Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A12O0170

LOSS OF CONTROL AND COLLISION WITH TERRAIN

SOCATA TBM 700N, C-FBKK
RENFREW, ONTARIO 20 NM SW
08 OCTOBER 2012

Canada

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

Aviation Investigation Report

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Summary

The privately owned SOCATA TBM 700N (registration C-FBKK, serial number 621) departed from Ottawa/Carp Airport, Ontario, on an instrument flight rules flight plan to Goderich, Ontario. Shortly after takeoff, the pilot and sole occupant altered the destination to Wiarton, Ontario. Air traffic control cleared the aircraft to climb to flight level 260 (FL260). The aircraft continued climb through FL260 and entered a right hand turn, which quickly developed into a spiral dive. At approximately 1219 Eastern Daylight Time, the aircraft struck the ground and was destroyed. Small fires broke out and consumed some sections of the aircraft. The pilot was fatally injured. The 406 MHz emergency locator transmitter on board the aircraft was damaged and its signal was not sensed by the search and rescue satellite-aided tracking (SARSAT) system.

Ce rapport est également disponible en français.

Factual Information

History of the Flight

On the day of the occurrence, the aircraft departed Goderich, Ontario (CYGD), at approximately 1030 [1] with 3 people on board. The aircraft owner was piloting the aircraft from the left cockpit seat, the occurrence pilot was in the right seat, and the owner's spouse was seated in the cabin. This flight was completed under instrument flight rules (IFR) at flight level [2] 250 (FL250) and landed at Carp, Ontario (CYRP), at approximately 1130. The engine was shut down and everyone onboard deplaned. After approximately 15 minutes, the occurrence pilot reboarded the aircraft and closed the main door. The engine was started and the aircraft was taxied for departure. At 1200 the aircraft was taxied into position on Runway 28, with the pilot in the right-hand seat, and departed without event.

At 1204 while climbing through 7000 feet above sea level (asl), the pilot contacted Ottawa Terminal air traffic control (ATC) and received an IFR clearance to CYGD. The pilot requested a destination change to Wiarton (CYVV) and was cleared as requested via radar vectors to climb to FL230. Prior to departure, the pilot had decided to change the destination in order to pick up an aircraft manual left in Wiarton, and elected to make this change once airborne to save time.

At 1207, Ottawa Terminal instructed C-FBKK, now climbing through 11 500 feet asl, to contact Montreal Centre ATC.

At 1208, Montreal Centre cleared C-FBKK, now climbing through 14 000 feet asl, direct to CYVV and instructed the pilot to contact Toronto Centre ATC.

At 1211, Toronto Centre cleared C-FBKK to FL240 and a minute later cleared the aircraft to FL260. The pilot read back the clearance to FL260 at 1212:56 while climbing through FL219. This was the last recorded transmission by the pilot.

Between 1208 and 1216, the aircraft's horizontal track varied slightly to the left and right of the direct track to CYVV. Previous flights with the autopilot engaged showed little or no deviation from the direct track.

At 1216, the aircraft climbed through FL260 and a minute later, upon reaching FL275, it entered a right turn, which rapidly developed into a spiral dive. During the dive the aircraft reached vertical velocities in excess of 25 000 feet per minute (fpm), and was recorded on radar as leveling off for approximately 6 seconds at 8000 feet asl before reentering the spiral dive. The last recorded radar return at 1218:50 shows the aircraft at 4900 feet asl with a vertical speed of 13 200 fpm.

The aircraft was seen and heard by observers below the last recorded altitude executing various unusual manoeuvers described as rapid climbs and descents, loops, steep banks, and inverted

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1. All times are in Eastern Daylight Time (Coordinated Universal Time minus 4 hours).
2. Flight level is a level of constant atmospheric pressure related to a reference datum of 29.92 inches of mercury, and is stated in 3 digits that represent hundreds of feet, e.g., flight level 250 represents a barometric altimeter indication of 25 000 feet asl.

flight. The noise was described as rapid and variable high-pitched revving of the engine. The aircraft struck a forest area at an elevation of approximately 1085 feet asl.

Weather

The weather conditions at the time and location of the accident were not considered a contributing factor. The sky was clear, there was no precipitation, and visibility was over 15 statute miles. There were no reports of icing or turbulence from other aircraft in the area.

