmental stress cracking (ESC) is a phenomenon in which a plastic resin is degraded by a chemical agent while under stress". During ESC, "[t]he chemical agent does not cause direct chemical attack or molecular degradation. Instead, the chemical penetrates into the plastic structure and interferes with the intermolecular forces binding the polymer chains", which accelerates craze

degradation. This degradation would have further contributed to the embrittlement of the scoop material. The crack initiation date and rate of progression could not be determined.

The stall warning system was tested in the TSB Laboratory to determine the effects of a potential breach on the system. It was observed that a breach in the plastic tube was sufficient to silence the horn. This reduction of airflow through the reed would have the same effect as a lower angle of attack and would adversely affect the operation of the stall warning system.

The stall warning system is not the pilot's only indication of an impending aerodynamic stall. As the aircraft approaches an aerodynamic stall, several other symptoms should be present, including; reduced indicated airspeed, high angle of attack, decreased flight control effectiveness and aerodynamic buffeting or vibration.

## *Pilot*

The pilot was certified and qualified in accordance with applicable regulations. The pilot held a Commercial pilot's license and had accumulated approximately 229 total flight hours, 200 of which were on the aircraft type. The majority of the pilot's private and commercial flight training was conducted at WWFC.

## *Weather*

The weather was suitable for visual flight rules flight, and was not considered a factor in the occurrence.

## *Company*

WWFC holds a valid flight training unit operator certificate. WWFC has a written policy according to which all spins shall be performed only with a company flight instructor on-board. The pilot had previously signed a waiver/agreement with the WWFC, acknowledging this policy.

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initiation and increases the rate of brittle crack extension. (Jeffrey A. Hansen, "Environmental Stress Cracking - The Plastic Killer," *Advanced Materials & Processes* [June 2004], p. 50.)

[5] Weathering is a degradation mechanism that can occur during exposure of plastics to environmental factors, such as solar radiation, temperature, humidity and pollutants, combining to produce changes in the chemical composition of the material. Weathering changes the properties of plastics relative to their initial specified properties, resulting in reduced tensile strength and impact resistance and increased embrittlement. Changes in color (yellowing) and surface cracks are also typically observed.

## *Spins*

Spinning is an autorotation that develops after an aggravated stall [6] wherein the aircraft follows a downward corkscrew path. Entry into a spin can be either intentional or unintentional and can occur at practically any airspeed, as long as there is a sufficient yaw rate while the aircraft is stalled.

> [D]uring a spin, much of the rudder usually is in the stalled wake of the horizontal tail and sometimes the wing, over which the dynamic pressure is low or abnormal airflow conditions exist. […] This figure [Figure 1] illustrates the dead-air region over much of the vertical tail, which is caused by the stalled wake of the horizontal tail and which seriously decreases the effectiveness of the rudder. [7]

In general, airplanes "spin flatter as the center of gravity [CG] is moved rearward". [8]

> This result is, of course, adverse since the control effectiveness normally decreases as the airplane spin angle of attack increases. The center-of-gravity position can significantly affect the spin and recovery characteristics of an airplane. [9]

The effect is generally unpredictable and depends on a number of factors.

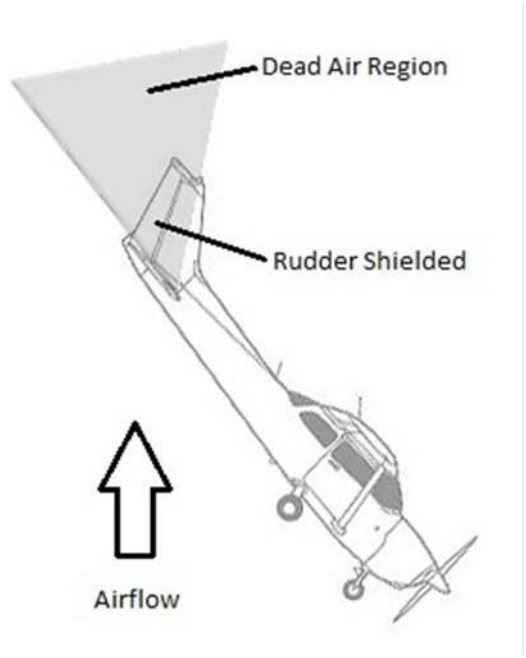


Figure 1. Dead air region caused by horizontal tail (Reproduced from NASA Technical Note 6575, p. 28)

> "As a rough estimate, an altitude loss of approximately 500-feet per each 3-second turn [an approximate descent rate of 10 000-fpm] can be expected in

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6 Sandy Macdonald and William Peppler, *From the Ground Up* (28th ed.), (Aviation Publishers Co., Ltd.: 2010).

