

AVIATION INVESTIGATION REPORT

A01Q0122

RISK OF COLLISION

BETWEEN CARGAIR LTD.

CESSNA 172N C-GIXH

AND

AIR CANADA REGIONAL INC.

DE HAVILLAND DHC-8-102 C-GONH

DORVAL / MONTRÉAL INTERNATIONAL AIRPORT, QUEBEC

6 nm NE

18 JULY 2001

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

Aviation Investigation Report

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Summary

A Cessna 172N, registration C-GIXH, serial number 17267628, was inbound from Mascouche Airport, Quebec. It was identified on radar and cleared to proceed to the Ville-Marie sightseeing circuit over Montréal at 1700 feet above sea level (asl). When the circuit was completed, the controller assigned the Cessna 172N a northerly heading and an altitude of 1500 feet asl. A few minutes before, an Air Canada Regional Inc. DHC-8-102, serial number 093, operating as Air Nova Flight 728, was cleared for take-off on Runway 06 right (06R) at Dorval / Montréal International Airport. After take-off, control of the DHC-8 was transferred to the departure controller. On the initial climb at approximately 2600 feet asl and established on a heading of 025°, the DHC-8 flight crew advised the departure controller that they were descending in response to a resolution advisory (RA) from the traffic alert and collision-avoidance system. During its descent, the DHC-8 flight crew saw the Cessna straight ahead at a lower altitude. The descent was arrested immediately to avoid a collision. The two aircraft crossed at 6 nautical miles northeast of Dorval with a vertical separation of about 200 feet, then continued their flights without further incident.

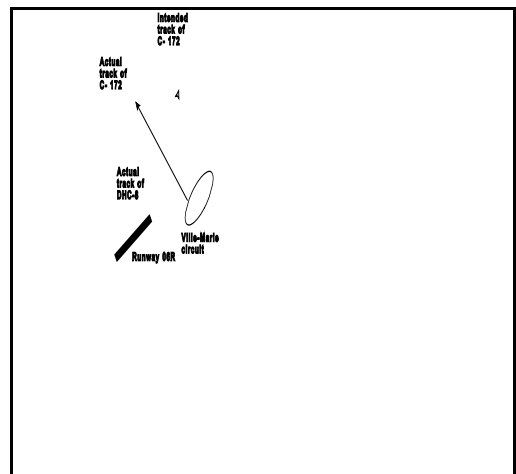
Ce rapport est également disponible en français.

Other Factual Information

Intending to watch the fireworks at the La Ronde amusement park on Sainte-Hélène Island, Quebec, a pilot rented a Cessna 172N, owned by Cargair Ltd. Around 2150 eastern daylight time,¹ the Cessna, with the pilot and three passengers on board, took off from Mascouche Airport on a sightseeing flight over Montréal under visual flight rules (VFR). Before entering the Dorval control zone, the pilot established communications on the Dorval tower frequency and was identified by radar. He received clearance to fly over Montréal and follow the Ville-Marie sightseeing circuit, maintaining an altitude of 1700 feet above sea level (asl). The Ville-Marie circuit is oval-shaped and allows aircraft to fly over the city while remaining south of the departure paths of Dorval / Montréal International Airport runways 06R and 06L. The circuit extends about 8 nautical miles (nm) from northeast to southwest. The southwest end is closest to the airport, 4 nm east of the Runway 24L threshold (the end of Runway 06R). (See Figure 1).

The Cessna entered the circuit around 2157. Besides the Cessna, three other aircraft were flying the Ville-Marie circuit to watch the fireworks. Around 2217, the airport controller asked the Cessna pilot about his altitude, because the altitude shown on the radar was not the same altitude he was given clearance for, namely 1700 feet asl. To make sure there was adequate vertical separation between all the aircraft in the circuit, the controller ensured that the Cessna pilot had received the correct altimeter setting. The pilot read back the altimeter setting and confirmed that he was at 1700 feet asl. As requested by the controller, the pilot of another aircraft flying at 1500 feet asl in the same circuit confirmed that he had the Cessna visual and that it was about 200 feet higher than him. When the circuits over the city were completed, the Cessna pilot requested to proceed to Mirabel / Montréal International Airport for a touch-and-go landing before returning to Mascouche. The controller assigned him a northerly heading and instructed him to maintain 1500 feet asl.