Aircraft Owner

The owner purchased C-FBKK intending to fly the aircraft himself. The owner had completed simulator training and a flight test, and had employed an experienced TBM 700 pilot (the accident pilot) to fly with him for the first 5 days to smooth the transition to the new aircraft type.

Accident Pilot

The pilot held a valid airline transport pilot licence, which included a current instrument rating and a type rating on the TBM 700, and had over 19 200 hours of flight experience and approximately 700 hours on type. The pilot had completed initial training and type rating in 2001, and had taken 8 recurrent courses since that year.

The pilot had a valid category 1 medical certificate, having successfully completed an examination on 05 September 2012, 33 days before the accident. The examination included an electrocardiogram, which assists the examiner in assessing the condition of the patient's heart. The pilot was 74 years old and was on medication for high blood pressure and high cholesterol. The Civil Aviation Medical Examiner and the Regional Aviation Medical Officer were aware of the conditions and associated medications, and decided these did not preclude the issuance of a category 1 medical certificate.

Data recorded on the Civil Aviation Medical Examination Report shows that, at the time of the examination, the pilot had a body mass index (BMI) of 33.1. A person with a BMI above 30 is considered obese.

Under the report section entitled "Cardio Vascular (CV) Risk Factors", the examiner had checked Hypertension (High Blood Pressure), Serum Lipids (High Cholesterol) and Obesity.

Aircraft

The aircraft, a TBM 700N (trade name TBM 850), is a high-performance, pressurized, single-engine turbine aircraft with a certified maximum operating altitude of 31 000 feet asl. C-FBKK was manufactured in 2012, received its initial certificate of airworthiness on 22 June 2012, and was imported into Canada by the owner in September 2012. The owner's intention was to fly the aircraft himself.

At the time of the accident, the aircraft had accumulated approximately 64 hours total flying time, 17 of which were flown after its import into Canada.

Records indicate that the aircraft was certified, equipped, and maintained in accordance with existing regulations and approved procedures. The aircraft was not equipped with a stand-alone flight data recorder or a cockpit voice recorder, nor was either required by regulation.

Avionics

The aircraft was equipped with a Garmin 1000 (G1000) avionics suite, which included a 15-inch multi-function display (MFD) screen in the center of the instrument panel, and two 10.4-inch primary flight displays located directly in front of either cockpit seat. The MFD displays numerous aircraft and engine parameters for monitoring purposes, including cautions, warnings and crew alert system (CAS) messages, which are displayed in the lower left corner of the MFD. The G1000 system can record many parameters and save the data to a memory card inserted in a slot the upper right corner of the MFD.

The aircraft was also equipped with a Garmin GFC 700 automated flight control system. There is a standard restriction in the TBM 850 *Pilot Information Manual* (PIM) stating that autopilot operation requires a pilot to be seated in the left-hand seat.

Pressurization System

The TBM 700N is pressurized by bleed air taken from the compressor section of the engine, and the pressurization is controlled by an onboard computer called the Global Air System Controller (GASC).

The output of compressed air from the engine is controlled by a flow control/shut-off valve (FCSOV). The FCSOV is a butterfly-type valve located in the engine compartment forward of the firewall. It is an electro pneumatic regulating and shut-off valve commanded by a torque motor, which is part of the FCSOV assembly. The valve actuates by using engine bleed air pressure. The valve is closed by an internal spring when the torque motor is de-energized or when there is no engine bleed air supply. Electrical current for the torque motor is controlled by the GASC, which receives signals from the bleed differential pressure sensor and the cabin pressure sensor. The valve is normally open during flight. The FCSOV will close if any of the following abnormal conditions occur: an over-temperature condition is sensed at the air inlet or outlet; bleed pressure is lost; electrical power is lost; or the guarded bleed switch on the environmental control system panel is set to OFF. When the FCSOV is closed, an amber BLEED OFF CAS message is displayed on the MFD.

The pressurization system is computer-controlled, but there is a cabin pressurization control panel (CPCP) located on the instrument panel in front of the right seat occupant’s left knee. On this panel there is a cabin altitude selector, which is set by the pilot to assist the GASC in smoothly altering the cabin altitude during climb and descent. There is an instruction in the PIM directing pilots to set the selector to cruise altitude +1000 feet while climbing and to the destination airfield elevation while descending.