7 National Aeronautics and Space Administration, James S. Bowman, Jr., *Summary of Spin Technology as Related to Light General-Aviation Airplanes*, NASA Technical Note 6575, p. 7.

8 Ibid. p. 9.

9 Ibid. p. 15.

> most small aircraft in which spins are authorized. Greater losses can be expected at higher density altitudes." [10]

## *Aircraft*

The aircraft was manufactured in 2000 and had accumulated approximately 4928 hours since new. Records indicate that the aircraft was certified, equipped and maintained in accordance with existing regulations and approved procedures.

The aircraft was certified by the United States Federal Aviation Administration (FAA) in both the normal and utility categories. The normal category is limited to airplanes intended for nonacrobatic operation; airplanes certified in the utility category may be used in limited acrobatic operations, including spins. The significant difference between the 2 categories is an increased load factor in the utility category, achieved by limiting the gross weight and CG position. Aircraft certified in the normal category, although not approved for intentional acrobatic manoeuvers (including spins), must be able to recover from a one-turn spin in not more than 1 additional turn, and it must be impossible to obtain unrecoverable spins with any use of the flight or engine power controls. [11]

The pilot's operating handbook (POH) for the Cessna 172S states that intentional spins are approved when the airplane is operated in the utility category; they are prohibited with baggage loadings or when the rear seats are occupied. A placard located in the cockpit stated that no acrobatic manoeuvers, including spins, were approved in the normal category.

The spin recovery procedure outlined in the POH is the following:

> 1. RETARD THROTTLE TO IDLE POSITION.
> 2. PLACE AILERONS IN NEUTRAL POSITION.
> 3. APPLY AND **HOLD** FULL RUDDER OPPOSITE TO THE DIRECTION OF ROTATION.
> 4. JUST **AFTER** THE RUDDER REACHES THE STOP, MOVE THE CONTROL WHEEL **BRISKLY** FORWARD FAR ENOUGH TO BREAK THE STALL. Full down elevator may be required at aft center of gravity loadings to assure optimum recoveries.
> 5. **HOLD** THESE CONTROL IMPUTS UNTIL ROTATION STOPS. Premature relaxation of the control inputs may extend the recovery.

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10 U.S. Department of Transportation, Federal Aviation Administration, Advisory Circular No 61-67C: Stall and Spin Awareness Training (20 September 2007), pages 6-7.

11 U.S. Department of Transportation, Federal Aviation Administration, *Federal Aviation Regulations*, Section 23.221 - Spinning.

6. AS ROTATION STOPS, NEUTRALIZE RUDDER, AND MAKE A SMOOTH RECOVERY FROM THE RESULTING DIVE. [12]

The maximum take-off weight (MTOW) for this aircraft type in the utility category is 2200 pounds, and the CG limit ranges from 35 inches to 40.5 inches aft of datum. In the normal category, the aircraft's MTOW is 2550 pounds, while its CG limit ranges from 35 inches to 47.3 inches aft of datum.

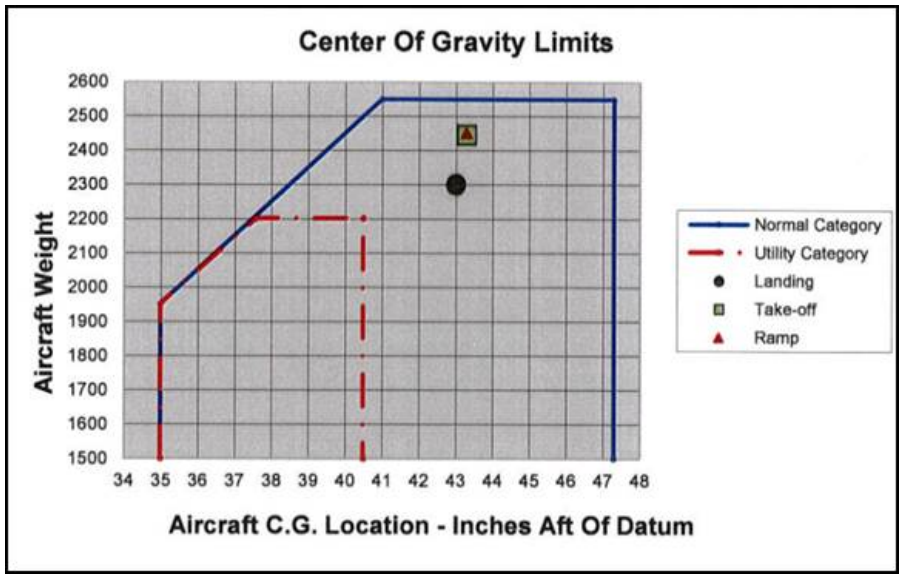


**Figure 2**. C-FNET calculated weight and balance chart (Source: Waterloo-Wellington Flying Club)

The aircraft departed with a take-off weight of 2446 pounds and a CG located approximately 43.25 inches aft of datum.[13] The foreseen landing weight was 2300 pounds and CG location, 43 inches aft of datum. The aircraft was operated in the normal category for the entire flight (Figure 2).

