Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A01P0111

AIR PROXIMITY—SAFETY NOT ASSURED

NAV CANADA
VANCOUVER AREA CONTROL CENTRE
AIR CANADA AIRBUS A320
AND
CESSNA 172M
NEW WESTMINSTER, BRITISH COLUMBIA
12 MAY 2001

Canada

Aviation Investigation Report

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Summary

The Air Canada Airbus A320 (ACA1118) departed Vancouver International Airport, British Columbia, from Runway 08R at 1640 Pacific daylight time. The Vancouver departure north controller cleared the aircraft to turn left to 360° upon reaching 3000 feet. At the same time, under the supervision of the same controller, a visual flight rules Cessna 172M was carrying out approved aerial work at 5000 feet over the city area, 7 to 10 nautical miles east of the airport. The A320 began to turn left shortly after passing 3000 feet, and at 1642:52, the pilots received a traffic alert and collision-avoidance system resolution advisory to climb as a result of the Cessna traffic ahead of them. The spacing between the two aircraft decreased to 0.7 nautical mile laterally and 700 feet vertically. The A320 pilots saw the Cessna as it was passing on their right; the Cessna pilot did not see the A320. Visual meteorological conditions existed at the time. Although there was no risk of collision because the flight paths were diverging, the safety of the two aircraft had not been assured.

Ce rapport est également disponible en français.

Other Factual Information

The Vancouver non-directional beacon (NDB) is 4.1 nautical miles (nm) from the threshold of Runway 26L on the extended centreline of the runway. The NDB is a navigation aid that the controller was using as a reference point for aircraft departing Runway 08R.

In the time surrounding this incident, two other visual-flight-rules (VFR) aircraft were engaged in parachute dropping operations in the airspace over the Pitt Meadows airport, about 15 nm east of Vancouver, and were operating up to 10 000 feet. At the time of the incident, the workload for the departure position in the Vancouver terminal was moderate, with normal complexity.

About 90 seconds before the incident, there was a controller change-over for the Vancouver departure north position. The controller handover briefing did not mention any proposed air traffic control (ATC) actions for the A320 and the VFR Cessna, because both controllers considered such actions to be the oncoming controller's personal decision. One of the controller's responsibilities was to provide conflict resolution between the instrument-flight-rules A320 and the VFR Cessna.

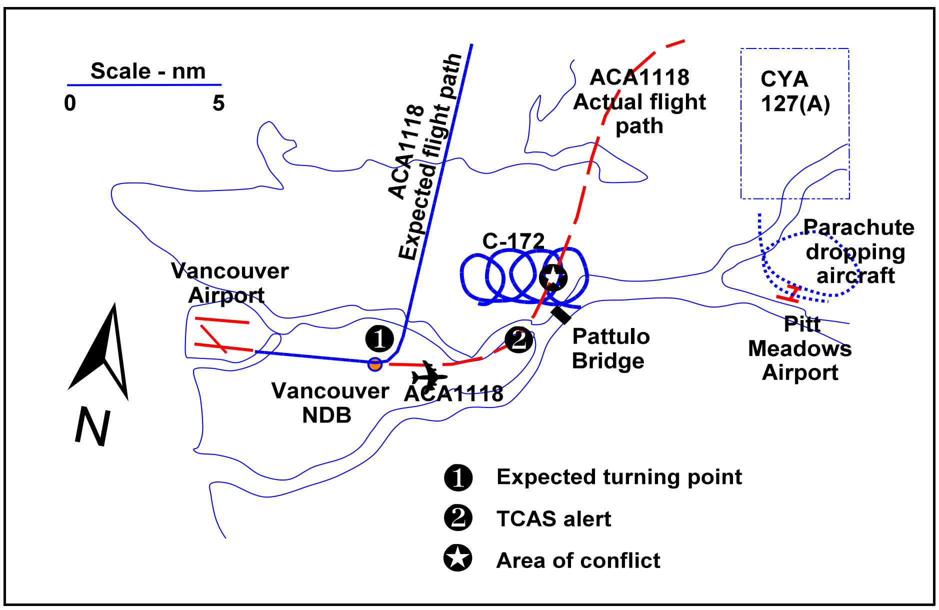

Figure 1 - ACA1118 flight path

The new departure north controller's plan was to turn the A320 north so as to pass west of the VFR Cessna and avoid the other VFR aircraft operating near Pitt Meadows. Previous experience with other jet aircraft on departure from this runway led the controller to anticipate that the A320 would reach 3000 feet approaching the NDB and start the left turn. The controller judged that a turn near the NDB would have provided ample spacing between the A320 and the Cessna.