Less than two minutes before instructing the Cessna to maintain a northerly heading, the controller had cleared an Air Nova DHC-8 to take off from Dorval Runway 06R and turn left on a heading of 025° after take-off. The DHC-8, with 3 crew members and 16 passengers on board, was on a flight under instrument flight rules (IFR) from Dorval Airport to Québec / Jean-Lesage International Airport as Flight ARN 728. When climbing through 1300 feet asl, the DHC-8 crew left the tower frequency to establish communications with the departure controller. The departure controller cleared them to maintain a heading of 025° and climb to 15 000 feet asl. At that time, the Cessna, still on the tower frequency, was crossing the departure path of Runway 06R, about 6 nm from the runway end on a northwesterly heading.



When climbing through 2600 feet asl, the DHC-8 crew advised the departure controller that they were descending in response to a traffic alert and collision-avoidance system (TCAS) advisory. The first officer, who was at the controls, immediately followed the TCAS advisory by pushing the flight controls forward to initiate

¹ All times are eastern daylight time (Coordinated Universal Time minus four hours).

a descent. During the descent, in the beam from the landing lights, the flight crew saw the Cessna straight ahead at an altitude 200 feet below theirs. Both pilots in the DHC-8 pulled back on the flight controls simultaneously to avoid a collision. Almost at the same time, the Cessna pilot saw the DHC-8 and advised the tower that he was descending. At that time the Cessna was at 2250 feet asl, whereas it should have been at 1500 feet asl. The two aircraft crossed with a vertical separation of about 200 feet at a point 6 nm northeast of Dorval Airport. The DHC-8 continued its route to Quebec Airport without further incident. The Cessna proceeded to Mirabel Airport, where it made a touch-and-go landing before returning to Mascouche.

On the evening of the incident, weather conditions were favourable for visual flight. The skies were clear and visibility was greater than 15 statute miles. Despite good visibility, the pilots did not see each other until their tracks crossed. When two aircraft are on a collision course and their speeds and headings are constant, the relative bearing also stays the same. Under these conditions, each aircraft, if detected, will appear to the other pilot as if it is stationary. Due to this illusion, it is more difficult for the pilots to establish visual contact.

The Cessna pilot held a valid private pilot licence. He obtained his licence in 1997 and a night rating in 1998. He had 215 flying hours, including 30 hours of night flying. The flight crew of the DHC-8 were certified and qualified for the flight in accordance with existing regulations. The captain had about 14 000 flying hours, including 9000 on DHC-8; the first officer had about 5000 flying hours, including 2500 on DHC-8.

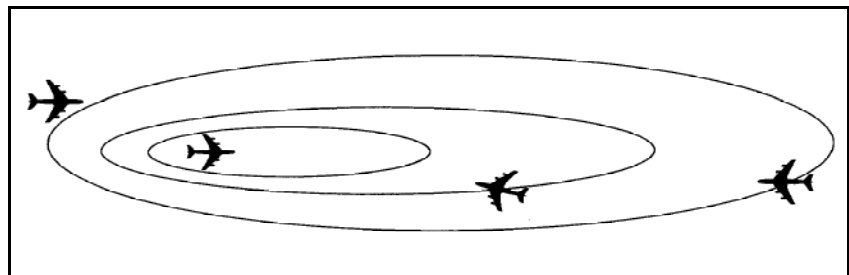
The airport controller and the controller in the terminal control centre were certified and qualified in accordance with existing regulations. The airport controller had been certified for 28 years; the terminal controller had been certified for about 22 years. The supervisors of these controllers were absent at the time of the occurrence, but the tower and the terminal control centre were otherwise staffed in accordance with unit standards. The two supervisors had just finished their shifts when the occurrence happened. It was reported that the radar systems were functioning normally at the time of the occurrence.

Information on TCAS

TCAS equipment is designed to operate independently of air traffic control (ATC). Current Canadian regulations do not require this equipment to be used in Canadian airspace. The DHC-8 was equipped with a TCAS II. This type of TCAS constantly monitors the space around an aircraft by interrogating and monitoring the return signal transmitted by nearby aircraft that are equipped with a transponder. A TCAS II is designed to operate in areas of high traffic density and can detect up to 24 aircraft within a radius of 5 nm.

The return signal is tracked by the TCAS, allowing it to predict the track of an aircraft. The TCAS is designed to prevent other aircraft from entering a collision area. (See Figure 2.) The TCAS defines a collision area as a three-dimensional airspace whose dimensions vary according to the closure rate. If an aircraft is on a track that will lead it inside the collision

area around an aircraft equipped with a TCAS, the system will issue an advisory to the pilot. The TCAS II issues two types of advisory: a traffic advisory (TA) and a resolution advisory (RA). These advisories are time-based and are issued as soon as an



intruding aircraft enters the caution area or the warning area. The dimensions of these two areas vary according to closure speed. When the system predicts that an intruder will enter the collision area within 20 to 48 seconds (the caution area), the TCAS issues a TA to the pilot. A TA provides information on nearby traffic and is designed to help the crew visually detect conflicting traffic and to warn a pilot that an RA may follow.