## *TSB Laboratory reports*

The following TSB Laboratory reports were completed:

- LP189/2012 –Aircraft Instruments Analysis
- LP191/2012 – C172 Stall Warning System Analysis

These reports are available from the TSB upon request.

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12 The Cessna Aircraft Company, Cessna Model 172S Pilot's Operating Handbook, Revision 4, Section 3 - Emergency procedures, pages 3-19.

13 Weight and centre of gravity chart was produced by pilot prior to departure.

# *Analysis*

The aircraft was complete and intact before the impact. There was a fracture with the stall warning system, but the effect of the fracture on the stall warning system operation could not be determined. No other abnormalities with the aircraft or its systems were discovered. The pilot was appropriately licensed, and was certified and qualified in accordance with the applicable regulations.

It was determined that the passengers switched seats during the flight. Currently, no regulation prohibits passengers from exchanging seat positions while the aircraft is airborne. However, because of the confined cabin space and proximity to the pilot and the flight controls, it is not a safe practice; switching seats could lead to inadvertent contact with the flight controls or the pilot, affecting the controllability of the aircraft. Movement within the cabin would also shift the aircraft's centre of gravity, possibly adding to control issues. The seat exchange was not a factor in the occurrence, as all occupants were seated and wore their seat belts and shoulder harnesses.

The investigation determined that the aircraft entered a spin. Therefore, this analysis focuses on reasons for stall/spin entry and non-recovery.

The aircraft was not approved for spins when operated in the normal category. This limitation was stated in the pilot's operating handbook (POH) and on a placard located in the aircraft. Waterloo-Wellington Flying Club (WWFC) policies also prohibited spins without an instructor on-board.

The aircraft climbed to a higher altitude and broadcast the intention of performing airwork in the practise area, indicating that the pilot intended to perform some type of manoeuver (airwork). However, it could not be determined whether the spin was entered intentionally or unintentionally; both possibilities are discussed in this analysis.

The pilot held a Commercial license, was experienced on the aircraft type, and was aware of the limitations and company policies. If the spin was entered intentionally, then the limitations and policies were ignored. The pilot may not have realized that exceeding these limitations may change the stall recovery characteristics of the aircraft.

The spin may have been entered unintentionally. As discussed, a stall must precede a spin manoeuver. If an aircraft is slowed, the airspeed can decrease to a point that a stall may occur. Additionally, the stall speed increases with the angle of bank. While manoeuvering, the aircraft may have been intentionally slowed and/or banked, resulting in an unanticipated stall occurring with an aft centre of gravity (CG). Also, if the stall warning was either erroneous or absent, the aircraft may have stalled with little or no prior warning from the stall warning horn.

During the spin, the angle of attack increased due to an aft CG. As a result, the horizontal tail likely blanketed the airflow over the rudder, reducing its efficiency and delaying spin recovery. In the normal category, the aircraft is certified to recover from a one-turn spin in less than one additional turn, assuming the proper control inputs are applied.

# Findings

## Findings as to causes and contributing factors

1. The aircraft entered a spin in a weight and balance configuration for which spins were not authorized; the pilot did not recover from the spin prior to ground impact.

## Findings as to risk

1. If passengers switch seat positions during flight in a small aircraft, there is an increased risk of inadvertent flight control movement as well as a risk of causing the centre of gravity to shift, possibly adding to control issues.
2. If a stall warning horn is damaged, it may activate too late or fail to activate, increasing the risk that pilots are not warned of an impending stall in a timely manner.

# Safety Action

## Safety action taken

*Waterloo-Wellington Flying Club*

Since this occurrence, the Waterloo-Wellington Flying Club (WWFC) implemented the following measures to its flight program and aircraft:

- Re-emphasized to all pilots the difference between operations in the "Normal" and "Utility" categories as well as the WWFC policies regarding the requirement that an instructor be on-board to perform airwork;
- Strengthened the airwork component of their groundschool programs.

The WWFC's entire fleet will also be equipped with a global positioning system (GPS) tracker and a cockpit voice recorder.

*This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 18 December 2013. It was officially released on 20 February 2014.*

*Visit the Transportation Safety Board's website (www.bst-tsb.gc.ca) for information about the Transportation Safety Board and its products and services. You will also find the Watchlist, which identifies the transportation safety issues that pose the greatest risk to Canadians. In each case, the TSB has found that actions taken to date are inadequate, and that industry and regulators need to take additional concrete measures to eliminate the risks.*