Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A10O0089

RISK OF COLLISION

NAV CANADA – TORONTO AREA CONTROL CENTRE
TORONTO / BILLY BISHOP TORONTO CITY AIRPORT
TORONTO, ONTARIO, 6 NM SE
11 MAY 2010

Canada

Aviation Investigation Report

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Synopsis

Porter Airlines Inc. Flight 406, a Bombardier DHC8-402 (registration C-FLQY, serial number 4306) was on an instrument flight rules flight to the Toronto/Billy Bishop Toronto City Airport, Ontario. Southeast of the airport, the flight was cleared for a visual approach to Runway 08. Another Porter Airlines Inc. Flight 249, also a Bombardier DHC8-402 (registration C-GLQX, serial number 4282) was departing Runway 08 on an IFR flight eastbound with a clearance to depart under visual flight rules until 10 minutes after departure. At approximately 0839 Eastern Daylight Time, about 6 nautical miles southeast of the airport, both aircraft responded to resolution advisories from their respective traffic collision-avoidance systems. The aircraft crossed paths separated by approximately 300 feet vertically.

Ce rapport est également disponible en français.

Other Factual Information

Air traffic services (ATS) at the Toronto/Billy Bishop Toronto City Airport (Billy Bishop Airport) are provided by NAV CANADA through a control tower located on the airport, and the Toronto Area Control Centre (ACC) located at Toronto/Lester B. Pearson International Airport.

Instrument flight rules (IFR) control services at the ACC are provided by the Airports Specialty and is divided into 3 sectors:

- East Satellite;
- West Satellite; and
- London.

At the time of the occurrence, there were 4 controllers, 1 supervisor and 1 controller in training on duty.

The London sector was only staffed by 1 controller. The East and West satellite sectors were combined and being staffed by the occurrence controller while the supervisor was providing on-the-job instruction to the controller in training. The other 2 controllers were on break but were available for immediate recall.

Sectors may be combined when traffic levels and controller workload are low which can ease workload by reducing coordination between the sectors. However, when traffic increases, combining sectors can result in overlapping air-ground and ground-ground communications. This resulted in less time available for the controller to identify and resolve conflicts. The responsibility to combine or split the sectors is based on actual and anticipated traffic and rests with the supervisor.

The occurrence controller (satellite controller) was occupying the radar position of the combined satellite sectors. The supervisor was providing on-the-job instruction related to the data position. At the time of the occurrence, the satellite controller was engaged in discussions with the controller in training. According to the Unit Operations Manual (UOM), the duties of the data position include, in part, identifying and resolving conflicts and coordinating with the radar controller. [1]

At 0834 [2] Porter Flight 406 (POE406) was 20 nautical miles (nm) east of the Billy Bishop Airport at 7000 feet above sea level (asl). The satellite controller cleared POE406 for a visual approach to Runway 08. As no request to restrict the descent of IFR arrivals had been received from the Billy Bishop Airport controller (airport controller) as per the Arrangement between ACC and the Toronto City Control Tower (Arrangement), [3] the visual approach clearance authorized POE406 to descend at the flight crew's discretion, with no restriction.

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1 Unit Operations Manual ES 1.5 – Duties of West Satellite Data Position.

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

3 Article D.2.10 of the Arrangement states: "The Toronto ACC shall, when requested by the control tower, apply a descent restriction to aircraft cleared for a visual approach in accordance with Attachment A, unless otherwise coordinated." Attachment A stipulates: "Not below 3000′ until advised by the tower."

Meanwhile, Porter Flight 249 (POE249) asked the airport controller for its IFR clearance with a request for a visual flight rules (VFR) departure. Normally, departing IFR aircraft would be issued the Island Eight SID (standard instrument departure). However, weather permitting IFR flights often request clearances to conduct VFR departures to expedite traffic during busy periods. As the weather conditions were suitable, the airport controller issued a clearance in accordance with article D.1.6 of the Attachment to the Arrangement which states: "Maintain VFR for 10 minutes after take-off. Climb not above 2,000 feet." The airport controller included a heading of 141° which forms part of the Island Eight SID.

Subsection 801.02(3) of the *Canadian Aviation Regulations* (CARs) states: "Where air traffic services are provided to aircraft operating in Class D airspace (such as the airspace surrounding CYTZ), the services shall include (b) separation between all IFR aircrafts." The minimum separation required in this case would be 1000 feet vertically or 3 nm laterally.

With regard to IFR clearances with VFR restrictions, subsection 6.2.1 of the Aeronautical Information Manual (TP14371) reminds pilots of their responsibility to provide their own separation from other IFR aircrafts. It further explains that: "controllers normally issue traffic information concerning other IFR aircrafts" and that "if compliance with the restriction is not possible, the pilot should immediately advise air traffic control (ATC) and request an amended clearance." In this occurrence, traffic information was not issued.