The pilot is warned of the condition of the pressurization system in flight by aural and visual alerts. The upper left quadrant of the MFD displays cabin altitude, cabin differential pressure, cabin altitude rate of change, selected altitude, and oxygen cylinder pressure. If cabin altitude exceeds 10 000 feet, the displayed cabin altitude blinks red, a red CABIN ALTITUDE CAS message appears in the lower left quadrant of the MFD, the red master caution light on the upper left glare shield starts blinking, and a repetitive aural alert (a chime) sounds in the headsets. The aural alert and blinking light continue until acknowledged by pressing the master caution pushbutton indicator.

In the event of pressurization loss there are emergency oxygen masks for the rear passengers, and quick-donning emergency oxygen masks for the occupants of the cockpit. If the pilot is wearing a mask and needs to make a radio broadcast, a mask radio transfer switch on the far left side of the instrument panel must be set to ON to allow the push-to-talk (PTT) button to activate the mask microphone.

All the masks on the aircraft are connected to an oxygen cylinder, which is located near the right wing root, accessible by a small door located near the right karman.[3] The cylinder has an isolation valve on its head, which cannot be accessed from the cockpit, and must be set to ON before flight. The oxygen system is normally tested while on the ground by pressing a switch on the quick-donning masks and listening for a faint hissing sound emitted by the oxygen flowing. Oxygen pressure is displayed digitally on the MFD. If the oxygen cylinder isolation valve is set to OFF, a red CAS message is displayed on the MFD.

Current *Canadian Aviation Regulations*, section 605.31 – Oxygen Equipment and Supply, stipulate that pressurized aircraft must be equipped with sufficient oxygen to supply all crew members for the entire period of flight at cabin altitudes above 13 000 feet asl. If the oxygen cylinder had been fully charged and selected ON, it would have had the capacity to supply approximately 226 minutes of oxygen to a single crew member.

Procedures

In the event of a loss of cabin air pressure, pilots are instructed by the PIM to initiate an emergency descent (Appendices

Appendix A – *TBM 850 Emergency Descent* Procedure) to the minimum enroute altitude and, if possible, below 10 000 feet.

Hypoxia

Hypoxia is defined in Transport Canada’s *Aeronautical Information Manual* (AIM) (TP 14371E) under Airmanship, section 3.0 Medical Information, as follows:

> The literal definition of hypoxia is “low oxygen”. Therefore, hypoxia implies a lack of sufficient oxygen for the body to operate normally. Its onset is insidious and may be accompanied by a feeling of well being, known as euphoria. Even minor hypoxia impairs night vision and slows reaction time. More serious hypoxia interferes with reasoning, gives rise to unusual fatigue and, finally, results in a loss of consciousness.

There are different forms of hypoxia; these are described in Source: DAHER-SOCATA, TBM 850 Pilot’s Operating Handbook, ed. 1, rev. 0, 22 June 2007, p. 3.6.3

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[3] A karman is also called the wing-to-fuselage fairing.

Appendix B.

Test and Research

Flight tests performed during aircraft certification demonstrated that the aircraft type has positive static and dynamic stability: in other words, it has a tendency to return towards the neutral or previously trimmed state following an upset. It was noted that with the aircraft trimmed for a nose-up attitude and a high power setting, significant control force was needed to establish a descending spiral. Once the control input was relaxed, the aircraft pitch would tend toward its previously trimmed state and roll would tend toward neutral. Subsequent tests completed in collaboration with the TSB for the investigation produced similar results.

Wreckage

The aircraft struck the ground at very high forward and vertical speeds. Wreckage parts were dispersed over several hundred square metres. Several small pockets of post-impact fire consumed various pieces and components. Impact marks on surrounding trees suggest the aircraft was in steep right bank and nose-down attitude when it struck the ground.

The right-hand cockpit seat and seatbelts were located; deformation indicated that the seat had been occupied. The left-hand seatbelts were found to be neither connected nor deformed.

The oxygen cylinder was recovered; it had exploded. The neck-mounted isolation valve was recovered and was found in the OFF position. There were no impact marks or material transfer on the isolation valve to suggest the valve had moved during the accident sequence. However, the possibility that the valve had moved to the OFF position during the impact sequence could not be ruled out.

