



Transportation  
Safety Board  
of Canada

Bureau de la sécurité  
des transports  
du Canada

# AVIATION INVESTIGATION REPORT A15P0081



## **In-flight breakup**

Carson Air Ltd.

Swearingen SA226-TC Metro II, C-GSKC

North Vancouver, British Columbia

13 April 2015

Canada

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Mode investigation report A15P0081

Cat. No. TU3-5/15-0081E-PDF  
ISBN 978-0-660-23657-5

This report is available on the website of the  
Transportation Safety Board of Canada at [www.tsb.gc.ca](http://www.tsb.gc.ca)

*Le présent rapport est également disponible en français.*

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

## Aviation Investigation Report A15P0081

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### *Summary*

On 13 April 2015, Carson Air Ltd. flight 66 (CA66), a Swearingen SA226-TC Metro II (registration C-GSKC, serial number TC-235), departed Vancouver International Airport (CYVR), British Columbia, with 2 pilots on board for an instrument flight rules flight to Prince George, British Columbia. At 0709 Pacific Daylight Time (PDT), approximately 6 minutes after leaving Vancouver, the aircraft disappeared from air traffic control radar while climbing through an altitude of 8700 feet above sea level in instrument meteorological conditions, about 4 nautical miles north of the built-up area of North Vancouver.

Deteriorating weather conditions with low cloud and heavy snowfall hampered an air search; however, aircraft wreckage was found on steep, mountainous, snow-covered terrain by ground searchers at approximately 1645 PDT. The aircraft had experienced a catastrophic in-flight breakup. Both pilots were fatally injured, and the aircraft was destroyed. Although the aircraft's 406-megahertz emergency locator transmitter activated, the antenna was damaged and no signal was received by the Cospas-Sarsat (international satellite system for search and rescue). The accident occurred during daylight hours.

*Le présent rapport est également disponible en français.*



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## 1.0 *Factual information*

### 1.1 *History of the flight*

The Carson Air Ltd. (Carson Air) Swearingen SA226-TC Metro II (registration C-GSKC, serial number TC-235) was operating as flight 66 (CA66), a weekday cargo flight between Vancouver International Airport (CYVR) and Fort St. John (CYXJ), British Columbia, with planned stops in Prince George (CYXS) and Dawson Creek (CYDQ)—a total distance of about 360 nautical miles (nm).

The occurrence flight was on a Monday morning, 13 April 2015, following a 2-day weekend period during which flights were not carried out. On the morning of the occurrence, CA66's first officer arrived at the airport at approximately 0600.<sup>1</sup> The first officer appeared to be in good spirits and spent about 5 minutes in the flight planning room before going to the aircraft to prepare it for that day's flights. The captain arrived at approximately 0615 and went directly to the flight planning room to begin preparing the morning's flight plan. He appeared to be in a positive state of mind and spent a few minutes speaking with other company pilots who were also preparing to operate flights. He used a company computer to access weather information and placed a telephone call to NAV CANADA<sup>2</sup> to file an instrument flight rules flight plan. No abnormal behaviour was observed by anyone with whom he had contact. The captain then walked to the aircraft and spent about 10 minutes in the flight deck before assisting the first officer with loading the flight's cargo. Final flight preparations were carried out by both flight crew members before they boarded the aircraft and started the engines, at about 0645.

At 0703, CA66 began its take-off run. Ground radar returns taken by airport surface detection equipment showed that the aircraft lifted off after an approximate ground-run distance of 2800 to 3000 feet. This was within the expected normal performance for the aircraft type.

Shortly after takeoff, CA66 contacted CYVR terminal departure control and was cleared to 9000 feet above sea level (ASL).<sup>3</sup> A short time later, the air traffic controller assigned the flight a northbound heading. At 0707, CYVR terminal departure control instructed CA66 to change radio frequencies and contact CYVR centre control. Upon initial contact with CYVR centre control, while climbing through 7500 feet, CA66 was again cleared to the aircraft's final flight planned altitude of flight level 200.<sup>4</sup> At 0708, the crew acknowledged a clearance

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<sup>1</sup> All times are in Pacific Daylight Time (Coordinated Universal Time minus 7 hours).

<sup>2</sup> NAV CANADA provides civil air navigation services, including flight planning and air traffic control services within Canada.

<sup>3</sup> All altitudes are above sea level unless otherwise noted.

<sup>4</sup> Flight level is the "altitude expressed in hundreds of feet indicated on an altimeter set to 29.92 in. of mercury or 1013.2 mb." In this case, flight level 200 signifies 20000 feet above sea level. Source:

to climb to flight level 200; this was CA66's last radio transmission. One minute and 20 seconds later, while climbing through an altitude of 8700 feet on an assigned heading of 350° magnetic, the aircraft disappeared from secondary surveillance radar displays at air traffic control.<sup>5</sup>

CA66's radar track, from the time it first became visible on radar at 0702 until a steep descent toward ground, was approximately 7 minutes. The track showed an apparently routine climb from CYVR, at an average climb rate of 1500 feet per minute. Aircraft speed during the climb increased gradually until a ground speed of approximately 185 knots was reached.<sup>6</sup>

The last 3 radar returns from CA66 showed the aircraft beginning an abrupt, steep descent. At 0709, a radar return showed that the aircraft was at 8700 feet; this was the highest altitude it reached. The 2 subsequent radar returns showed that the aircraft had dropped rapidly to 7600 feet and then 5000 feet while continuing in the direction of flight. There were no further returns (Figure 1).

During the initial stage of the descent, the aircraft pitched down at about 6° per second, and its vertical acceleration reached -0.6g.<sup>7</sup> The descent to 5000 feet likely occurred within 10 to 14 seconds.<sup>8</sup> During that period, the aircraft's descent rate exceeded 30 000 feet per minute, and aerodynamic forces caused structural disintegration of the aircraft (in-flight breakup). There was no Mayday call or other communication from the aircraft during this period.

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Transport Canada, TP 14371, *Transport Canada Aeronautical Information Manual (TC AIM)*, (13 October 2016), General, Section 5.1 Glossary of Aeronautical Terms.

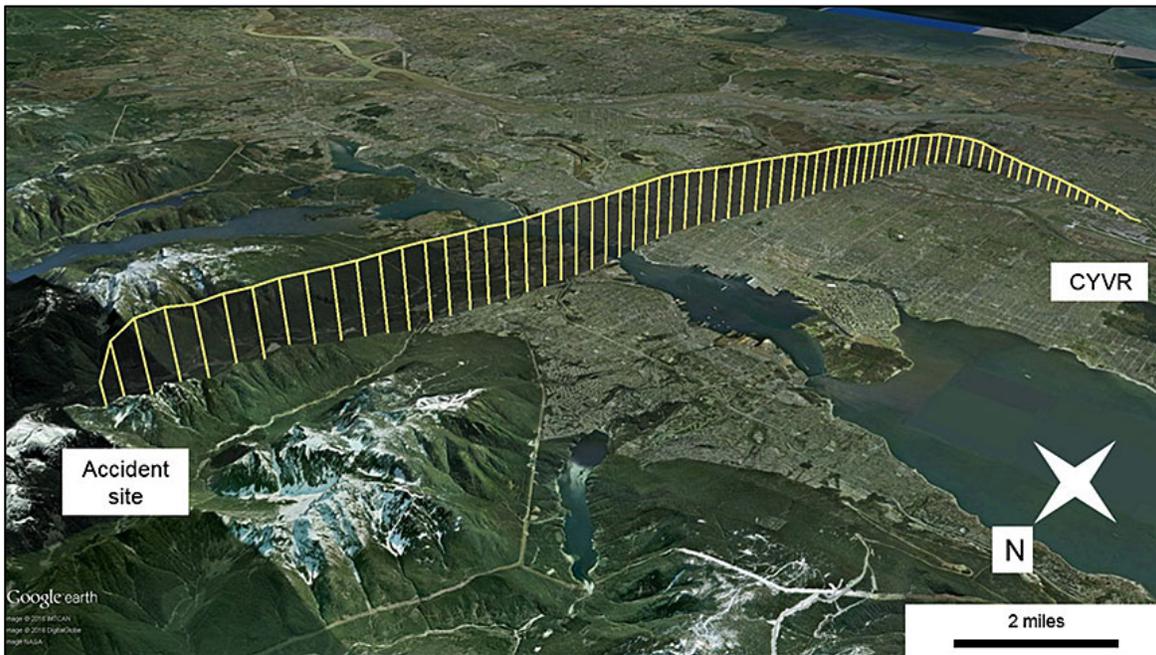
<sup>5</sup> The Vancouver Radar Data Processing System Rehost does not display track updates for returns showing vertical rates greater than 140 feet per second or 8400 feet per minute.

<sup>6</sup> The aircraft ground speed was determined to have resulted from a true airspeed of 180 knots. This would have resulted in an indicated airspeed of approximately 190 knots.

<sup>7</sup> A gravity-force measurement of 1g is equivalent to the force of the earth's gravity upon an object. An object accelerating towards the earth will experience a reduced or negative g force and an apparent decrease in weight. At 0g, an object's apparent weight is 0.

<sup>8</sup> A more precise calculation of time was not possible given the radar refresh rate of approximately 4.8 seconds.

Figure 1. Accident flight path (Source: Google Earth, with TSB annotations)



Deteriorating weather conditions with low cloud and heavy snowfall hampered an air search; however, aircraft wreckage was found on steep, mountainous, snow-covered terrain by ground searchers at approximately 1645. Both pilots had been fatally injured.

Although the aircraft's 406-megahertz emergency locator transmitter activated, the antenna was damaged and no signal was received by the Cospas-Sarsat (international satellite system for search and rescue).

## 1.2 Injuries to persons

Table 1. Injuries to persons

	Crew	Passengers	Others	Total
Fatal	2	-	-	2
Serious	0	-	-	0
Minor/None	0	-	-	0
Total	2	-	-	2

## 1.3 Damage to aircraft

The aircraft was destroyed.

## 1.4 Other damage

An unknown quantity of fuel<sup>9</sup> was spilled from the aircraft's right- and left-wing fuel tanks into 2 tributaries of Lynn Creek.<sup>10</sup> The collision caused some environmental fire damage in a shallow ravine where the aircraft's right wing came to rest.

## 1.5 Personnel information

Table 2. Personnel information

	Captain	First officer
Pilot licence	Commercial pilot licence (CPL)	Commercial pilot licence (CPL)
Medical expiry date	01 July 2015	01 March 2016
Total flying hours	2885	1430
Flight hours on type	1890	57
Flight hours in the last 7 days	20	26
Flight hours in the last 30 days	75	57
Flight hours in the last 90 days	245	89
Flight hours on type in the last 90 days	245	57
Hours on duty prior to occurrence	1	1.2
Hours off duty prior to work period	56	56

### 1.5.1 Captain

The captain was certified and qualified for the flight in accordance with existing regulations and held a valid commercial pilot licence.

<sup>9</sup> The in-flight breakup of the aircraft resulted in fracturing of the aircraft's wing fuel cells, and fuel was subsequently atomized and subject to aerial dispersal. Therefore, the amount of fuel remaining in the tanks when they came to rest could not be determined.

<sup>10</sup> Norvan Creek and the upper portion of Lynn Creek lie within the Lynn Headwaters Regional Park. Runoff from both streams flows into Burrard Inlet in the Metro Vancouver area.

The captain was hired by Carson Air in May 2013 to fly as a first officer on the company's Metro II aircraft. At that time, he was provided with ground instruction, including crew resource management (CRM)<sup>11</sup> training, and flight training on the SA226-TC Metro II aircraft. He successfully completed an initial pilot proficiency check on 11 July 2013.

Since starting with the company, the captain had been based at Carson Air's CYVR base, although he had been temporarily assigned to, and flying out of, the base at the Calgary International Airport (CYXC), Alberta, on occasion.