There is no requirement in the CARs for ATC to provide separation between IFR and VFR aircrafts in Class D airspace. However the ATC Manual of Operations (MANOPS) requires that conflict resolution be provided when equipment and workload permits. Conflict resolution requires either visual separation or a minimum of 500 feet vertically or 1 mile laterally.

As POE249 requested a VFR departure, its flight crew assumed responsibility for separation and reduced the spacing from other IFR aircraft that would be afforded to them by ATC.

At 0835, as per the Arrangement, the satellite controller informed the airport controller that POE406 was 20 nm to the east and cleared for a visual approach for Runway 08. The airport controller acknowledged this information and requested validation of the IFR clearance for POE249. The satellite controller validated the IFR clearance with the instruction to depart VFR.

For the next 2 minutes, the satellite controller became moderately busy, making approximately 15 transmissions pertaining to other aircrafts or units in the combined sectors. During the period leading up to the occurrence, aircraft transmissions sometimes overlapped communications with other ATC facilities.

At 0836, the airport controller cleared POE249 for take-off. In an attempt to ensure there was no conflict with local airport traffic, the airport controller retained POE249 on the tower frequency until it was 3nm east of the airport climbing through 1900 feet asl. When the airport controller released POE249 to the ACC frequency at 0837, the airport controller did not believe there to be a conflict with POE406 as the airport controller knew the satellite controller was aware of both aircraft.

At this time, POE406 was 10 nm east-southeast of the airport descending through 3300 feet asl. The satellite controller vectored POE406 by instructing it to fly heading 270° to accommodate POE249 departing. Forgetting that a clearance for an unrestricted visual approach had already been issued, the satellite controller informed POE406 that it would receive an approach clearance and frequency change shortly.

At 0837, POE249 attempted to contact the satellite controller advising that it was leveling at 2000 feet asl and in the turn to heading 141°. The satellite controller did not hear this call since he was busy communicating with a different controller regarding an unrelated control issue in the West satellite sector. The satellite controller then called the airport controller seeking communications with POE249. Sixteen seconds later, communication was established between POE249 and the satellite controller, and POE249 restated its position. Without acknowledging that transmission, the satellite controller immediately instructed POE406 to level off at 2500 feet asl. POE406 reported that it had already descended through 2300 feet asl but would climb back to 2500 feet asl.