The G1000 MFD was partially recovered, although it was heavily damaged and partially burnt. The slot where the memory card would normally be inserted was identified, but the memory card could not be found, and was determined to have been destroyed.

The cabin altitude selector was recovered and determined to be set at an aircraft altitude of 18 300 feet or cabin altitude of 2500 feet.

The FCSOV was recovered and found to have been in the closed position upon impact.

The GASC was recovered slightly damaged, but upon disassembly it was discovered that the memory chip, which would have recorded data from the last flight, was destroyed.

The engine and propeller were recovered and it was determined that the engine was producing power when the aircraft hit the ground.

A pathological examination of the pilot was not possible.

TSB Laboratory Reports

The following TSB Laboratory reports were completed:

- LP215/2012 – Avionics Analysis
- LP216/2012 – Airframe Reconstruction and Engine and Propeller Examination

The reports are available from the TSB upon request.

Analysis

Given the high level of destruction and the fact that recorded data was limited to ATC recordings above 4900 feet asl, it was not possible to conclude with any certainty the reason why the aircraft entered the rapid descending turn and hit the ground.

Several factors identified in the investigation were outside normal operations, but any link among them could not be determined. These factors include the position of the oxygen cylinder valve; the occupied right seat; the disengaged autopilot; the CPCP setting; the FCSOV position; the rapid entry into a spiral dive; the brief level-off during the descent; and the manoeuvers observed below radar coverage.

The oxygen cylinder valve position is normally checked before the first flight, as is the quantity of oxygen and operation of the oxygen system from the cockpit. If this switch is in the OFF position and the aircraft is flown, a noticeable CAS warning appears on the MFD. It is dangerous to continue to fly above 10 000 feet without emergency oxygen: in the event of depressurization, a pilot would quickly become incapacitated.

It could not be determined with any certainty whether the position of the valve changed during the accident sequence.

The pilot sat in the right-hand seat for the initial flight from CYGD because the owner was flying from the left-hand one. It could not be determined why the pilot decided to occupy the right-hand seat for the return trip given that the pilot was the sole occupant. While the aircraft can easily be operated from either seat, certain switches, such as the mask radio transfer switch, become more difficult to operate, and the master warning and caution lights and MFD CAS messages are no longer directly in the field of view from the right-hand seat.

Radar recordings of the horizontal flight path and lack of altitude capture at FL260 suggest that the autopilot was not being used. It would be considered abnormal not to use it, especially during higher workload scenarios such as single-pilot IFR operations. The PIM states that autopilot operation is contingent on a pilot being seated in the left seat. This restriction may have been known to the pilot, which might explain why the autopilot was not used.

The cabin altitude selector on the CPCP was found set to an altitude that did not match any settings recommended in the PIM. The setting would not disable the computer-controlled pressurization system, but it would not provide an optimized rate of change of cabin altitude. It was considered possible that this selection was made in error or during incapacitation or rapid descent.

The FCSOV was determined to have been in the closed position when the aircraft struck the ground. There are 5 possible reasons for the valve being closed, but only 1, the loss of upstream pressure, could be mostly ruled out due to known engine operation. If the valve were closed during flight, the cabin would stop receiving pressurized air, and eventually its pressure would equalize with the outside air pressure. This loss of pressure would trigger several warnings in the cockpit including a master warning and a constant repetitive aural alert.

The rapid development of a spiral dive is difficult to explain without pilot initiation. If the aircraft is climbing with the engine set to climb power and the trim condition set to normal, it does not have a tendency to enter this type of manoeuver unaided. Likewise, it is difficult to account for the dramatic change in the rate of descent during the spiral dive and the manoeuvers observed below radar coverage without control input.

The pilot's age and medical condition were considered as a possible source of incapacitation. A medical incapacitation event is consistent with a loss of control but inconsistent with the determined position of the FCSOV, the rapid entry into the spiral dive, the reduction in the rate of descent, and the observed manoeuvers.

An undetermined loss of pressurization is consistent with the FCSOV position and, combined with the unavailability of onboard oxygen, could explain the controlled initiation of an emergency maximum rate of descent shortly followed by incapacitation and loss of control, possibly due to hypoxia. However, the reduction in the rate of descent, observed manoeuvers, and other unusual factors present too many uncertainties to conclude that hypoxia was the cause.