On 05 December 2014, the captain had qualified as a captain on Metro aircraft. On 11 December 2014, the captain underwent an employee performance review after another company pilot reported an incident in which he had had to take control from the captain. During the review, he was accompanied by a check pilot for 1 day of operational flying. At that time, he was assessed as effective, competent, or highly effective in most evaluated categories. No areas of concern with his performance were identified.

On 03 March 2015, the captain received a non-disciplinary letter to clarify expectations following an incident in which he had played a role in uploading an improper fuel quantity, which had resulted in a reduced cargo payload for a flight he was to operate. In addition, the captain had not immediately reported the incident. The letter advised the captain that this incident was being considered as isolated and that the captain was expected to comply with the company operations manual at all times.

On 20 March 2015, the captain applied for the position of Vancouver base chief pilot for the company's cargo operation. On 26 March 2015, the company advised him that the position had been awarded to another candidate.

On 13 April 2015, the day of the accident, the captain was returning to work following a rest period of 2 days. The investigation was unable to establish the captain's activity or rest patterns in the 56 hours that he had been free from flying duties.

### 1.5.2 *First officer*

The first officer was certified and qualified for the flight in accordance with existing regulations and held a valid commercial pilot licence.

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<sup>11</sup> In its guidance material, Transport Canada defines crew resource management as "[t]he effective use of all available resources—human resources, hardware, and information—to achieve safe and efficient flight." Source: Transport Canada, Commercial and Business Aviation, Development and Implementation of an Advanced Qualification Program, Definitions, available at <https://www.tc.gc.ca/eng/civilaviation/standards/commerce-aqp-definitions-325.htm> (last accessed on 22 September 2017).

The first officer was an experienced pilot and described as a very good member of a team or flight crew. He had experience flying Twin Otters and the Beechcraft King Air 350 type (BE-30) in instrument flight rules operations. The first officer had recently been hired by Carson Air and had begun training with the company during the month before the accident. He had completed his flight and ground training, including CRM, and had successfully passed his pilot proficiency check on the SA226-TC aircraft on 23 March 2015. Since that date, he had flown 9 shifts on the company's CYVR Metro operations. The first officer had not flown or worked during the 2 days before the accident. During that time, he received adequate rest and nourishment.

## 1.6 Aircraft information

### 1.6.1 General

Table 3. Aircraft information

Manufacturer	Swearingen
Type, model, and registration	SA226-TC Metro II, C-GSKC
Year of manufacture	1977
Serial number	TC-235
Certificate of airworthiness / flight permit issue date	24 October 2006
Total airframe time	33 244.9 hours
Engines	TPE 331 10UA
Propellers	Hartzell HC-B3TN-5
Maximum allowable take-off weight	5670 kg
Recommended fuel type(s)	Jet A, Jet A-1, Jet B
Fuel type used	Jet A

### 1.6.2 SA226-TC general information

The Swearingen SA226-TC Metro II aircraft (Figure 2) is a pressurized twin-engine turboprop aircraft originally manufactured by Swearingen Aircraft, beginning in 1974, and later made by Fairchild Industries. Although the aircraft type is no longer in production, the type certificate is currently held by M7 Aerospace. The Metro II was designed primarily to serve as a commuter passenger aircraft.

Figure 2. Carson Air Ltd. Swearingen SA226-TC Metro II C-GSKC (Source: Carson Air Ltd.)



The occurrence aircraft was built in 1977 and was originally used as a 19-seat passenger aircraft. In October 2006, it was purchased by Carson Air and imported to Canada from the United States. At that time, it was reconfigured to carry cargo. Among other changes, the conversion involved the removal of all passenger seats and cabin windows, and the installation of cargo net bulkheads for securing freight.

The SA226-TC flight controls are conventionally arranged, with dual flight controls and instrumentation at both pilot positions. Elevator, rudder, and aileron control surfaces are connected to the flight controls by cable and pulley systems, while pitch trim is controlled by an electrically operated actuator on the aircraft's horizontal stabilizer. The occurrence aircraft was not equipped with an autopilot, nor was it required to be by regulation.

#### 1.6.2.1 SA226-TC anti-ice systems, controls, and indications

The SA226-TC is certified for flight in environmental icing conditions and is equipped with a number of anti-icing systems. These include electrically powered heaters for an angle-of-attack vane-driven sensor that is part of the aircraft's stall avoidance system (SAS)<sup>12</sup> as well as for 2 pitot tubes. Pitot tubes project into the aircraft's airstream. In flight, dynamic air pressure is routed from the pitot tubes to the aircraft's airspeed system and provides the flight crew with airspeed information. For flight in icing conditions, pitot tubes need to be heated to prevent ice build-up that would lead to a loss of airspeed information. If pitot tubes become blocked, the airspeed indicator may behave like an altimeter (i.e., show an increase in airspeed as the aircraft climbs and a decrease in airspeed as the aircraft descends).

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<sup>12</sup> The SA226-TC SAS system couples an aerodynamic angle-of-attack sensor and display with a control-column pusher system that pitches the aircraft down if sensors indicate abnormally high angles of attack. The pusher system can apply a maximum nose-down force of approximately 65 pounds on the pilot control columns. This system is automatically disabled above 140 knots indicated airspeed.

Electrical power for the SAS and pitot heaters is controlled by 2 rocker-style selector switches located in the lower left area of the captain's instrument panel. To control its associated electrical heater, each switch may be placed in 1 of 3 settings: electrical power off, pitot heat on, or both pitot and SAS heat on. The switches are positioned for use and access by the captain (left-hand seat). They were out of reach and outside the normal scan from the first officer's (right-hand) seat.

The SA226-TC is equipped with a warning light and annunciator panel in the mid-upper instrument panel area. This panel provides both flight crew members with warning, caution, and status lights for a number of aircraft systems, including the aircraft's anti-icing systems. A green indicator light illuminates on this panel when both SAS and pitot heaters are powered. The occurrence aircraft was not equipped with specific annunciator lights that indicate when the pitot heaters are powered independently of the SAS heater or when the heaters are not powered.

#### *1.6.2.1.1 Carson Air Ltd. SA226-TC anti-icing operating procedures*

Carson Air uses standard operating procedures for SA226-TC flight operations. These procedures include the use of checklists to ensure that pilots correctly configure aircraft system settings before, during, and after a flight. For take-off, Carson Air SA226-TC pilots use 3 checklist procedures:

- originating checks
- line-up checks
- after-takeoff checks

Each of these 3 checks requires that the captain select pitot and SAS heaters on and then verbally respond to that effect when challenged by the first officer.

Because there was no cockpit voice recorder, the investigation was unable to determine the extent to which checklist procedures were used by the flight crew during the occurrence flight.

#### *1.6.3 Review of aircraft maintenance records*

Maintenance records show that the occurrence aircraft was certified, equipped, and maintained in accordance with existing regulations and approved procedures. There was no documented indication of any technical problem(s) before the occurrence that may have played a role.

#### *1.6.4 Aircraft weight and balance*

The aircraft journey log, flight plan, and weight-and-balance report were not recovered from the accident site. A small portion of the aircraft's cargo was ejected during the in-flight breakup and subsequently lost. However, the investigation determined the aircraft's cargo weight and position from documentation, such as air-freight waybills, retained at base operations.

The aircraft departed CYVR with 2050 pounds of fuel in the main tanks and about 1471 pounds of cargo, resulting in a take-off weight of 12 131 pounds and a centre of gravity (index) of approximately -11.3. Both of these were within the allowed weight-and-balance limits for the aircraft. The investigation determined that, during aircraft operation at a speed of 180 knots true airspeed, this centre of gravity required a horizontal stabilizer trim position approaching the nose-down range limit of the system.

## 1.7 *Meteorological information*

The hourly aerodrome routine meteorological report taken at 0700 for CYVR described the weather conditions at the airport as winds from 150° true (T) at 4 knots and varying from 090°T to 190°T, visibility 15 statute miles in light rain, a few clouds at 3300 feet above ground level (AGL), scattered cloud at 4200 feet AGL, broken cloud ceiling at 5400 feet AGL, and overcast at 6900 feet AGL, temperature 7 °C, dew point 4 °C, and altimeter 29.90 inches of mercury. The accident occurred approximately 15 nm north of CYVR in mountainous terrain.

The geographic effect of the North Shore Mountains overlooking Vancouver often accounts for significant variation in weather conditions between the mountains and the area surrounding CYVR, which is at sea level. At the time of the accident, the reported cloud ceiling in the accident area near the Coliseum Mountain<sup>13</sup> area was variable, with an overcast cloud base estimated to be as low as 5000 feet ASL. Winds were light from the south-southeast. There was no precipitation. A number of aircraft transited the area of CA66's last radar position both immediately before and after the accident. Pilot reports from these aircraft described smooth flying conditions with light turbulence and cloud tops at 14 000 feet ASL. Light rime icing conditions were reported in cloud.

Satellite weather coverage showed no significant cumulus or convective cloud in the area where the accident occurred. Sensors did not detect any lightning discharges in the area.<sup>14</sup>

## 1.8 *Aids to navigation*

The investigation identified no issues associated with aids to navigation that might have been a factor in the accident.

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<sup>13</sup> Coliseum Mountain and The Needles peaks, which lie in the immediate accident area, rise to elevations of 4744 feet ASL and 3946 feet ASL, respectively.

<sup>14</sup> Environment and Climate Change Canada has established and maintains the Canadian Lightning Detection Network, which comprises approximately 80 sensors that can detect up to 90% of cloud-to-ground lightning and 10% of cloud-to-cloud lightning.

## 1.9 *Communications*

Radio communications between CA66 and air traffic control were unremarkable throughout the flight, and no issues with communication were identified during the course of the investigation.

The investigation determined that all radio calls from CA66 during the occurrence flight were made by the first officer.

### 1.10 *Aerodrome information*

There were no factors associated with aerodromes that contributed to the accident.

### 1.11 *Flight recorders*

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

#### 1.11.1 *On-board recorders*

In 2013, following the loss of control and fatal in-flight breakup of a de Havilland DHC-3 Otter,<sup>15</sup> the Board identified the difficulties posed to that investigation resulting from the absence of on-board recorders in that aircraft. In particular, the Board found the following:

If cockpit or data recordings are not available to an investigation, then the identification and communication of safety deficiencies to advance transportation safety may be precluded.<sup>16</sup>

The Board went on to state the following:

Given the combined accident statistics for CARs [*Canadian Aviation Regulations*] subparts 702, 703, and 704 operations, there is a compelling case for industry and the regulator to proactively identify hazards and manage the risks inherent in these operations. In order to manage risk effectively, they need to know why incidents happen and what the contributing safety deficiencies may be. Moreover, routine monitoring of normal operations can help these operators both improve the efficiency of their operations and identify safety deficiencies before they result in an accident. In the event that an accident does occur, recordings from lightweight flight recording systems will provide useful information to enhance the identification of safety deficiencies in the investigation.

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<sup>15</sup> TSB Aviation Investigation Report A11W0048.

<sup>16</sup> *Ibid.*

The Board acknowledges that there are issues that will need to be resolved to facilitate the effective use of recordings from lightweight flight recording systems, including questions about the integration of this equipment in an aircraft, human resource management, and legal issues such as the restriction on the use of cockpit voice and video recordings. Nevertheless, given the potential of this technology combined with FDM [flight data monitoring] to significantly improve safety, the Board believes that no effort should be spared to overcome these obstacles.<sup>17</sup>

Consequently, the Board recommended that

the Department of Transport work with industry to remove obstacles and develop recommended practices for the implementation of flight data monitoring and the installation of lightweight flight recording systems for commercial operators not required to carry these systems.