The departure controller's first ATC instruction was at 1641:41 Pacific daylight time[1] for ACA1118 to turn to a heading of 360° for traffic when reaching 3000 feet. (See Appendix A for a chronology of the events.) The pilot correctly acknowledged this instruction. However, the A320 did not begin to turn north where the controller had anticipated—near the NDB—and the controller recognized a developing traffic conflict. At 1642:16, he instructed the A320 to turn further left to 350°, which the pilot acknowledged. About 15 seconds after passing 3000 feet,

[1] All times are Pacific daylight time (Coordinated Universal Time minus seven hours).

about 2.5 nm past the NDB, the A320 began to turn left, to the north. At 1642:30, the controller informed the Cessna pilot about the conflicting A320 traffic. At no time did the Cessna pilot see the approaching A320.

The controller saw that the spacing was decreasing and, at 1642:39, directed ACA1118 to turn left to 330° and advised that the Cessna was about 3.5 nm ahead at 5000 feet. This was the first time that information about the Cessna was provided to ACA1118. The controller did not convey any sense of urgency during this transmission, nor did he incorporate the standard published safety alert phraseology[2] to indicate any need for an immediate turn. Almost coincident with the controller's instructions, the ACA1118 pilots received a traffic alert (TA) at 1642:42 from the on-board traffic alert and collision-avoidance system (TCAS) triggered by the VFR Cessna traffic ahead of them. Because of the TA, they did not completely hear the ATC instruction to turn or the information about the Cessna.

At 1642:52, the controller repeated his previous transmission, but by this time the pilots had initiated their response to the TCAS resolution advisory (RA) to climb. They did not hear this repeated instruction or traffic information, because it was blocked out by the TCAS warning.

At 1643:07, the A320 pilot reported that they had the Cessna in sight, passing below them on their right-hand side. In three subsequent transmissions to ACA1118, the controller advised the A320 pilot that the Cessna pilot had the A320 in sight; in fact, the Cessna pilot never saw the A320.

Radar data show that ACA1118 was in a gradual left turn until it passed the Cessna; the aircraft's track was no farther west than 358°. ATC information confirms that the A320 had not yet turned to 350°.

Nav Canada is the principal provider of ATC services in Canada and is responsible for all Canadian civil aeronautical information. Nav Canada is required to monitor all aircraft to ensure conformance with published ATC procedures.

The Vancouver International Airport Authority has developed an aeronautical noise management program. Noise-abatement procedures for the take-off climb ensure that the necessary safety of normal flight operations is maintained while exposure to noise on the ground is minimized. According to approved civil aeronautical information documents (*Canada Air Pilot* [CAP]*: Instrument Procedures*) in effect at the time of the incident, only two different vertical noise-abatement procedures (VNAP) were authorized at Canadian airports: procedures "A" and "B". These procedures are published under the authority of Nav Canada and were consistent with the two noise-abatement procedures promulgated by the International Civil Aviation Organization (ICAO) and used internationally. In summary, VNAP A provided a steeper climb at slower speed than VNAP B. Recently, ICAO has issued changes to its directives and standards concerning noise-abatement procedures. Nevertheless, one of the basic tenets of noise-abatement procedures in general is that they are not intended to be used solely for air traffic separation. Other procedures, such as standard instrument departures (SIDs), are designed for that purpose.

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[2] Nav Canada, *Air Traffic Control Manual of Operations* 507.1.

At the time of the incident, all air carriers in Canada were required to follow either VNAP A or VNAP B on take-off from selected Canadian airports. According to the general noise-abatement procedures published in CAP, volume 2, all jet aircraft departing from Vancouver were to use VNAP A only and were to follow the assigned SID to 3000 feet before proceeding on course. There was a restriction on the SID that aircraft were not to exceed 280 knots until above 7000 feet above sea level. An important reason for standardizing VNAP A at Vancouver was to provide similar jet aircraft departure performance and to facilitate aircraft turning on course. Nav Canada also believed that using one VNAP procedure at Vancouver would be more useful in managing traffic and reducing performance conflicts between departing jet aircraft.

Pilots who fly Air Canada aircraft are instructed to the follow the Air Canada fleet noise-abatement procedures contained in the Transport Canada-approved Air Canada operations manual for the specific aircraft type. The Air Canada fleet procedure differs markedly from VNAP A: the Air Canada vertical profile flown by the A320 aircraft is flatter, and the speed on departure is higher. Accordingly, Air Canada A320 aircraft departing from Vancouver do not follow the published VNAP A profile. Transport Canada inspectors involved in the ongoing oversight of Air Canada were aware of the significant procedural and operational differences that resulted from the implementation across Canada of these unique, fleet-wide noise-abatement procedures.