When the system predicts that an intruding aircraft will enter the collision area within 15 to 35 seconds (the warning area), the TCAS issues an RA to a pilot. For the TCAS to issue an RA, the intruding aircraft must have a transponder and automatic pressure-altitude transmission equipment (Mode C). RAs are divided into two categories: preventive advisories, which direct a pilot to maintain and avoid specific vertical velocities, and corrective advisories, which order a pilot to get off the current track by climbing or descending.

As soon as the TA was issued, the DHC-8 flight crew tried unsuccessfully to detect the intruding aircraft. At that time, the traffic displays indicated to the crew that an intruder was at one o'clock about 2 nm away and 400 feet above. The elapsed time between the TA and the RA could not be accurately determined, but it was reported that the interval was only a few seconds. The pilots did not see the intruding aircraft on their individual traffic displays until the TA was issued. It could not be determined if the traffic displays showed the Cessna during the minutes leading up to the TA or if the flight crew simply did not see the Cessna.

Since the RA led the DHC-8 closer to the intruder instead of away from it, it had to be confirmed that the TCAS was operating correctly. The manufacturer, Rockwell Collins Inc., examined and tested the TCAS. It was determined that the TCAS did not pass a suppression test. However, according to Rockwell Collins, this deficiency does not affect intruder detection and display. No test could prove that the TCAS was not serviceable at the time of the occurrence. Neither could it be determined whether the self-test of the TCAS had been carried out before departure or on previous flights on the day of the occurrence. Nevertheless, the self-test would not have revealed this deficiency because it does not include a test of the suppression interface.

The probability that the TCAS could not detect nearby aircraft depends on the number of aircraft in the area. The more aircraft in the area, the greater the probability that one will not be detected. At the time of the occurrence, about six aircraft were within a 10-nm radius of the DHC-8. Since information received by the TCAS indicated to the crew that the intruder was straight ahead and at a higher altitude, it is reasonable to conclude that the RA issued by the TCAS telling the crew to descend was justified.

Information on the Cessna 172N Mode C

The Cessna was equipped with a Mode C transponder, as required for flight within the Dorval control zone. Besides enabling the TCAS to issue RAs when required, Mode C also enables controllers to see the altitude of the aircraft on their radar display. Radar data revealed that, on several occasions while the Cessna was within the Dorval control zone, the altitude reading transmitted by the Cessna's Mode C indicated variations in excess of 300 feet from its actual altitude.

Cargair Ltd. maintenance personnel were advised several times that the Cessna's Mode C was not functioning properly. Checks were made, but the problem could not be duplicated; the problem seemed to be intermittent. Three days before the occurrence, the Mode C malfunction was again reported to company maintenance personnel. For undetermined reasons, the Mode C was not checked or repaired after this notification.

The pilot was not advised of the Mode C malfunction before taking possession of the Cessna at Mascouche Airport. The malfunction did not prevent him from operating the aircraft outside Class C airspace.

Information on ATC procedures

The Dorval control zone is designated as a Class C control zone, a controlled airspace where IFR and VFR flights are authorized. Air traffic control (ATC) maintains separation between all IFR flights and, where necessary, between VFR and IFR flights to resolve conflicts. ATC notifies pilots of any radar targets that could come into conflict with them. To fly in Class C airspace, VFR flights must request clearance from ATC, the aircraft must be equipped with a radio allowing two-way communication with the pertinent ATC, and the aircraft must carry a transponder and automatic pressure-altitude transmission equipment in serviceable condition.

Air Traffic Control Manual of Operations (ATC MANOPS) indicates that when a radar altitude readout is invalid, the controller is required to ensure that the aircraft has received the correct altimeter setting and to ask the pilot to do another altitude check. If the altimeter setting is correct and the readout is still invalid, the controller is required to instruct the pilot to reset his transponder and, if the readout is still invalid after the transponder is reset, to shut off his Mode C. Note 1 to section 503.1 of the ATC MANOPS states:

An altitude readout is valid if the readout value does not differ from the aircraft-reported altitude by more than 200 feet.

The airport controller did not follow this procedure: he did not ask the Cessna pilot to reset his transponder or shut off his Mode C when he realized that the altitude readout for the Cessna was invalid.