**TSB Recommendation A13-01**

In January 2017, in its most recent response to Recommendation A13-01, TC stated, in part:

TC agrees that FDM would enhance airline safety in Canada. [...] In 2017, TC will conduct a focus group, including representatives from the industry, to evaluate the challenges and benefits associated with widespread installation of lightweight multi-function recording devices in small aircraft. TCCA will invite the TSB to appoint an observer to this focus group.

In March 2017, the TSB reassessed TC's response to Recommendation A13-01, stating the following:

TC's response indicates its renewed proposal to conduct a focus group in 2017, something which it has been planning to do since 2013. However, until the focus group reaches conclusions as to the challenges and benefits associated with the installation of lightweight multi-function recording devices in small aircraft, and TC provides the TSB with its plan of action moving forward following those conclusions, it is unclear when or how the safety deficiency identified in Recommendation A13-01 will be addressed. Therefore, the response to Recommendation A13-01 is assessed as **Unable to Assess**.

## 1.12 *Wreckage and impact information*

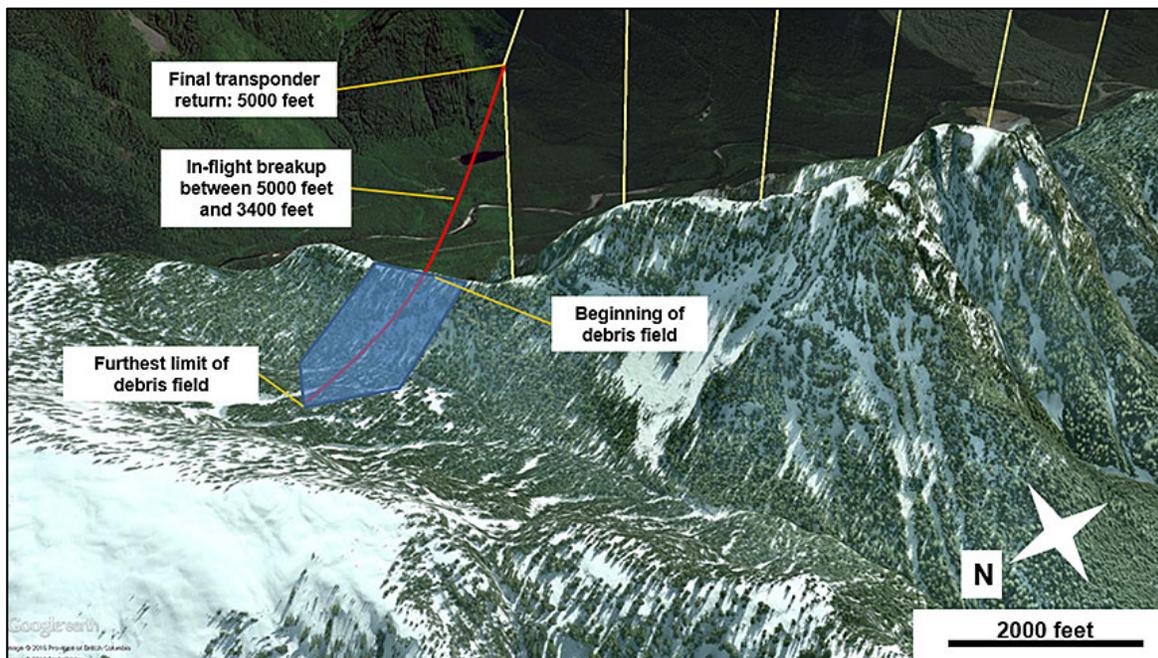
Aircraft debris was located and subsequently recovered from a debris field approximately 1400 feet long by 1000 feet wide (Figure 3). In the direction of flight, the first wreckage was located on a mountain ridgeline at an elevation of approximately 3400 feet ASL. From that point, wreckage continued down the slope to an approximate elevation of 2900 feet ASL. Lighter, less massive components were located at the beginning of the field, while heavier

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<sup>17</sup> Ibid.

components were found at the furthest distances. This pattern was consistent with estimated ballistic trajectories of falling debris from the aircraft's breakup point.

Figure 3. Wreckage debris field (blue-shaded area) (Source: Google Earth, with TSB annotations)



Approximately 98% of the aircraft and cargo contents were recovered from the accident site and transported to a Transportation Safety Board (TSB) facility. To the extent possible given the severity of the damage, examination of the wreckage revealed no evidence of component or system failure that may have contributed to the accident. All components of the aircraft showed damage consistent with aerodynamic overload resulting from the high speeds reached during the rapid descent.

Examination of the fuselage area immediately inboard of the propeller arcs of either engine showed symmetrical damage to its structure. This damage was consistent with high-energy cutting by the propeller blades as the wings folded upward.

Both engine propeller assemblies showed evidence of high-energy rotational damage and damage to the blades' leading edge, consistent with contact with the fuselage.

The section of fuselage bearing the cockpit area was approximately 80 feet west of the aft section of the main fuselage. It was extensively fragmented aft of the forward pressure bulkhead/instrument panel area, with separation of portions of windscreen, cabin roof, and side-wall and floor areas. Because of the significant damage that this part of the fuselage sustained, it was impossible to determine the position or settings of many systems controls, or functional aspects of the radios. Particular attention was given to the pitot-static system, but any assessment of its condition before the in-flight breakup or collision with terrain was precluded by the damage.

The investigation determined that, at the time of the crash, the horizontal stabilizer trim actuator was positioned to its maximum extension, resulting in a full aircraft nose-down trim setting.

It was determined that no mechanical failure or malfunction of the actuator had occurred before the breakup.

Metallurgical examination of the upper-attachment mounts of the actuator revealed evidence of stress corrosion cracking. It was determined that these fittings had reduced strength due to the cracking, which likely contributed to their failure during the aircraft's break-up sequence. However, there was no evidence that these mounts failed before the breakup of the aircraft or factored into the rapid descent.

### *1.13 Fire*

A portion of the aircraft's right wing that included the engine nacelle and fuel-tank area was recovered from a creek within a shallow rock ravine. This wreckage showed extensive damage from a fuel-fed fire that burned until ultimately extinguishing on its own after the accident. Physical examination of the wreckage determined that this fire ignited after the in-flight breakup and that there was no in-flight fire.

### *1.14 Survival aspects*

The accident was not survivable.

### *1.15 Tests and research*

#### *1.15.1 Pilot seating position and ergonomics*

The investigation determined that both pilots were wearing shoulder harnesses at the time of the accident. This would have effectively prevented either pilot from exerting a significant forward force on the control column if they had fallen on it while incapacitated or unconscious.

An examination of the pilot seating position and flight controls established that an individual of either pilot's size with subtle or complete incapacitation, while wearing a shoulder harness, could have exerted a force of about 20 to 30 pounds forward pressure on the flight controls. The other pilot would have been capable of overcoming this force on his own set of controls.

#### *1.15.2 TSB laboratory reports*

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

- LP096/2015 – Vertical Stabilizer Beacon Light Bulb Analysis
- LP125/2015 – Examination of Actuator

- LP087/2015 – NVM Recovery – GPS and PED’S [Non-volatile memory recovery – global positioning system and personal electronic devices]
- LP113/2015 – Radar Flight Path Analysis
- LP109/2015 – Structure Analysis

## 1.16 *Medical and pathological information*

Post-mortem examinations and toxicological screening were conducted on both pilots.

### 1.16.1 *First officer’s pathological information*

The first officer’s most recent aviation medical examination had been completed on 27 February 2015. The TSB examination of Transport Canada (TC) aviation medical records and post-mortem and toxicological examination of the first officer revealed no abnormal findings. The investigation concluded that there were no physiological factors affecting his ability to fly on the day of the accident.

### 1.16.2 *Captain’s pathological information*

The captain was 34 years old at the time of the accident. His most recent aviation medical examination had been completed on 27 June 2014. The captain’s TC aviation medical records did not reveal any indication of a medical condition or history that might have played a role in the accident.

Post-mortem toxicological screening revealed the presence of ethyl alcohol in the captain’s system. Femoral blood was found to contain 52 mmol/L (0.24% blood alcohol content [BAC]). Urine was found to contain 54 mmol/L (0.25%), and vitreous humour contained 59 mmol/L (0.27%). These concentrations established that the captain had likely consumed alcohol over a period of several hours, until shortly before the flight’s departure. An autopsy identified focal severe coronary artery atherosclerosis<sup>18</sup> and both steatosis and hepatitis<sup>19</sup> in the captain’s liver. Finding these conditions in a 34-year-old person suggests excessive alcohol consumption over a significant period.

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<sup>18</sup> Atherosclerosis is the narrowing of the arteries by deposits (plaques) made up primarily of cholesterol. As a result of this narrowing, the flow of blood and oxygen through arteries may not provide tissues with enough blood for proper function. There is also a risk that a plaque will break off into circulation and occlude an artery completely, causing a heart attack or stroke; however, the autopsy found no evidence of an acute cardiac event.

<sup>19</sup> Steatosis or “fatty liver” is an abnormal condition of high fat concentration within the liver. Hepatitis is an inflamed condition of the liver. Both can be associated with the consumption of a large amount of alcohol over a prolonged period of time. A threshold daily alcohol intake of 40 g (approximately 3 standard drinks) is necessary to cause alcoholic hepatitis. Consumption of more than 80 g (approximately 6 standard drinks) per day is associated with an increase in the severity of alcoholic hepatitis, but not in the overall prevalence.

A number of company employees had suspicions, and some had voiced concerns with colleagues, that the captain had a drinking problem. On at least one occasion, a company employee told a Carson Air supervisor that he had smelled alcohol on the captain's breath; however, the supervisor did not detect an alcohol odour, so the issue was not pursued further. Instead, a decision was made to monitor the situation.

### 1.16.3 *Effects of alcohol on human performance*

Ethyl alcohol impairs human performance, having negative effects on virtually all types of cognitive function and psychomotor abilities. Alcohol also affects risk-taking behaviour, in that it promotes taking actions on impulse, without a full appreciation of, or concern about, the potential negative consequences of such actions.<sup>20</sup> The effects of alcohol on risk-taking behaviour are of particular concern when alcohol is used by pilots.<sup>21</sup>

### 1.16.4 *Performance effects of 0.24% blood alcohol content*

The following table lists the typical effects of increasing BAC levels on behaviour and performance.<sup>22</sup> Note that the effects can vary significantly as a result of differences in tolerance.

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<sup>20</sup> C. M. Steele and R. A. Josephs, "Alcohol myopia: Its prized and dangerous effects," *American Journal of Psychology*, Vol. 45, Issue 8 (1990), pp. 921-933.

<sup>21</sup> J. G. Modell and J. M. Mountz, "Drinking and flying – The problem of alcohol use by pilots," *New England Journal of Medicine*, Vol. 323, Issue 7 (1990), pp. 455-461.

<sup>22</sup> G. J. Salazar and M. J. Antunano, AM-400 – 94-2, *Alcohol and Flying: A Deadly Combination* (Oklahoma City, OK: Federal Aviation Administration, 1994), at <https://www.faa.gov/pilots/safety/pilotsafetybrochures/media/alcohol.pdf> (last accessed on 23 August 2017).

Table 4. Scale of impairment due to alcohol use

BAC (%)*	Typical effects on behaviour and performance
0.01–0.05	Average individual appears normal
0.03–0.12	Mild euphoria, talkativeness, decreased inhibitions, decreased attention, impaired judgment, and increased reaction time
0.09–0.25	Emotional instability, loss of critical judgment, impairment of memory and comprehension, decreased sensory response, and mild muscular incoordination
0.18–0.30	Confusion, dizziness, exaggerated emotions (anger, fear, grief), impaired visual perception, decreased pain sensation, impaired balance, staggering gait, slurred speech, and moderate muscular incoordination
0.27–0.40	Apathy, impaired consciousness, stupor, significantly decreased response to stimulation, severe muscular incoordination, inability to stand or walk, vomiting, and incontinence of urine and feces
0.35–0.50	Unconsciousness, depressed or abolished reflexes, abnormal body temperature, and coma; possible death from respiratory paralysis (at a BAC of 0.45% or higher)

Source: Federal Aviation Administration, FAA-H-8083-25A, Pilot's Handbook of Aeronautical Knowledge (2014).