In March 2001, Nav Canada advised Air Canada that Nav Canada had "no concerns regarding ATC separation applications with respect to Air Canada's aircraft departing Vancouver operating under [the Air Canada fleet noise-abatement] procedures." Nav Canada advised that it did not anticipate any ATC separation problems at Vancouver or at six other major Canadian airports used by Air Canada. Nav Canada did not examine any operational or performance issues associated with these modified procedures for any of the Air Canada aircraft types at any of the seven airports involved. Nav Canada was unaware of the marked differences between the published VNAP A profile and the Air Canada fleet procedures.

The investigation found that Vancouver controllers have determined by experience that when aircraft following VNAP A from Runway 08R cross the Vancouver NDB, they are consistently higher than 3000 feet and at approximately 200 knots. This was confirmed by a review of the aircraft take-off profiles for the one-hour period surrounding the incident (except for two aircraft whose regular flight paths and altitude profiles were known and expected to differ from the others). Furthermore, Vancouver controllers generally believe that Air Canada aircraft follow VNAP A, since the controllers have not been informed otherwise. Those controllers were unaware that the Air Canada profile differed procedurally from the approved VNAP A. Anecdotal information suggested that few Vancouver controllers had encountered significant separation difficulties with departing Air Canada aircraft.

Flight profile tests carried out in an A320 simulator after the incident show that an A320, configured the same as the incident aircraft and in controlled conditions, crosses the NDB at about 3650 feet and 205 knots when following VNAP A; when following the Air Canada VNAP, the aircraft crosses the NDB at about 3050 feet and 230 knots.

In this incident, the A320 crossed the NDB at 2600 feet and 230 knots and passed 3000 feet at 250 knots. The A320 had accelerated to 280 knots by the time of the TCAS RA.

The take-off weight of the A320 was 69 200 kg; the maximum take-off weight for this aircraft was 75 500 kg. The pilot flying was controlling the A320 manually. Reportedly for passenger comfort, he chose a flatter flight path and a higher climbout speed than the parameters indicated on the Air Canada VNAP. The pilot also turned the aircraft using 15° of bank when 25° would have been normal. Appendix B briefly demonstrates the general relationship between airspeed and radius of turn for 15° and 25° of bank and the time to complete a 90° turn at 15° of bank. For example, a 50-knot increase in speed from 230 to 280 knots requires about a 50% greater radius of turn, and the radius of turn at 15° of bank and 280 knots (25 900 feet) is about 2½ times the radius that the controller would have expected (10 000 feet).

The pilot assessed that, since the controller's initial instruction to turn to 360° was based on his reaching a specified altitude, there was no pressing need to turn his aircraft as a result of the advised traffic. As well, he concluded that, since the controller had issued a turn to the left, the traffic conflict was ahead and/or to his right. It was not until 15 seconds after the A320 had begun its left turn—that is, 44 seconds after passing the NDB—that the controller transmitted to the crew information about the conflicting traffic to the north of their position. The receipt of this information by the pilots, however, was thwarted twice by the TCAS warnings and activities on the flight deck.

Analysis

The chain of events that led to this incident included controller expectations, and planning and monitoring issues coupled with aircraft handling and performance.

ATC controllers consider the radii of turn of jet aircraft and their departure speeds to accurately judge the space required for aircraft to turn, climb, and manoeuvre under various conditions. In this incident, the lateral spacing required for the departing A320 to avoid conflict with the Cessna would have been achieved with the A320 turning at or shortly after crossing the NDB, even accounting for an angle of bank of 15° and a speed of 250 knots. The A320 started to turn 44 seconds after passing the NDB, however, and this delay caused the required lateral space to move towards the Cessna, thus infringing on the buffer the controller had envisaged. That the A320 was about 50 knots faster than normal significantly exacerbated this dynamic situation.

Based on previous experience with other jet aircraft on departure from Runway 08R, the departure controller anticipated that ACA1118 would have reached at least 3000 feet at the NDB, thus allowing the aircraft to begin a turn. Had the aircraft followed any of the VNAP profiles—that is, either A, B, or Air Canada's—it would have crossed the NDB at an altitude and a speed that would have been consistent with the controller's expectations. As well, there would have been sufficient spacing between the aircraft under his control.