Besides showing that the Cessna's Mode C was transmitting altitudes that varied from its actual altitude by more than 300 feet, radar data also revealed that the Cessna, from the time it left the circuit, maintained a heading of about 300° instead of the northerly heading assigned to it by the tower. Figure 1 indicates that the Cessna crossed the flight path of the DHC-8 sooner than expected, allowing less time for the DHC-8 to reach a higher altitude than the Cessna, which had been instructed to maintain 1500 feet asl.

When a controller believes that there is a risk of conflict between an aircraft under his/her control and an aircraft controlled by another unit, he/she must advise the controller in the other unit. In this occurrence, the

airport controller had assigned a heading to each of the aircraft involved to ensure that there would be no conflict. Based on the heading and altitude assigned to each aircraft and the rate of climb of the DHC-8, the airport controller believed that there would be no conflict between these two aircraft. Consequently, the controller did not inform the Cessna pilot that the DHC-8 was on its track, and it was not necessary to mention the Cessna's presence to the departure controller to whom he had earlier transferred control of the DHC-8.

The airport controller was assisted by a radar coordinator. One of the responsibilities of the radar coordinator is to identify potential conflicts and to report them to the airport controller. This responsibility does not prevent the airport controller from using radar to resolve conflicts. It could not be determined why the radar coordinator and the airport controller did not detect a conflict between these two aircraft. In the minutes preceding the occurrence, the coordinator was in communication with the Saint-Hubert tower to coordinate aircraft in the Saint-Hubert control zone that wanted to enter the Dorval control zone to fly the Ville-Marie circuit. The coordinator might have been paying less attention to the radar screen while he was coordinating those flights.

The departure controller took control of the DHC-8 when it climbed through 1300 feet asl and was established on a heading of 025°. The departure controller swept his radar screen to ensure that there was no traffic in the area that might come into conflict with the DHC-8, then he cleared the flight to continue climbing to 15 000 feet asl. At that time, the Cessna was on the runway centreline about 6 nm from the runway end and proceeding northwest. Knowing that the Cessna was under tower control and having received no confirmation of the altitude and track of the Cessna, the departure controller believed that there was no risk of conflict between the two aircraft. He therefore diverted his attention from the DHC-8 radar target and concentrated on other aircraft under his control. The departure controller did not see that the two radar targets overlapped until the DHC-8 crew advised that they were descending in response to an RA.

By accepting the Cessna in Class C airspace with the knowledge that his radar display of the Cessna's altitude was incorrect, the airport controller put himself in a situation that did not allow him to determine the actual altitude of the Cessna. He could only assume that the Cessna would maintain its assigned altitude. However, the Cessna gained altitude as it got closer to the track of the DHC-8, which was continuing its climb as authorized. The Cessna pilot had diverted his attention from his on-board instruments and visual references on the ground to program his global positioning system (GPS) for Mirabel, his next destination. The Cessna pilot did not realize that his aircraft was gaining altitude and that he was no longer on his assigned heading. It could not be determined why the airport controller did not notice that the Cessna was not following its assigned heading.

After the occurrence, the DHC-8 continued its flight to Quebec Airport without further incident. Control of the Cessna was transferred to the Mirabel airport controller, who was advised of the Cessna's Mode C malfunction. Despite this malfunction, the Mirabel airport controller cleared the Cessna to enter the Mirabel control zone, which is a Class C airspace requiring serviceable Mode C equipment. The Cessna left the Mirabel control zone around 2308 for Mascouche.

Analysis

Since the TCAS uses the altitude transmitted by the Mode C of intruding aircraft (whether the altitude is accurate or not) to issue a RA, the crew of the DHC-8 followed the RA instructions that guided their aircraft directly toward the Cessna. The DHC-8 flight crew could not have known that the altitude transmitted by the Cessna's Mode C was incorrect. Therefore, the reaction of the DHC-8 crew to the RA was appropriate because

they could not establish visual contact with the other aircraft. The DHC-8 crew had less chance to make visual contact with the Cessna because the TA indicated that they should look upward, while the Cessna was actually at a lower altitude than the DHC-8.

The problem with the TCAS did not prevent the system from detecting intruding aircraft or issuing RAs in the event of conflicting tracks. Based on this fact and the limited number of aircraft near the DHC-8, it is reasonable to conclude that the TCAS detected the Cessna according to design specifications and warned the DHC-8 crew in time. The vigilance of the DHC-8 flight crew, good exterior visibility, and the use of aircraft landing lights greatly contributed to the avoidance of a collision. The pilots of both aircraft might not have been able to see one another sooner because of their respective tracks and because their relative bearing stayed the same, making visual contact more difficult.