\* BAC percentage is determined from grams of alcohol per decilitre of blood.

BAC calculators<sup>23</sup> indicate that, to attain a BAC of 0.24%, an average male with a weight similar to the captain's would have to consume approximately 17 to 20 standard drinks over a 12-hour period. If consumption had taken place over a 4-hour period immediately before reporting for work, a BAC of 0.24% would have required approximately 14 standard drinks.

#### 1.16.5 Tolerance to the effects of alcohol

Physical dependence on alcohol involves tolerance to alcohol's effects, and withdrawal symptoms when drinking is stopped.<sup>24</sup> Three types of tolerance to alcohol can develop: functional, acute, and metabolic tolerance. Functional tolerance to alcohol's effects on brain function, behaviour, and performance leads to consumption of increasing amounts of alcohol on future occasions. Chronic heavy drinkers often display functional tolerance, showing few obvious signs of intoxication, even at a very high BAC that, in others, would be incapacitating or even fatal (e.g., more than 0.35% BAC).<sup>25</sup> For example, research on people with alcohol dependence who voluntarily entered a detoxification centre for treatment

<sup>23</sup> Examples of blood alcohol calculators include Blood Alcohol Calculator (at <http://bloodalcoholcalculator.org/>) and the Cleveland Clinic blood alcohol calculator (at [http://my.clevelandclinic.org/health/tools-quizzes/Blood\\_Alcohol\\_Calculator](http://my.clevelandclinic.org/health/tools-quizzes/Blood_Alcohol_Calculator)) (last accessed on 23 August 2017).

<sup>24</sup> Centre for Addiction and Mental Health (CAMH), "Alcohol," at [http://www.camh.ca/en/hospital/health\\_information/a\\_z\\_mental\\_health\\_and\\_addiction\\_information/alcohol/Pages/alcohol.aspx](http://www.camh.ca/en/hospital/health_information/a_z_mental_health_and_addiction_information/alcohol/Pages/alcohol.aspx) (2012) (last accessed on 17 October 2017).

<sup>25</sup> G. Chesher and J. Greeley, "Tolerance to the effects of alcohol," *Alcohol, Drugs and Driving*, Vol. 8, Issue 2 (1992), pp. 93–106.

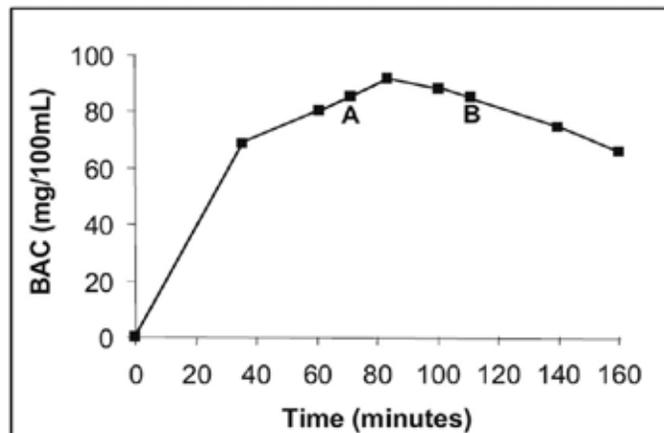
showed that many had normal speech and gait, as well as an unimpaired ability to undress, even with BACs of 0.35% and greater.<sup>26</sup>

Acute tolerance to some of alcohol's effects can develop within a single drinking session. This effect is related to the pharmacokinetics<sup>27</sup> of alcohol in the body and what is called the "BAC curve." Alcohol-induced impairment is greater when BAC is measured soon after beginning alcohol consumption than when it is measured later in the drinking session, even if the BAC is the same at both times<sup>28</sup> (Figure 4). The intoxicating effect of the same BAC is considerably less when it lies on the descending slope of the curve (point B) than on the ascending slope (point A).

Although individuals develop acute tolerance to the feeling of intoxication experienced after alcohol consumption, they do not develop acute tolerance to all effects of alcohol.<sup>29</sup> This may prompt the drinker to consume more alcohol, which in turn can impair performance or bodily functions, as the individual does not develop acute tolerance to these effects.

Metabolic tolerance is an increased rate of blood alcohol clearance, or more rapid elimination of alcohol from the body, that develops over time with chronic drinking; it results in a lower BAC for the same amount of alcohol ingested.

Figure 4. Example of a BAC curve, where points A and B have the same BAC, but are on the ascending and descending slopes of the curve, respectively (Source: T. A. Schweizer and M. Vogel-Sprott, "Alcohol-impaired speed and accuracy of cognitive functions: A review of acute tolerance and recovery of cognitive performance," *Experimental and Clinical Psychopharmacology*, Vol. 16, Issue 3 [2008])



Tolerance to all of alcohol's effects on performance does not develop simultaneously, or at the same rate. For instance, research has found that, whereas social drinkers showed

<sup>26</sup> J. A. Perper, A. Twerski, and J. W. Wienand, "Tolerance at high blood alcohol concentrations: A study of 110 cases and review of the literature," *Journal of Forensic Sciences*, Vol. 31, Issue 1 (1986), pp. 212-221.

<sup>27</sup> Pharmacokinetics are the mechanisms of bodily absorption, distribution, metabolism, and excretion of a drug or substance.

<sup>28</sup> T. A. Schweizer and M. Vogel-Sprott, "Alcohol-impaired speed and accuracy of cognitive functions: A review of acute tolerance and recovery of cognitive performance," *Experimental and Clinical Psychopharmacology*, Vol. 16, Issue 3 (2008), pp. 240-250.

<sup>29</sup> M. D. Vogel-Sprott, "Acute recovery and tolerance to low doses of alcohol: Differences in cognitive and motor skill performance," *Psychopharmacology*, Vol. 61, Issue 3 (1979), pp. 287-291.

behavioural signs of intoxication at a BAC of 0.10%, those with alcohol dependence showed virtually none, although both groups were equally impaired on measures of cognitive performance involving the recall of lists of numbers and words.<sup>30</sup>

Because of the effects of tolerance, the level of behavioural (observed) intoxication of an individual cannot be directly inferred from a measured BAC. Those who are tolerant to the effects of alcohol show fewer signs of impairment and intoxication at a high BAC than others who are not tolerant. On the morning of the occurrence, the captain was observed speaking with other company pilots, using a computer, walking, and loading cargo. No abnormal behaviour was observed.

#### 1.16.5.1 *Withdrawal symptoms*

As people develop tolerance to the effects of alcohol, they will need more and more to produce the desired effect. People who are physically dependent on alcohol will develop withdrawal symptoms, such as sleeplessness, tremors, nausea and seizures, within a few hours after their last drink. These symptoms can last from 2 to 7 days and range from mild to severe, depending on the amount of alcohol consumed and the period of time over which it was used.<sup>31</sup>

The captain was occasionally observed to be shaking while he was flying. Some pilots believed that this was related to being nervous, since it seemed to be worse during training and proficiency-check flights.

#### 1.16.6 *Effects of alcohol on a pilot's flying performance*

Alcohol impairs almost all forms of cognitive functioning, including attention, information processing, decision making, and reasoning. The performance of any complex or demanding cognitive task, including flying an aircraft, is consequently impaired by alcohol because of these effects.<sup>32</sup> Because alcohol impairs new-information processing, problem solving, and abstract thinking, performance suffers most when an unexpected or unanticipated event

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<sup>30</sup> L. J. Rosen and C. L. Lee, "Acute and chronic effects of alcohol use on organizational processes in memory," *Journal of Abnormal Psychology*, Vol. 85, Issue 3 (1976), pp. 309–317.

<sup>31</sup> Centre for Addiction and Mental Health (CAMH), "Alcohol," at [http://www.camh.ca/en/hospital/health\\_information/a\\_z\\_mental\\_health\\_and\\_addiction\\_information/alcohol/Pages/alcohol.aspx](http://www.camh.ca/en/hospital/health_information/a_z_mental_health_and_addiction_information/alcohol/Pages/alcohol.aspx) (2012) (last accessed on 17 October 2017).

<sup>32</sup> D. G. Newman, *Alcohol and human performance from an aviation perspective: A review* (Canberra, Australia: Australian Transport Safety Bureau, March 2004), at [http://www.atSB.com.au/media/36525/Alcohol\\_and\\_human\\_performance.pdf](http://www.atSB.com.au/media/36525/Alcohol_and_human_performance.pdf) (last accessed on 23 August 2017).

occurs.<sup>33</sup> At a very high BAC, alcohol can impair a pilot's performance by leading to incapacitation.<sup>34</sup>

Visual and vestibular functions are adversely affected by alcohol; as a result, ingestion of alcohol can contribute to spatial disorientation in pilots. Alcohol-related impairment of vestibular function can decrease a pilot's perception of aircraft attitude, and impair visual tracking and visual fixation. This can lead to reduced ability to control the aircraft, see the instruments, maintain situational awareness, and avoid collisions.<sup>35</sup>

By changing the specific gravity of the fluid within the human vestibular system, alcohol produces exaggerated vestibular stimulation during movement.<sup>36</sup> Nystagmus – i.e., involuntary, oscillatory eye movements due to stimulation of the vestibular system – can usually be suppressed by the viewer visually fixating on a target. However, alcohol significantly – and proportionately with the BAC – interferes with the ability to suppress nystagmus, especially during dynamic tracking tasks, leading to blurring of vision, poor tracking performance, and increased potential for spatial disorientation.<sup>37</sup>

Alcohol reduces the speed and latency of eye movements<sup>38</sup> and increases the time required for the eyes to accommodate changes in focus.<sup>39</sup> Positional alcohol nystagmus – repetitive, uncontrolled eye movements – can occur even in the absence of a turn or other angular acceleration, reducing visual acuity and causing problems with depth perception.<sup>40</sup>

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<sup>33</sup> Ibid.

<sup>34</sup> A. Martin-Saint-Laurent, J. Lavernhe, G. Casano, and A. Simkoff, "Clinical aspects of inflight incapacitation in commercial aviation," *Aviation, Space, and Environmental Medicine*, Vol. 61, Issue 3 (1990), pp. 256–260.

<sup>35</sup> D. G. Newman, *Alcohol and human performance from an aviation perspective: A review* (Canberra, Australia: Australian Transport Safety Bureau, March 2004), at [http://www.atsb.com.au/media/36525/Alcohol\\_and\\_human\\_performance.pdf](http://www.atsb.com.au/media/36525/Alcohol_and_human_performance.pdf) (last accessed on 23 August 2017).

<sup>36</sup> Ibid.

<sup>37</sup> R. D. Gilson, D. J. Schroeder, W. E. Collins, and F. E. Guedry, "Effects of different alcohol dosages and display illumination on tracking performance during vestibular stimulation," *Aerospace Medicine*, Vol. 43, Issue 6 (1972), pp. 656–660.

<sup>38</sup> Z. Katoh, "Slowing effects of alcohol on voluntary eye movements," *Aviation, Space, and Environmental Medicine*, Vol. 59, Issue 7 (1988), pp. 606–610.

<sup>39</sup> J. Levett and L. Karras, "Effects of alcohol on human accommodation," *Aviation, Space and Environmental Medicine*, Vol. 48 (1977), pp. 434–437.

<sup>40</sup> American Optometric Association, "Nystagmus," at <http://www.aoa.org/patients-and-public/eye-and-vision-problems/glossary-of-eye-and-vision-conditions/nystagmus?sso=y> (last accessed on 23 August 2017).