The controller's intended flight path for ACA1118 required that the A320 begin the turn to the north at or near the NDB. Although the controller's plan would likely have succeeded had the A320 reached 3000 feet at the NDB and therefore begun to turn, it was fundamentally flawed in that the criterion he established for ACA1118 to begin the turn was based on the A320 reaching a specific altitude. Essentially, the controller had to ensure separation between the A320 and three obstacles: the Cessna 172M and two parachute aircraft. Providing vertical spacing from these obstacles was not a plausible option, and lateral spacing was required. For example, by instructing ACA1118 to reach 3000 feet and turn at or near the NDB, the lateral spacing he wanted could have been assured. In the event that the pilot of the A320 declined such instructions for reasons of potential aircraft performance, the controller could have reverted to an alternative plan, such as continuing the aircraft straight ahead on the runway heading.

When the A320 did not turn as expected, the controller attempted to salvage the quickly deteriorating situation with small heading changes. It is improbable that the controller's last two instructions to turn left to 350° and 330° would have had any remedial effect on the developing collision situation. Because of the A320's wide radius of turn at 280 knots and 15° of bank, and in consideration of pilot and aircraft reaction times, the A320's flight path would have been only slightly affected in the brief time before safety would not have been assured with the Cessna.

More-imperative and timely instructions by the controller, when he recognized that the A320 was not flying as expected, would have alerted the crew of ACA1118 to the developing traffic conflict situation. If he had heard more-imperative instructions, the pilot flying might have responded more quickly and used a greater angle of bank in turning the aircraft. Considering the aircraft's speed, a steeper angle of bank would not likely have returned the aircraft to the original flight path intended by the controller, but it would have provided more passing clearance between the two aircraft.

In essence, as soon as the controller instructed ACA1118 to turn further to 350°, he initiated a course of events that, without substantive flight path correction by the A320, was inevitable. That the Cessna was already established in a left orbit was fortuitous, because it created a diverging flight path situation, so no real risk of collision existed. Nonetheless, the safety of the two aircraft was not assured.

The Air Canada VNAP profile did not directly contribute to this incident; however, it is an anomaly in the general noise-abatement procedures approval process and potentially creates ATC separation difficulties in some circumstances.

Nav Canada reasonably assessed that having only one noise-abatement procedure (VNAP A) at Vancouver would improve traffic management and reduce performance conflicts between departing jet aircraft. Although it was not found in this investigation that the VNAP was being specifically used as an aircraft separation method, the enticement to do so exists. Such use of the VNAP would not be in accordance with the noise-abatement procedures' intended purpose, which has been emphasized by the new ICAO directives.

Two VNAP procedures are presently in effect in Vancouver—CAP's and Air Canada's—each with remarkably different vertical profiles. The Vancouver controllers were generally unaware that Air Canada aircraft followed a procedure similar to VNAP B. This lack of awareness introduced elements of inconsistency and complexity that elevated the level of risk for a loss-of-separation event and increased the opportunity for an unsafe situation. When a choice existed between VNAP A and B, controllers were informed of the profile about to be flown and took appropriate traffic management action. In the operating environment at the time of this incident, however, the potential for a loss of separation or a collision was further increased because the controllers were not aware of the remarkable differences in the profiles or that the Air Canada profile existed.

Transport Canada, Nav Canada, Air Canada, and the Vancouver International Airport Authority apparently did not collaborate in the implementation of the Air Canada noise-abatement procedures. This lack of cooperation created a situation where Air Canada was authorized to conduct a noise-abatement profile that differed from the authorized VNAP A profile. It also created a situation of inconsistency and increased risk among air carriers operating from Vancouver International Airport.

Findings as to Causes and Contributing Factors

1. The pilot of ACA1118 did not conform to the published vertical noise-abatement procedure (VNAP) A for Vancouver or the Air Canada VNAP profile. As a result, his flight path was inconsistent with normal departure profiles, which were the basis for an air traffic control (ATC) clearance.

2. Although he acknowledged the instructions, the pilot of ACA1118 was tardy in his response to the departure controller's instruction to turn left to 360° at 3000 feet. As a result, he introduced a significant displacement of the planned flight path to avoid the Cessna.

3. Instead of using a geographical fix, such as the non-directional beacon (NDB), the departure controller used a specific altitude as the parameter to initiate a flight path. This decision did not provide sufficient lateral spacing to avoid an air proximity event.