Cargair Ltd. was aware of the Cessna Mode C malfunction. The company should have informed the pilot before his departure and should have restricted the operation of the aircraft to outside Class C airspace.

If the Cessna pilot had maintained his authorized altitude and heading, the incident would not have happened. The two aircraft would have crossed later, allowing the DHC-8 to gain more altitude, thereby increasing vertical separation between the aircraft. The GPS can be a very useful navigation aid, especially at night. But using it should not interfere with control of the aircraft. The Cessna pilot might have spent too much time looking down at the GPS to program it, diverting his attention from exterior visual references and on-board instruments that he needed to use to maintain the altitude and heading assigned by the tower controller.

Delivery of effective radar service depends on communications, the equipment available, and the accuracy of the information displayed on the radar screen. In this occurrence, the radar equipment was operating normally. However, the readout of the Cessna altitude on the radar screen was not valid because of the Cessna's malfunctioning Mode C, and the tower controller could not ensure that the Cessna was maintaining its assigned altitude. Because of this situation, the controller could not anticipate the conflict between the two aircraft. Based on the assumption that the Cessna pilot was maintaining his assigned altitude, the controller had valid grounds to believe that there would be no conflict between these aircraft. From the time the Cessna left the circuit, the airport controller and the radar coordinator paid little attention to the radar screen because they had not noticed that the Cessna's altitude and track did not match the instructions given to the pilot.

About 50 minutes elapsed between the realization that the Cessna's Mode C was malfunctioning and the time the Cessna left Class C airspace for Mascouche. At no time during this period was the Cessna pilot asked to shut off his Mode C. Transmission of an inaccurate altitude by a Mode C can significantly affect nearby aircraft equipped with a TCAS. This situation triggered an RA that was incorrect due to the inaccuracy of the altitude transmitted by the Cessna's Mode C. The inaccurate altitude could also have been transmitted to other nearby aircraft equipped with a TCAS, thus affecting their TAs and RAs. When it was realized that the altitude readout for the Cessna was incorrect, the Cessna pilot should have been instructed to shut off his Mode C as prescribed in the ATC MANOPS. If the Cessna's Mode C had been shut off, the DHC-8's TCAS would not have issued an RA to the crew. The DHC-8 would have continued its climb, thereby increasing vertical separation from the Cessna.

Findings as to Causes and Contributing Factors

1. The pilot of the Cessna did not maintain the heading and altitude for which he was given clearance. Thus, the two aircraft crossed sooner than expected, with decreased vertical separation.
2. The airport controller, the radar coordinator, and the departure controller did not detect the conflict. As a result, the two aircraft crossed with a vertical separation of 200 feet.
3. The Cessna's Mode C transmitted an incorrect altitude to the DHC-8 traffic alert and collision-avoidance (TCAS). As a result, the DHC-8 crew followed a resolution advisory (RA) that brought their aircraft closer to the Cessna instead of farther away.

Findings as to Risk

1. The airport controller did not ask the Cessna pilot to reset his transponder and shut off his Mode C—although such action was required by the *Air Traffic Control Manual of Operations*—when he realized that the altitude readout for the Cessna was not valid. Thus, the Cessna's transponder continued transmitting an incorrect altitude.
2. Because of the TCAS design, it is not possible to know whether the altitude transmitted by the Mode C of an intruding aircraft is correct or incorrect. As a result, the TCAS may issue an RA that produces a result opposite from what it is designed to achieve.
3. The Cessna was in Class C airspace for about 50 minutes despite the controller's awareness that its Mode C was defective. The TCAS of other aircraft in the area could have received the incorrect altitude transmitted by the Cessna's Mode C and could have issued misleading traffic alerts or RAs, thus decreasing separation with other aircraft.
4. Cargair Ltd did not inform the Cessna pilot of the mode C intermittent problem. This information could have influenced the Cessna pilot to turn off the mode C and to remain outside Class C airspace. This would have prevented erroneous altitude transmission to other TCAS equipped aircraft, which could have issued misleading traffic alerts or RAs, thus decreasing separation.

Other Findings

1. The landing lights of the DHC-8 were on during the occurrence; the lights were an effective aid to visual detection.

Safety Action

After the occurrence, Cargair Ltd. immediately replaced the Mode C in the occurrence Cessna 172.

After the occurrence, Air Canada Regional Inc. checked the DHC-8 traffic alert and collision-avoidance system (TCAS). After establishing that the malfunction could not be detected by the self-test, Air Canada Regional Inc. sent the TCAS to the manufacturer for repair.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 18 September 2002.