Alcohol interferes with normal sleep patterns by reducing the percentage of rapid eye movement (REM) sleep obtained, reducing total sleep time, and increasing the number of awakenings,<sup>41</sup> all of which can increase the risk of fatigue.

#### 1.16.7 *Effects of alcohol on suicidal behaviour*

There is a significant relationship between alcohol use and suicidal behaviour. Both the acute effects of alcohol intoxication and the corollary effects of alcohol dependence increase the risk of suicide.<sup>42</sup> Although the risk of suicide affects people who do not have an alcohol dependence, those who are alcohol-dependent are at a higher risk due to their increased exposure to alcohol and its effects. People with alcohol use disorder<sup>43</sup> are at a 60 to 120 times greater risk of suicide than members of the population without a psychiatric illness.<sup>44</sup> Suicide accounts for 20% to 33% of the increased death rate among those with alcohol dependence compared with the general population.<sup>45</sup> Similarly, high rates of a positive BAC have been found among those who attempt suicide (46% to 77%) and those who complete suicide (33% to 59%).<sup>46</sup>

People with alcohol dependence are at greatest risk of suicide during periods of active drinking.<sup>47</sup> The increased suicide risk is often characterized by social withdrawal, breakdown of social bonds, and social marginalization, which are common outcomes of untreated alcohol abuse and dependence.<sup>48</sup>

The captain, who lived alone and did not routinely socialize with co-workers, mostly kept to himself. His co-workers and family were not aware of how he spent his time outside work.

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<sup>41</sup> S. Chokroverty, *Sleep Disorders Medicine: Basic Sleep, Technical Considerations, and Clinical Aspects* (Boston, MA: Butterworth-Heinemann, 1999).

<sup>42</sup> M. R. Hufford, "Alcohol and suicidal behavior," *Clinical Psychology Review*, Vol. 21, Issue 5 (2001), pp. 797–811.

<sup>43</sup> The U.S. National Institute on Alcohol Abuse and Alcoholism defines alcohol use disorder as a chronic, relapsing brain disease characterized by compulsive alcohol use, loss of control over alcohol intake, and a negative emotional state when not using (Source: National Institute on Alcohol Abuse and Alcoholism, "Alcohol Use Disorder," at <https://www.niaaa.nih.gov/alcohol-health/overview-alcohol-consumption/alcohol-use-disorders> [last accessed 26 September 2017]).

<sup>44</sup> G. E. Murphy and R. D. Wetzel, "The lifetime risk of suicide in alcoholism," *Archives of General Psychiatry*, Vol. 47 (1990), pp. 383–392.

<sup>45</sup> M. Berglund and A. Öjehagen, "The influence of alcohol drinking and alcohol use disorders on psychiatric disorders and suicidal behavior," *Alcoholism: Clinical and Experimental Research*, Vol. 22 (1998), pp. 333S–345S.

<sup>46</sup> M. R. Hufford, "Alcohol and suicidal behavior," *Clinical Psychology Review*, Vol. 21, Issue 5 (2001), pp. 797–811.

<sup>47</sup> *Ibid.*

<sup>48</sup> M. Pompili et al., "Suicidal behavior and alcohol use," *International Journal of Environmental Research and Public Health*, Vol. 7 (2010), pp. 1392–1431.

On the few occasions when the captain did join his co-workers to socialize, he was not observed drinking alcohol excessively.

Suicidal (and homicidal) behaviour in pilots flying commercial aircraft has been documented previously in aviation investigations.<sup>49</sup> A phenomenon of similar “copycat” acts has also been documented, with the number of fatal airplane crashes increasing in the weeks following significant media coverage of murder or suicide events.<sup>50</sup> On 24 March 2015, 20 days before this accident, a first officer who had been having symptoms of depression and psychosis deliberately flew a Germanwings Airbus A320 into terrain, killing all on board.

### 1.17 Transport Canada regulatory medical standards and oversight

Both the *Criminal Code of Canada*<sup>51</sup> and the *Canadian Aviation Regulations* (CARs) section 602.03 prohibit operation of an aircraft while impaired by alcohol. CARs section 602.03 states, in part:

No person shall act as a crew member of an aircraft

- (a) within eight hours after consuming an alcoholic beverage;
- (b) while under the influence of alcohol [...].<sup>52</sup>

Further to this, to ensure medical fitness of aircrew members, the Civil Aviation Medicine (CAM) branch of TC has a defined mandate, which is, in part, “to provide medical advice and assistance in setting out physical standards for Civil Aviation personnel [...]”.<sup>53</sup> The Branch’s mission is

to ensure aircrew and air traffic controllers are medically fit, to close gaps in scientific knowledge of Canadian aviation medicine, to promote health and

<sup>49</sup> T. Anthony, “Human factors in extremis: the rogue pilot phenomenon,” in: *Proceedings of the 2015 International Society of Air Safety Investigators (ISASI) Annual Seminar*, Augsburg, Germany, 24–27 August 2015, at <http://www.isasi.org/Documents/library/technical-papers/2015/Human%20Factors%20in%20Extremis%2006.26.2015.pdf> (last accessed on 23 August 2017).

<sup>50</sup> D. P. Phillips, “Airplane accident fatalities increase just after newspaper stories about murder and suicide,” *Science*, Vol. 201, Issue 4357 (1978), pp. 748–750.

<sup>51</sup> Subsection 253(1) of the *Criminal Code of Canada* provides that it is an offence for a pilot to operate an aircraft, assist in its operation, or have the care or control over it, if (1) the pilot’s ability to operate the aircraft is impaired by alcohol, or (2) if the alcohol concentration in the pilot’s blood exceeds 80 mg of alcohol in 100 mL of blood. While both are distinct offences that may arise together, the mere impairment of a pilot’s ability to fly an aircraft due to alcohol triggers an offence under subsection 253(1) of the *Criminal Code of Canada*.

<sup>52</sup> *Canadian Aviation Regulations* (CARs), section 602.03: Alcohol or Drugs – Crew Members.

<sup>53</sup> Transport Canada, Civil Aviation Medicine Branch, TP 13312, *Handbook for Civil Aviation Medical Examiners*, March 2004, at <https://www.tc.gc.ca/eng/civilaviation/publications/tp13312-2-menu-2331.htm> (last accessed on 23 August 2017).

safety in the field of aviation and to prevent aircraft accidents due to medically related human factors.<sup>54</sup>

To accomplish these goals, TC has published Standard 424 of the CARs, which establishes the medical standards for Civil Aviation Document holders, including pilots. In support of this standard, CAM has published the *Handbook for Civil Aviation Medical Examiners*,<sup>55</sup> which provides guidance to civil aviation medical examiners,<sup>56</sup> who are authorized by the Minister of Transport to carry out pilot medical examinations. The document is publicly available on TC's website.

The handbook includes general guidance for assessing pilot fitness in regard to neurology, cardiovascular fitness, diabetes, and asthma. It does not include specific information or guidance relating to cases in which drug or alcohol abuse is identified or suspected, but it does provide the following general statements as guidance for medical examiners relating to a candidate's mental health and drug and alcohol issues:

It is your responsibility to interview and perform a complete examination on all applicants for aviation medical certification. You may be the only physician in the normal course of events who has talked to the pilot and had a "hands-on" opportunity to form an impression [...].<sup>57</sup>

The handbook also states that

[a]viation personnel, although not basically dishonest, may not volunteer information which may affect their medical certification. They will, however, respond to direct questions and will sometimes give you much more information than you expect if you convince them that your prime interest is keeping them at work. Sometimes they have problems that may affect their medical certification that they would like to discuss with someone of good will. Of particular importance in the interview is any suggestion of substance abuse, mental instability, lack of insight or inappropriate reactions. You have the opportunity to decide whether this is the type of person with whom you would fly or to whom you would entrust your family.<sup>58</sup>

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<sup>54</sup> Ibid.

<sup>55</sup> Ibid.

<sup>56</sup> A civil aviation medical examiner is a medical doctor who has been delegated as an agent of the Minister of Transport and who conducts medical examinations to recommend either for or against medical certification of a pilot candidate to the Transport Canada regional aviation medical officer.

<sup>57</sup> Transport Canada, Civil Aviation Medicine Branch, TP 13312, *Handbook for Civil Aviation Medical Examiners*, March 2004, at <https://www.tc.gc.ca/eng/civilaviation/publications/tp13312-2-menu-2331.htm> (last accessed on 23 August 2017).

<sup>58</sup> Ibid.

When these issues are encountered, CAM instructs civil aviation medical examiners to refer the matter to the regional aviation medical officer (RAMO) for individual evaluation on a case-by-case basis. In identified cases, the RAMO monitors treatment. When CAM and the RAMO believe that successful treatment of these issues has been confirmed, CAM may reissue a pilot or air traffic controller's medical certificate. There is no written or published TC policy relating to this evaluation process.

### 1.18 *Efforts to limit drug and alcohol impairment in aviation*

In a recent report on alcohol consumption in Canada, the Chief Public Health Officer of Canada revealed that, in 2013, "an estimated 22 million Canadians, almost 80 percent of the population, drank alcohol in the previous year," adding that "[a]t least 3.1 million of those drank enough to be at risk for immediate injury and harm."<sup>59</sup> A Statistics Canada portrait of national substance abuse rates, from results of the 2012 Canadian Community Health Survey, reports that

[a]pproximately 21.6% of Canadians (about 6 million people) met the criteria for a substance use disorder during their lifetime [...]. Alcohol was the most common substance for which people met the criteria for abuse or dependence at 18.1%.<sup>60</sup>

Aviation personnel are as susceptible to drug and alcohol use as the rest of the general population.<sup>61</sup> An Australian-based review exploring the introduction of drug and alcohol testing in the aviation industry states that

[i]t has been estimated that alcohol abuse and dependence affects approximately 5%-8% of all pilots, similar to the proportions in other professional occupations such as law and medicine. Maintenance personnel, cabin crew and management are similarly affected.<sup>62</sup>

<sup>59</sup> G. Taylor, Government of Canada, *The Chief Public Health Officer's Report on the State of Public Health in Canada 2015: Alcohol Consumption in Canada* (January 2016), at <https://www.canada.ca/en/public-health/services/publications/chief-public-health-officer-reports-state-public-health-canada/2015-alcohol-consumption-canada.html> (last accessed on 22 September 2017).

<sup>60</sup> C. Pearson, T. Janz, and J. Ali, Statistics Canada, "Mental and substance use disorders in Canada," *Health at a Glance* (catalogue No. 82-624-X, September 2013), at <http://www.statcan.gc.ca/pub/82-624-x/2013001/article/11855-eng.htm> (last accessed on 22 September 2017).

<sup>61</sup> Australian Department of Transport and Regional Services and Civil Aviation Safety Authority, *Review into Safety Benefits of Introducing Drug and Alcohol Testing for Safety Sensitive Personnel in the Aviation Sector* (January 2006), at [http://www.infrastructure.gov.au/aviation/safety/pdf/Final\\_Report\\_Drug\\_Alcohol\\_Testing.pdf](http://www.infrastructure.gov.au/aviation/safety/pdf/Final_Report_Drug_Alcohol_Testing.pdf) (last accessed on 28 August 2017), pp. 4-5.