4. The departure controller did not use imperative phraseology when he issued the instruction for ACA1118 to turn. Imperative phraseology would have indicated a degree of urgency to the A320 pilot to turn quickly.

Findings as to Risk

1. The Air Canada fleet noise-abatement procedures are not consistent with the noise-abatement procedures that Canadian ATC controllers expect jet aircraft to follow. Consequently, ATC controllers are exposed to inconsistent aircraft climb performance, and there is an elevated risk of loss of separation.

2. ATC controllers in Vancouver were generally unaware that Air Canada aircraft did not follow the published VNAP A profile. As a result, the controllers were unable to make allowance for performance differences between departing aircraft.

3. Although aware of the differences between Air Canada's VNAP profiles and the published VNAP profiles, Transport Canada approved the implementation of the fleet noise-abatement procedures without examining operational or performance issues in depth.

4. Without examining operational or performance issues, Nav Canada assessed that the Air Canada fleet noise-abatement procedures would not affect aircraft separation.

5. Although the departure controller recognized that the A320 was not responding to his initial instructions in a timely manner, he did not issue corrective instructions that would have been effective in preventing the traffic conflict. The crew did not hear these instructions clearly enough to understand them.

6. When the departure controller realized that ACA1118 was not adhering to his instructions, he issued incremental corrective heading changes. The changes could not have prevented the air proximity event because of the A320's high speed and large radius of turn.

Other Findings

1. The traffic alert and collision-avoidance system on board ACA1118 effectively alerted the A320 pilots to the proximity of the Cessna. However, the associated traffic alert and resolution alert warnings thwarted ATC instructions intended to warn the pilots of the approaching traffic and adjust their flight path to reduce the risk of collision.

Safety Action

In January 2002, Transport Canada convened meetings with representatives of Air Canada, Nav Canada, the Vancouver Airport Authority, and other air carriers to present and discuss the noise-abatement procedures issues. During these meetings, the most recent directives from ICAO concerning noise-abatement procedures were reviewed and deliberated. From this review, several items of interest were raised, and a sound base for communication was established, aimed at resolving common and specific problems associated with noise-abatement procedures, their application, and their implementation.

In March 2002, Nav Canada issued Operations Bulletin 02-072 to the Vancouver Area Control Centre informing all Terminal staff of the Air Canada fleet noise-abatement procedures. Also in this correspondence was the reminder that the VNAP was a written description of aircraft performance and not a separation standard.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 26 June 2002.

Appendix A—Chronology of Events

Chronology of Events			ACA1118	
Time	**Unit**	**Event**	**Speed (knots)**	**Altitude (feet)**
1640:32	ACA1118	Airborne from Runway 08R	170	100
1640:45	ACA1118	Calls airborne	170	1100
1640:51	ATC	Clears ACA1118 to 16 000 feet	170	1200
1641:16	ACA1118	Passes 2000 feet and begins to accelerate	180	2000
1641:30	ATC	Departure controller change-over	200	2300
1641:41	ATC	Instructs ACA1118 to turn to 360° for traffic once at 3000 feet	220	2500
1641:55	ACA1118	Passes Vancouver NDB	230	2600
1642:09	ACA1118	Passes 3000 feet	250	3000
1642:16	ATC	Instructs ACA1118 to turn left to 350°	260	3300
1642:24	ACA1118	Begins left turn	260	3500
1642:30	ATC	Informs Cessna of A320	270	3800
1642:39	ATC	Instructs ACA1118 to turn to 330° and advises of Cessna	270	4100
1642:42	ACA1118	TCAS TA	270	4200
1642:52	ATC	Instructs ACA1118 to turn to 330° and advises of Cessna	280	4500
1642:52	ACA1118	TCAS RA	280	4500
1643:07	ACA1118	Sights Cessna on right: 1.25 nm and same altitude	280	5100
1643:15	ACA1118	Passes abeam Cessna: 0.6 nm and 600 feet above	280	5600
1643:15	ATC	Advises ACA1118 clear of Cessna and to proceed on course	280	5600

Appendix B—Radius of Turn

Radius of Turn (in level flight)			
True airspeed (knots)	**Radius of turn at 15° angle of bank (feet)**	**Time to turn 90° at 15° angle of bank (seconds)**	**Radius of turn at 25° angle of bank (feet)**
200	13 200	62	7600
210	14 500	65	8400
220	16 000	68	9200
230	17 500	71	10 000
240	19 000	74	11 000
250	20 600	77	11 900
260	22 300	80	12 800
270	24 000	83	13 800
280	25 900	86	14 900