Findings

Findings as to Causes and Contributing Factors

1. The pilot lost control of the aircraft for undetermined reasons and the aircraft collided with terrain.

Findings as to Risk

1. Operating an aircraft above 13 000 feet asl without an available emergency oxygen supply increases the risk of incapacitation due to hypoxia following depressurization.

Other Findings

1. The avionics system had the capability to record data essential to the accident investigation but the recording medium was destroyed in the accident.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 17 December 2013. It was officially released on 10 January 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.

Appendices

Appendix A – TBM 850 Emergency Descent Procedure

TBM
850 PILOT'S OPERATING HANDBOOK

SECTION 3
EMERGENCY PROCEDURES
EASA Approved

3.6 – EMERGENCY DESCENTS

MAXIMUM RATE DESCENT

1 – Power lever .... **IDLE**
2 – Oxygen .... **If necessary**
3 – Propeller governor lever .... **MAX. RPM**

Procedure in smooth air :

4 – Flaps .... **UP**
5 – Landing gear .... **UP**
6 – Speed .... V_{MO} **= 266 KIAS**

Procedure in rough air or in case of structure problem :

7 – Reduce speed .... **IAS ≤ 178 KIAS**
8 – Landing gear .... **DN**
9 – Flaps .... **UP**
10 – Keep .... **IAS ≤ 178 KIAS**

Edition 1 – June 22, 2007 EMERGENCY DESCENTS Page 3.6.3
Rev. 0

Source: DAHER-SOCATA, TBM 850 Pilot's Operating Handbook, ed. 1, rev. 0, 22 June 2007, p. 3.6.3

Appendix B – Types of Hypoxia

Hypoxia is classified into four different types; all are relevant to pilots and merit consideration.

(a) Hypoxic hypoxia

Hypoxic hypoxia is the result of low oxygen levels in the bloodstream. In pilots, this most often occurs with exposure to altitude (hypobaric hypoxia). At low altitudes, the partial pressure of oxygen in the atmosphere is adequate to maintain brain function at peak efficiency.

Atmospheric pressure and the partial pressure of oxygen both decline at higher altitudes. At 8 000 ft asl (2 440 m), some people may notice a slight increase in heart rate and speed of breathing (respiratory rate). By 10 000 ft ASL (3 050 m), the partial pressure of oxygen is low enough that all pilots will experience mild hypoxia and some will become symptomatic. Pilots operating at this altitude or higher should be alert for unusual difficulty completing routine calculations and should take corrective action if difficulties are noted. To avoid hypoxia, do not fly above 10 000 ft ASL (3 050 m) without supplemental oxygen or cabin pressurization.

(b) Anaemic hypoxia

Oxygen in blood is carried by haemoglobin, which is found in red blood cells. When the red blood cell count decreases, or the haemoglobin does not function properly, less oxygen can be carried by the blood. This can occur in conditions such as heavy bleeding, some cancers, sickle cell anaemia, or carbon monoxide poisoning, to name a few. A person suffering from anaemia may notice symptoms such as breathlessness, fatigue, or chest pain, and symptoms will worsen at higher altitudes, as the effects of hypoxia and anaemia are additive.

(c) Ischaemic hypoxia/stagnant hypoxia

The term ischaemia refers to inadequate supply of blood, and ischaemic hypoxia occurs when there is inadequate blood flow to body tissues. This can occur with constriction of blood vessels (for example, this is often seen in fingers and toes exposed to cold) as well as in situations of low blood pressure and cardiac output such as fainting, or during exposure to high sustained accelerations (stagnant hypoxia). Oxygen therapy is not very helpful in this form of hypoxia. The best remedy is to correct the underlying cause.

(d) Histotoxic hypoxia

Histotoxic hypoxia refers to an inability of the cells of the body to use the oxygen available. This type of hypoxia is rare in pilots, but it can occur with certain conditions such as cyanide poisoning, chemical poisoning, and intoxication with certain drugs. Histotoxic hypoxia can also be caused by high blood alcohol levels.

Source: Transport Canada, *Aeronautical Information Manual* (TP 14371E)