<sup>62</sup> Q. Snyder and W. Shaw, "Chemical Free Aviation Workplaces," Flight Safety Foundation/National Business Aviation Association Inc. Corporate Aviation Safety Seminar (April 2004), in: Australian Department of Transport and Regional Services and the Australian Civil Aviation Safety Authority, *Review into Safety Benefits of Introducing Drug and Alcohol Testing*

Previous TSB aviation investigations<sup>63</sup> have identified drug and alcohol use by flight crew as causal or contributing factors in aviation accidents. Recent high-profile incidents<sup>64,65</sup> have also demonstrated problematic alcohol use among some Canadian aviation personnel. The risks associated with substance misuse by pilots have been highlighted in several recent reports.<sup>66,67,68</sup>

The potential consequences of crew impairment can be severe. However, the effects of drug and alcohol use in individual employees may be difficult to identify. Further, employees in the aviation sector may feel pressured to fulfill their duties when intoxicated, given that it can be difficult to replace flight crew who are unfit for duty on short notice.<sup>69</sup>

For these reasons, risk-mitigation measures, including drug and alcohol testing and other measures, have been put in place in other aviation communities internationally and in other industries. The International Civil Aviation Organization defines safety-sensitive employees as those “who might endanger aviation safety if they perform their duties and functions improperly.”<sup>70</sup> Drug and alcohol testing offers a means of identifying, managing, and preventing substance abuse among safety-sensitive employees in aviation. In addition to its

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*for Safety Sensitive Personnel in the Aviation Sector* (January 2006), at [http://www.infrastructure.gov.au/aviation/safety/pdf/Final\\_Report\\_Drug\\_Alcohol\\_Testing.pdf](http://www.infrastructure.gov.au/aviation/safety/pdf/Final_Report_Drug_Alcohol_Testing.pdf) (last accessed on 23 August 2017).

<sup>63</sup> TSB aviation investigation reports A09Q0003, A11W0151, and A13W0009.

<sup>64</sup> L. MacDougal, “Calgary police charge pilot allegedly impaired, passed out in cockpit,” *The Globe and Mail* (31 December 2016), at <http://www.theglobeandmail.com/news/national/calgary-police-charge-pilot-allegedly-impaired-passed-out-in-cockpit/article33464543/> (last accessed on 28 August 2017).

<sup>65</sup> A. Ballingall, “Air Transat pilots jailed in Scotland on drinking charges,” *The Toronto Star* (19 July 2016), at <https://www.thestar.com/news/canada/2016/07/19/air-transat-pilots-arrested-for-suspected-drinking-before-flying-to-toronto.html> (last accessed on 28 August 2017).

<sup>66</sup> Office of the State Coroner (Queensland, Australia), *Finding of Inquest: Inquest into the Hamilton Island aircraft crash* (07 September 2006), at [http://www.courts.qld.gov.au/\\_\\_data/assets/pdf\\_file/0006/86640/cif-hamilton-isl-bowles-m-j-s-k-morris-a-legallo-ca-20060907.pdf](http://www.courts.qld.gov.au/__data/assets/pdf_file/0006/86640/cif-hamilton-isl-bowles-m-j-s-k-morris-a-legallo-ca-20060907.pdf) (last accessed 28 August 2017).

<sup>67</sup> G. Li, S. P. Baker, Q. Zhao, et al., “Drug violations and aviation accidents: Findings from the U.S. mandatory drug testing programs,” *Addiction* (July 2011), pp. 1287–1292.

<sup>68</sup> D.G. Newman, *Accidents and Incidents Involving Alcohol and Drugs in Australian Civil Aviation: 1 January 1975 to 31 March 2006* (30 June 2006), at [http://www.atsb.gov.au/publications/2006/b20060169\\_001.aspx](http://www.atsb.gov.au/publications/2006/b20060169_001.aspx) (last accessed 28 August 2017).

<sup>69</sup> Australian Department of Transport and Regional Services and Civil Aviation Safety Authority, *Review into Safety Benefits of Introducing Drug and Alcohol Testing for Safety-Sensitive Personnel in the Aviation Sector* (January 2006), at [http://www.infrastructure.gov.au/aviation/safety/pdf/Final\\_Report\\_Drug\\_Alcohol\\_Testing.pdf](http://www.infrastructure.gov.au/aviation/safety/pdf/Final_Report_Drug_Alcohol_Testing.pdf) (last accessed on 28 August 2017).

<sup>70</sup> International Civil Aviation Organization, Doc 9654-AN/945, *Manual on Prevention of Problematic Use of Substances in the Aviation Workplace*, 1st Edition, (1995), Definitions, p. vi.

use in detecting substance use, such testing can serve as a tool – together with self-referral – to address problematic use in individuals and to apply deterrents, including, when warranted, exclusion from safety-sensitive functions.

Given the significant safety-related risks associated with drug and alcohol use, random testing of drivers and other vehicle operators has been implemented in a number of jurisdictions worldwide. Random breath testing of drivers for alcohol intoxication, for example, was first introduced in Australia in the late 1970s and has shown success in reducing drunk driving and improving safety.<sup>71</sup> Stricter federal and provincial impaired-driving legislation in Canada, including increased roadside breathalyzer testing, has led to fewer deaths due to impaired driving.<sup>72</sup> For example, the percentage of fatally injured drivers on Canadian roads who had a BAC above the legal limit (0.08%) decreased from about 43% in 1987 to 28% in 2012.<sup>73</sup>

An advantage of random testing lies in its proactive, deterrent effect. However, research and experience internationally<sup>74</sup> suggest that a flexible mix of testing types is most appropriate. Drug and alcohol testing may be conducted

- pre-employment;
- for reasonable cause;
- post-incident or post-accident;
- periodically;
- post-treatment, in follow-up; or
- at random.

While it can be an effective deterrent,<sup>75,76</sup> drug and alcohol testing is only one aspect of a comprehensive response to inappropriate drug and alcohol use in aviation. Testing

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<sup>71</sup> M. Cameron, K. Diamantopoulou, N. Mullan, D. Dyte, and S. Gantzer, Report No. 126, *Evaluation of the Country Random Breath Testing and Publicity Program in Victoria, 1993–1994* (Melbourne, Australia: Monash University Accident Research Centre, 1997) at <http://www.monash.edu.au/miri/research/reports/muarc126.html> (last accessed on 23 August 2017)

<sup>72</sup> R. Solomon, E. Chamberlain, M. Abdoullaeva, and B. Tinholt, “Random breath testing: A Canadian perspective,” *Traffic Injury Prevention*, Vol. 12 (2011), pp. 111–119.

<sup>73</sup> S. W. Brown, W. G. M. Vanlaar, and R. D. Robertson, *Alcohol and Drug-Crash Problem in Canada: 2012 Report*. CCMTA Road Safety Research Report Series. (Ottawa, ON: Traffic Injury Research Foundation of Canada for the Canadian Council of Motor Transport Administrators, 2015), at <http://tirf.ca/TIRFCAD16G> (last accessed 22 September 2017).

<sup>74</sup> Australian Department of Transport and Regional Services and Civil Aviation Safety Authority, *Review into Safety Benefits of Introducing Drug and Alcohol Testing for Safety-Sensitive Personnel in the Aviation Sector* (January 2006), at [http://www.infrastructure.gov.au/aviation/safety/pdf/Final\\_Report\\_Drug\\_Alcohol\\_Testing.pdf](http://www.infrastructure.gov.au/aviation/safety/pdf/Final_Report_Drug_Alcohol_Testing.pdf) (last accessed on 28 August 2017).

<sup>75</sup> *Ibid.*

programs are most effective when they are complemented by other initiatives, such as education, employee assistance programs, rehabilitation and return-to-duty programs, and peer support.<sup>77</sup>

### 1.18.1 United States

The U.S. Department of Transportation Rule 49, *Code of Federal Regulations* (CFR) Part 40, outlines required procedures for conducting workplace drug and alcohol testing in federally regulated transportation industries, including aviation. The Office of Drug and Alcohol Policy and Compliance advises Department of Transport agencies, including the Federal Aviation Administration (FAA), on drug-enforcement and drug-testing issues, including how to conduct testing and how to return employees to safety-sensitive duties after they violate a drug and alcohol regulation. Each agency-specific regulation describes who is subject to testing, when, and in what situation(s). The U.S. Department of Health and Human Services certifies laboratories and determines both testing procedures and the drugs to be tested. The Drug Abatement Division of the FAA oversees the U.S. aviation industry's compliance with the law and regulations governing drug and alcohol testing.

Drug- and alcohol-testing regulations for employers and employees in the aviation industry are set out in 14 CFR Part 120: Drug and Alcohol Testing Program. Its requirements apply to "safety-sensitive aviation employees," defined as follows:

Each employee, including any assistant, helper, or individual in a training status, who performs a safety-sensitive function listed in this section directly or by contract (including by subcontract at any tier) for an employer as defined in this subpart must be subject to drug testing under a drug testing program implemented in accordance with this subpart. This includes full-time, part-time, temporary, and intermittent employees regardless of the degree of supervision. The safety-sensitive functions are:

- (a) Flight crewmember duties.
- (b) Flight attendant duties.
- (c) Flight instruction duties.
- (d) Aircraft dispatcher duties.
- (e) Aircraft maintenance and preventive maintenance duties.

<sup>76</sup> C. M. Rudin-Brown, E. Mitsopoulos-Rubens, and M. Lenné, "Perceived effectiveness of random testing for alcohol and drugs in the Australian aviation community," *Aviation Psychology and Applied Human Factors*, Vol. 2, Issue 2 (2012), pp. 72–81.

<sup>77</sup> Australian Department of Transport and Regional Services and Civil Aviation Safety Authority, *Review into Safety Benefits of Introducing Drug and Alcohol Testing for Safety-Sensitive Personnel in the Aviation Sector* (January 2006), at [http://www.infrastructure.gov.au/aviation/safety/pdf/Final\\_Report\\_Drug\\_Alcohol\\_Testing.pdf](http://www.infrastructure.gov.au/aviation/safety/pdf/Final_Report_Drug_Alcohol_Testing.pdf) (last accessed on 28 August 2017).

- (f) Ground security coordinator duties.
- (g) Aviation screening duties.
- (h) Air traffic control duties.
- (i) Operations control specialist duties.<sup>78</sup>

### 1.18.2 Australia

In 2004, in response to a number of aviation occurrences in which drugs and/or alcohol were found to be contributing factors, the Australian Civil Aviation Safety Authority and the Department of Transport and Regional Services jointly reviewed and established the safety benefits of a drug- and alcohol-testing program for safety-sensitive personnel in the aviation industry. In 2006, the Australian Commonwealth announced the introduction of Part 99 of the *Civil Aviation Safety Regulations 1998*, an initiative aimed at managing the risks associated with reduced performance in aviation personnel following use of drugs or alcohol. The regulation was fully implemented in April 2009.<sup>79</sup> It applies to all safety-sensitive aviation activities (Appendix A) and includes education, intervention, and random-testing requirements.

### 1.18.3 United Kingdom

The United Kingdom Civil Aviation Authority advises<sup>80</sup> all Air Operator Certificate (AOC) holders and Air Navigation Service Providers (ANSPs) to have a drug and alcohol policy as part of their safety management system (SMS). The policy should include

- 1) training and education programs covering:
  - i) the potential effects of alcohol and drugs;
  - ii) medication use (prescribed or bought from a pharmacy) to ensure the safe exercise of licence privileges whilst taking medication; and
  - iii) the early recognition and rehabilitation of individuals with an alcohol or drug problem; a peer intervention programme may be considered in this context.
- 2) briefing on self-awareness and facilitation of self-referral for help with an alcohol or drug problem.

<sup>78</sup> Federal Aviation Administration (FAA), *Code of Federal Regulations (CFR)*, Title 14, Part 120, Subpart E, Section 120.105: Employees who must be tested.

<sup>79</sup> Australian Civil Aviation Safety Authority, "CASR Part 99 – Drug and alcohol management plans and testing," at <https://www.casa.gov.au/standard-page/casr-part-99-drug-and-alcohol-management-plans-and-testing-0?WCMS%3APWA%3A%3Apc=PARTS099> (last accessed on 23 August 2017).

<sup>80</sup> UK Civil Aviation Authority, Information Notice IN-2015/012: Drugs and Alcohol Policies for Air Operator Certificate Holders and Air Navigation Service Providers (issued 20 February 2015).

- 3) procedures for monitoring program efficacy of the alcohol and drug policy; this is likely to include a drug and alcohol testing programme ('with cause', post incident/accident and random). AOC holders and ANSPs should review their employment contracts to ensure they permit testing.
- 4) monitoring and support for return to work after rehabilitation for an alcohol or drug problem.<sup>81</sup>

In its guidance material, the Civil Aviation Authority suggests that drug and alcohol policies should apply to "safety critical staff," which include flight crew, cabin crew, and air traffic controllers. However, it does not preclude an individual operator from expanding its policy to include more functions.

#### 1.18.4 Canadian Human Rights Commission guidance on drug and alcohol testing

In February 2017, the Canadian Human Rights Commission published *Impaired at Work: A Guide to Accommodating Substance Dependence*. Its purpose is to provide guidance to federally regulated employers such as air carriers in addressing substance dependence in the workplace in a manner compatible with human rights law in Canada. In part, it states that

[m]any federally-regulated workplaces have safety-sensitive<sup>[82]</sup> positions, leading some employers to have concerns regarding employee impairment by drugs or alcohol while at work. These employers may decide to conduct drug or alcohol testing as an additional precautionary measure.

In deciding whether and how to conduct drug or alcohol testing in the workplace, an employer must consider a variety of factors including human rights law, safety, privacy, labour standards, the provisions of any applicable collective agreements, regulatory requirements, the level of supervision available in the workplace, among other considerations.

Whether or not testing is permissible will depend on the nature and context of the employment. The same will be true in deciding what action is appropriate in the event of a positive test result. Employers should note that conducting testing on a person who does not occupy a safety-sensitive position is rarely permissible.

Employers should also remember that conducting testing is a form of medical examination, and it constitutes a significant invasion of privacy. It may also be discriminatory within the meaning of the *Canadian Human Rights Act*.

A positive result on a drug or alcohol test may be treated as an indicator of potentially greater risk, but should not be taken as concrete evidence of a

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<sup>81</sup> Ibid., section 4.1.

<sup>82</sup> The Canadian Human Rights Commission defines a safety-sensitive position as "one that, if not performed in a safe manner, can cause direct and significant damage to property, and/or injury to an employee, others around them, the public and/or the immediate environment."

substance dependence or that the person has or will, in fact, come to work impaired by drugs or alcohol.

When an employer receives an employee's positive test result, they have an obligation to initiate a conversation about possible substance dependence. This will help determine what workplace consequences, if any, are appropriate, and will provide an opportunity to discuss what support, assistance and accommodation the employee may need. Further medical assessment may be necessary or advisable in such circumstances.

Taking disciplinary action without initiating a conversation about substance dependence may run contrary to the provisions of the *Canadian Human Rights Act*.<sup>83</sup>

## 1.19 *Organizational and management information*

### 1.19.1 *Carson Air Ltd. general*

Carson Air is headquartered at the Kelowna International Airport (CYLW), British Columbia, and has satellite offices at the company's bases at CYVR and CYYC. At the time of the accident, the company operated 22 aircraft for contract courier flights and medical evacuation flights. In addition to these operations, the company operated a flight school at its CYLW base. In support of its flight operations, the company conducted aircraft maintenance at each of its hangar facilities at the operations bases at CYVR, CYYC, and CYLW.

Aircraft flown by the company included 12 Swearingen SA226 Metro II and SA227 Metro III aircraft and 1 Cessna Caravan aircraft, which were used for scheduled courier flights throughout British Columbia and Alberta, as well as 6 Beechcraft King Air 350 turboprops and 3 Cessna Citation jets, which were used for its medical evacuation flights. A variety of light single- and multi-engine aircraft were also operated at its flight school at CYLW.

The company holds operations certificates for operations under Subpart 703 of the CARs and is a TC-approved maintenance organization. At the time of the accident, the company employed approximately 120 full-time employees.

### 1.19.2 *Carson Air Ltd. operation control/flight dispatch system*

Carson Air was approved to use a Type D operational control system. In this system, authority over the formulation, execution, and amendment of an operational flight plan is delegated by the company operations manager to the pilot-in-command. Flights are self-dispatched and released by each flight's captain.

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<sup>83</sup> Canadian Human Rights Commission, *Impaired at Work: A Guide to Accommodating Substance Dependence* (Ottawa, ON: CHRC, 2017), at <http://www.chrc-ccdp.gc.ca/eng/content/impaired-work-guide-accommodating-substance-dependence> (last accessed on 23 August 2017).

### 1.19.3 Crew resource management training at Carson Air Ltd.

CRM training is not required at air carriers operating under CARs Subpart 703 or 704; however, Carson Air voluntarily conducted this type of training for its newly hired pilots as part of their initial training. The CRM training program had not been evaluated by the regulator, nor was it required to be evaluated by regulation.

### 1.19.4 Safety management at Carson Air Ltd.

In anticipation of a regulatory requirement for an SMS, Carson Air had prepared and implemented an SMS voluntarily beginning in 2013. However, Carson Air's SMS had not been evaluated by TC, nor was a federal evaluation required by regulation.

In 2016, following its investigation into an occurrence in May 2013 involving a controlled-flight-into-terrain accident in Moosonee, Ontario, the TSB recommended that

the Department of Transport require all commercial aviation operators in Canada to implement a formal safety management system.<sup>84</sup>

#### **TSB Recommendation A16-12**

In September 2016, TC responded to Recommendation A16-12 by stating, in part:

TC will address this recommendation in two ways. First, by continuing to promote voluntary adoption of a safety management system among the balance of commercial air operators. To support this, the department will publish updated guidance material aimed at smaller sized-operations [*sic*] this year. Secondly, over the next year and a half, the department will be reviewing the policy, regulations and program related to safety management systems in civil aviation. The expected outcome of the review is a determination on the scope, regulatory instrument, applicability and oversight model. This review will rely on the input of the department's employees, as well as industry, international authorities and other specialists in this area.

In November 2016, the Board assessed TC's response to Recommendation A16-12, by stating, in part:

The TSB is pleased that TC will continue to promote the benefits of SMS, and that it has published updated guidance material to assist smaller operators. TC also advised that it would review the policy, regulations, and program related to SMS in civil aviation. There is no clear indication at this time what TC will do once the review is complete and whether or not it intends to initiate a rule-changing process to require all commercial aviation operators to implement a formal SMS. Therefore the response to Recommendation A16-12 is assessed as **Unable to assess**.

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<sup>84</sup> TSB Aviation Investigation Report A13H0001.

Also in 2016, the Board recommended that

the Department of Transport conduct regular SMS assessments to evaluate the capability of operators to effectively manage safety.<sup>85</sup>

#### **TSB Recommendation A16-13**

In September 2016, TC responded to Recommendation A16-13. The regulator stated, in part:

While TC continually evaluates its tools to ensure they continue to be effective and makes updates, as required, the department is confident in its approach of using a combination of surveillance tools to verify regulatory compliance.

In December 2016, the Board assessed TC's response to Recommendation A16-13, by stating, in part:

TC's response does not fully address the underlying safety deficiency that led to this recommendation. Achieving minimum regulatory compliance does not necessarily guarantee that all commercial aviation operators are capable of effectively managing safety within their organization. TC must also confirm that operators have a mature, effective SMS and are managing safety risks effectively. [...] The Board considers the response to the recommendation to be **Satisfactory in Part**.

## *1.20 TSB Watchlist*

**Safety management and oversight is a Watchlist 2016 issue.** The Watchlist identifies the key safety issues that need to be addressed to make Canada's transportation system even safer. As this occurrence demonstrates, some transportation companies are not managing their safety risks effectively, and many are not required to have formal safety-management processes in place. Transport Canada oversight and intervention have not always been effective at changing companies' unsafe operating practices.

#### **Safety management and oversight will remain on the TSB Watchlist until**

- Transport Canada implements regulations requiring all commercial operators in the air and marine industries to have formal safety management processes and effectively oversees these processes;
- transportation companies that do have an SMS demonstrate that it is working – that hazards are being identified and effective risk-mitigation measures are being implemented; and
- Transport Canada not only intervenes when companies are unable to manage safety effectively, but does so in a way that succeeds in changing unsafe operating practices.

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<sup>85</sup> Ibid.

## 2.0 *Analysis*

### 2.1 *General*

There is no indication that environmental conditions or a pre-existing aircraft system malfunction played a role in this occurrence. In addition, there was no indication from the flight crew of an abnormal event before the aircraft's descent. The investigation determined that the aircraft was operating at a centre-of-gravity position and airspeed combination that would have resulted in a pitch trim setting close to the system's nose-down limit. Consequently, an uncommanded trim input would not have resulted in a significant nose-down force.

There were no survivors and no witnesses to the occurrence, the aircraft was destroyed by impact forces, and there were no cockpit voice or flight data recordings available to assist the investigation. Consequently, the investigation was unable to determine why the aircraft initially descended or why the pilots did not recover before structural failure. For unknown reasons, the aircraft descended in the direction of flight at high speed until it exceeded its structural limits, leading to an in-flight breakup. As this investigation and previous TSB investigations show, if cockpit or data recordings are not available to an investigation, then the identification and communication of safety deficiencies to advance transportation safety may be precluded.

The analysis section of this report will explore 3 possible theories, based on information obtained during the investigation, that would explain the events and unsafe conditions that may have played a role in this occurrence: a pitot system blockage, pilot incapacitation, and an intentional act.

### 2.2 *First scenario: Pitot system blockage*

The investigation determined that the occurrence aircraft had climbed into icing conditions after takeoff; however, those conditions would have been within the operating capabilities of the aircraft, if the aircraft's anti-ice systems were on and operating properly at the time of the occurrence.

All aircraft systems that could affect aircraft performance during flight were examined, and all but one potential system problem was eliminated. The remaining possibility was that failure or improper use of the pitot anti-icing system may have resulted in erroneous airspeed indications due to ice accumulation in the pitot tube when the aircraft entered icing conditions in cloud.

On 3 occasions before takeoff, the Carson Air Ltd. (Carson Air) operating procedures would have required the captain to select pitot and stall avoidance system (SAS) heaters on and then verbally respond to that effect when challenged by the first officer. However, on the SA226-TC, the pitot anti-icing system controls are located in a position only available and easily visible to the captain. As well, the aircraft was not equipped with specific annunciator

lights that indicate when the pitot heaters are powered independently of the SAS heater or when the heaters are not powered. Consequently, given the captain's level of impairment and the first officer's limited experience on the aircraft, the pitot heating system may not have been in operation at the time. If a pitot system blockage resulting from ice occurred while in cloud, the pilots may have inadvertently initiated a descent while attempting to ascertain what was happening with the aircraft.

However, analysis of the aircraft's radar returns and flight path established that the rapid descent almost certainly resulted in a vertical acceleration and negative g force that would have been apparent to both pilots. Further, the high rate of descent and airspeed during the dive continued for a period exceeding 10 seconds, which would likely have provided the pilots with sufficient time to recognize the flight path deviation and/or aircraft system malfunction and initiate some type of recovery action before impact.

### *2.3 Second scenario: Pilot incapacitation*

The 2nd accident scenario involves the possibility that 1 or both of the pilots were incapacitated. The investigation was unable to find any evidence of an event that would have rapidly incapacitated both pilots. The investigation examined issues relating to an in-flight fire or smoke, collision, bird strike, and cabin over- or under-pressurization, but no evidence was found to support those scenarios.

There was no indication, or reason to suggest, that the first officer became incapacitated in the moments leading up to the descent.

Based on the captain's high blood alcohol content (BAC), the investigation concluded that the captain had consumed a significant amount of alcohol on the day of the occurrence. As a result, alcohol intoxication almost certainly played a role in the events leading up to the accident. The captain's tolerance to some of the effects of alcohol likely allowed his impairment to go undetected on the morning of the accident. However, a BAC of 0.24% would have resulted in significant impairment in the captain's cognitive and psychomotor performance during the flight.

In particular, alcohol impairment can adversely affect visual and vestibular functions, which contributes to spatial disorientation. It can also decrease a pilot's perception of aircraft attitude, impair visual tracking, and cause visual fixation. Such impairments could have reduced the captain's ability to control the aircraft, interpret the instrument readings, and maintain situational awareness, particularly if a critical flight instrument, such as an airspeed indicator, malfunctioned. However, if the captain had become completely incapacitated, the first officer should have been able to take control of the aircraft if physically able to do so.

### *2.4 Third scenario: Intentional act*

The final scenario is that the aircraft was intentionally placed into a steep dive, which led to an in-flight breakup. The investigation identified a number of flight-specific factors that are consistent with an intentional act. These factors include

- the absence of technical or environmental factors to explain the sudden, rapid descent;
- the aircraft's full nose-down trim setting;
- the aircraft's descent in the direction of flight;
- the absence of any type of emergency communications (e.g., Mayday call) from the pilots to air traffic control; and
- the absence of any apparent recovery action during the descent.

These factors prompted a thorough examination of the potential for either pilot to have interfered with the flight controls. After review of the evidence related to the first officer, the investigation identified no predisposition toward committing an intentional act.

The well-publicized, deliberate Germanwings flight into terrain only 20 days before this occurrence, combined with the fact that the captain had a high BAC and was the pilot actively flying the aircraft, focused the investigation's attention on the potential for the captain to have committed an intentional act. The captain exhibited physical-health indicators of long-term heavy alcohol consumption, which included cirrhosis of the liver and coronary artery disease. These conditions are common outcomes of untreated alcohol abuse and dependence, which are associated with increased risk of suicide. Furthermore, although the investigation found no clear indication that the captain suffered from clinical depression or any other mental health condition, there were indications that he may have been socially withdrawn and that he may have lacked a strong social support network, which could have been a means of hiding a serious drinking habit.

Although there were several coincidental factors, the investigation could not make any conclusions about the captain's predisposition to committing an intentional act.

## 2.5 *Company safety management*

Although Carson Air had voluntarily implemented a safety management system (SMS) before the accident, it was not required to do so by regulation. Consequently, oversight by Transport Canada (TC) of the company did not extend to the SMS. As a result, TC had not assessed the company's SMS to determine whether the company was capable of effectively managing safety. If Subpart 703 operators are not required to have a TC-approved SMS, which is assessed on a regular basis, there is a risk that those companies will not have the necessary processes in place to manage safety effectively.

The concern about alcohol use was not entered into the company's SMS, nor were the concerns brought to the attention of senior or human resources managers. Consequently, the company did not have an opportunity to fully address those issues. As a result, a risk to co-workers and the public was left unmitigated. If safety issues, such as concerns related to drug or alcohol abuse, are not reported formally through a company's safety reporting system, there is a risk that hazards will not be managed effectively.

## 2.6 *Aviation medical standards in Canada*

The captain's most recent civil aviation medical examination had been conducted approximately 10 months before the accident. Records from that examination and from those before that time identified no issues related to alcohol abuse.

TC's civil aviation medicine branch provides general guidance to medical examiners regarding the evaluation of pilot candidates' mental health, including drug and alcohol issues. TC's *Handbook for Civil Aviation Medical Examiners* (TP 13312) does not address the complete range of conditions that may be affected by drug or alcohol dependence. As a result, there is an increased risk that undisclosed cases of drug or alcohol dependence in commercial aviation will go undetected, placing the travelling public at risk.

## 2.7 *Policy on substance abuse*

At present, there is no regulated drug- and alcohol-testing requirement in place in the Canadian aviation industry. While current laws, regulations, standards, and guidance may be effective at mitigating some of the risks associated with substance use among pilots and others in safety-sensitive transportation functions, there continue to be occurrences in which impaired personnel were not identified, or were not prevented from operating an aircraft.

Although random drug and alcohol testing can be an effective means of identifying individuals who may be at risk of performing safety-sensitive duties while impaired, it is only one aspect of a comprehensive response to inappropriate drug and alcohol use in aviation. Testing programs are most effective when complemented by other initiatives, including education, employee assistance programs, rehabilitation and return-to-duty programs, and peer support. If there is no regulated drug- and alcohol-testing requirement in place to reduce the risk of impairment of persons engaged in safety-sensitive functions, employees may undertake these duties while impaired, posing a risk to public safety.

## 3.0 Findings

### 3.1 Findings as to causes and contributing factors

1. For unknown reasons, the aircraft descended in the direction of flight at high speed until it exceeded its structural limits, leading to an in-flight breakup.
2. Based on the captain's blood alcohol content, alcohol intoxication almost certainly played a role in the events leading up to the accident.

### 3.2 Findings as to risk

1. If cockpit or data recordings are not available to an investigation, the identification and communication of safety deficiencies to advance transportation safety may be precluded.
2. If *Canadian Aviation Regulations* Subpart 703 operators are not required to have a Transport Canada-approved safety management system, which is assessed on a regular basis, there is a risk that those companies will not have the necessary processes in place to manage safety effectively.
3. If safety issues, such as concerns related to drug or alcohol abuse, are not reported formally through a company's safety reporting system, there is a risk that hazards will not be managed effectively.
4. Transport Canada's *Handbook for Civil Aviation Medical Examiners* (TP 13312) does not address the complete range of conditions that may be affected by drug or alcohol dependence. As a result, there is an increased risk that undisclosed cases of drug or alcohol dependence in commercial aviation will go undetected, placing the travelling public at risk.
5. If there is no regulated drug- and alcohol-testing requirement in place to reduce the risk of impairment of persons while engaged in safety-sensitive functions, employees may undertake these duties while impaired, posing a risk to public safety.

## 4.0 *Safety action*

### 4.1 *Safety action taken*

#### 4.1.1 *Carson Air Ltd.*

Carson Air Ltd. (Carson Air) has introduced a company drug and alcohol awareness campaign and implemented policies for dealing with suspected substance abuse. All company employees have received education regarding their rights and responsibilities pertaining to the policy.

The company has also amended its standard operating procedures to increase the period during which all company employees must abstain from alcohol, from the regulated 8 hours to 12 hours.

An improved emergency response plan has been implemented, and an anonymous online reporting tool has been introduced to encourage timely reporting of safety concerns.

### 4.2 *Safety action required*

A number of countries, including the United States, Australia, and the United Kingdom, have identified the hazards to aviation posed by drug and alcohol use and have implemented programs to help ensure that individuals are not impaired while carrying out safety-sensitive functions. In the United States, random testing for both drugs and alcohol is mandatory for all transportation workers, as well as for others employed in safety-sensitive occupations. In Australia, random breath-testing is now carried out in all transportation modes, including aviation, marine, rail, and public transport. In the United Kingdom, all air operator certificate holders and air navigation service providers are required to include a drug and alcohol policy in their safety management systems.

In addition to the *Criminal Code of Canada* prohibition against operating an aircraft while impaired, Transport Canada (TC) regulations prohibit pilots from operating aircraft while unfit for duty. TC has issued a framework for medical standards for pilots along with guidelines for civil aviation medical examiners, pilots, and other licensed employees in safety-sensitive functions. The framework relies significantly on self-policing by such personnel and, to a large extent, an expectation that they will voluntarily report a health issue (including a mental health issue such as drug or alcohol dependence) to their medical examiner and will remove themselves from active duty if medically unfit or impaired.

The TSB has identified drug and alcohol use as a factor in previous investigations. As well, several incidents involving pilots who reported for work while impaired have been covered prominently in the media. In a number of cases, it was an airport employee or a co-worker of an impaired pilot who ultimately served as the last line of defence and prevented the impaired pilot or pilots from operating an aircraft. While effective in those cases, this defence is insufficient on the whole.

Existing laws, regulations, standards, and guidance may be effective at mitigating some of the risks associated with substance use among pilots and others in safety-sensitive functions; however, there continue to be occurrences in which impaired individuals are not identified or prevented from operating an aircraft.

If there is no regulated drug- and alcohol-testing requirement in place to reduce the risk of impairment of persons while engaged in safety-sensitive functions, employees may undertake these duties while impaired, posing a risk to public safety. Although random drug and alcohol testing can be an effective way to identify individuals who may be at risk of performing safety-sensitive duties while impaired, it is only one aspect of a comprehensive response to inappropriate drug and alcohol use in aviation. Testing programs are most effective when complemented by other initiatives, including education, employee assistance programs, rehabilitation and return-to-duty programs, and peer support. Therefore, the Board recommends that

the Department of Transport, in collaboration with the Canadian aviation industry and employee representatives, develop and implement requirements for a comprehensive substance abuse program, including drug and alcohol testing, to reduce the risk of impairment of persons while engaged in safety-sensitive functions. These requirements should consider and balance the need to incorporate human rights principles in the *Canadian Human Rights Act* with the responsibility to protect public safety.

**TSB Recommendation A17-02**

*This report concludes the Transportation Safety Board of Canada's investigation into this occurrence. The Board authorized the release of this report on 13 September 2017. It was officially released on 02 November 2017.*

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

## Appendices

### Appendix A – Safety-sensitive aviation activities defined by Australia’s Civil Aviation Safety Regulations 1998

Australia’s *Civil Aviation Safety Regulations 1998* contain the following specifications concerning safety-sensitive aviation activities (SSAAs):

- (2) The specified SSAAs are:
- (a) any activity undertaken by a person, other than as a passenger, in an aerodrome testing area; and
  - (b) calculation of the position of freight, baggage, passengers and fuel on aircraft; and
  - (c) the manufacture or maintenance of any of the following:
    - (i) aircraft;
    - (ii) aeronautical products;
    - (iii) aviation radionavigation products;
    - (iv) aviation telecommunication products; and
  - (d) the certification of maintenance of a kind mentioned in paragraph (c); and
  - (da) the issuing of a certificate of release to service for an aircraft or aeronautical product in relation to maintenance carried out on the aircraft or aeronautical product; and
  - (e) the fuelling and maintenance of vehicles that will be used to fuel aircraft on aerodrome testing areas; and
  - (f) activities undertaken by an airport security guard or a screening officer in the course of the person’s duties as a guard or officer; and
  - (g) activities undertaken by a member of the crew of an aircraft in the course of the person’s duties as a crew member; and
  - (h) the loading and unloading of trolleys containing baggage for loading onto aircraft and the driving of such trolleys; and
  - (i) activities undertaken by a holder of an air traffic controller licence in the course of the person’s duties as a controller; and
  - (j) activities undertaken by the supervisor of a holder of an air traffic controller licence in the course of the person’s duties as such a supervisor; and
  - (k) providing flight information and search and rescue alert services:
    - (i) to a pilot or operator of an aircraft immediately before the flight of the aircraft; or

- (ii) to a pilot or operator of an aircraft, during the flight of the aircraft;  
or
- (iii) as an intermediary for communications between a pilot or operator of the aircraft, and an air traffic controller; and
- (l) providing aviation fire fighting services.<sup>86</sup>

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<sup>86</sup> Australian Civil Aviation Authority, *Civil Aviation Safety Regulations 1998* (registered 27 June 2017), Volume 3, Part 99, regulation 99.015, “SSAAs to which this Part applies,” paragraphs (2)(a) to (l), at [https://www.legislation.gov.au/Details/F2017C00470/Html/Volume\\_3#\\_Toc485981944](https://www.legislation.gov.au/Details/F2017C00470/Html/Volume_3#_Toc485981944) (last accessed 22 September 2017).