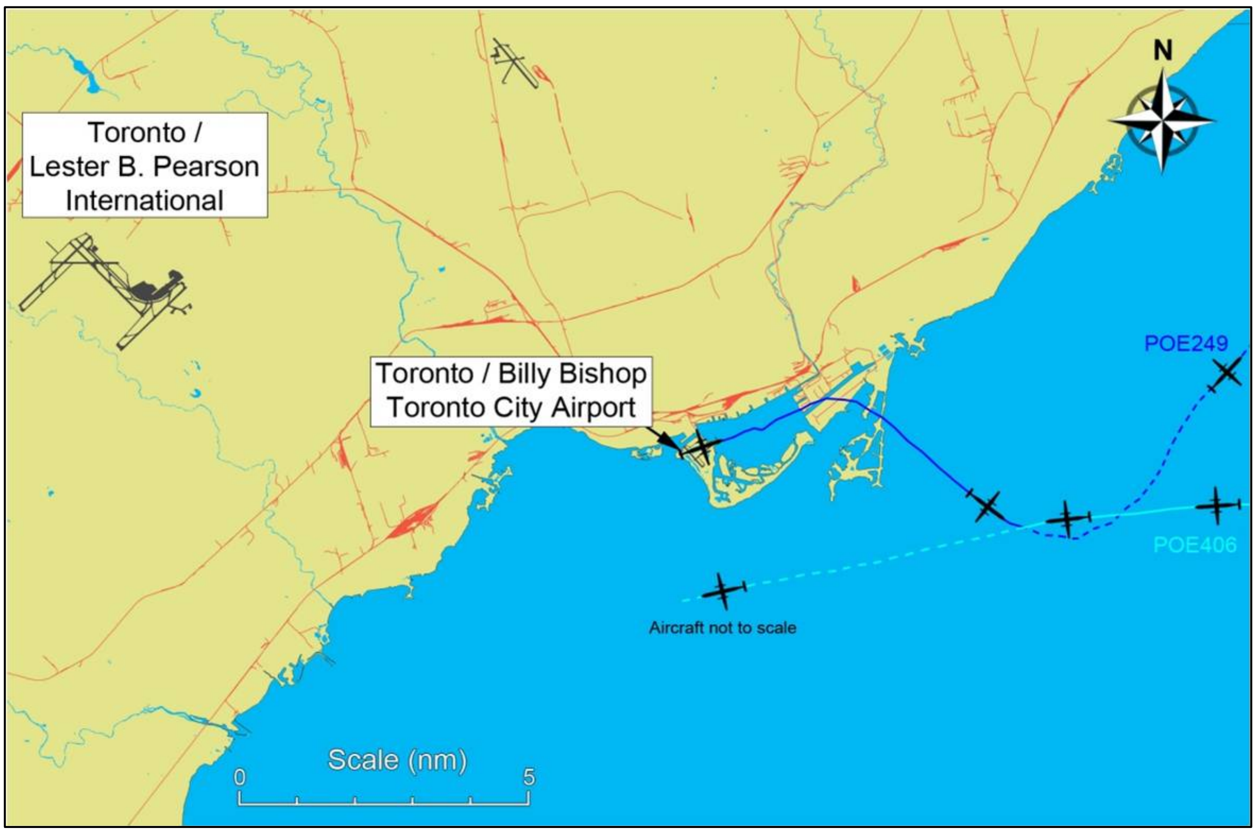

Figure 1. Flight Paths

At 0838, the satellite controller informed POE249 of the position of POE406 situated 1.5 nm away at 2300 feet asl. Six seconds later, POE249 reported the traffic in sight.

For 10 seconds, another aircraft transmitted on the frequency. During this time, both POE249 and POE406 received and responded to their respective traffic collision avoidance system (TCAS) resolution advisories. Seconds later, POE249 and POE406 crossed paths 300 feet vertically apart, 6 nm east southeast of Billy Bishop Airport (see Figure 1).

Controller History

The airport controller had been employed by NAV CANADA since 2006 and was certified and qualified in accordance with existing regulations. The airport controller had worked 5 consecutive days prior to this date as part of his regular schedule, and was considered well rested at the time of the occurrence.

The satellite controller had been employed by NAV CANADA since 2000 and was certified and qualified in accordance with existing regulations. The satellite controller's previous shift ended the evening before at 2300. Prior to this, the controller was off for 4 days. During this time off, the controller was attending to distressing personal matters that had been on-going since December 2009. Shortly after these personal matters began, the satellite controller's sleep quality diminished, and total sleep time was reduced to an average of 6 hours per night.

The satellite controller was not scheduled to work on this day but accepted an overtime shift and started work at 0700, having been called for this shift earlier that morning. At the time of the incident, the satellite controller was not well-rested.

Fatigue and Human Performance

Shortening a person's sleep time to less than what he or she requires results in fatigue. [4,5] Studies have also shown that the chronic restriction of sleep from 8 hours to 6 hours per night results in daytime fatigue. Fatigue will impair many facets of human performance. Impairments include reductions in memory and cognitive abilities. [6]

A controller's ability to maintain separation distances between aircraft as well as to predict separation distances from flight paths is dependent upon his or her working memory. Working memory refers to a memory system that temporarily stores information while it is being manipulated for tasks such as the problem solving and reasoning [7] as is required for maintaining and predicting separation between aircraft. It requires the simultaneous storage and processing of information. Working memory can be impaired by fatigue. [8]

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[4] A. M. Anch, et al., *Sleep: A Scientific Perspective,* New Jersey: Prentice-Hall, 1988.

[5] Tucker, P., Smith, L., MacDonald, I., & Folkard, S.,"Shift length as a determinant of retrospective on-shift alertness", *Scandinavian Journal of Work, Environment and Health*, 1998, 24(Suppl. 3), 49-54.

[6] See for examples:

(a) Dinges, D., Pack, F., Williams, K., Gillen, K., Powell, J., Ott, G., Aptowicz, C., and Pack, A. (1997) "Cumulative sleepiness, mood, disturbance, and psychomotor vigilance performance decrements during a week of sleep restricted to 4-5 hours per night" *Sleep*, 20(4), pp. 267-277.

(b) Ingre, M., Åkerstedt, T., Peters, B., Anund, A. & Kecklund, G. (2006). "Subjective sleepiness, simulated driving performance and blink duration: Examining individual differences", *Journal of Sleep Research*, 15, pp. 47-53.

[7] Baddeley, A. (1992). "Working memory", *Science*, 255(5044). pp. 556-559.

[8] See for examples:

(a) Dinges, D. (1992), "Probing the limits of functional capability: The effects of sleep loss on short –duration tasks", In Broughton, R. (Ed.) *Sleep, Arousal, and Performance*. Boston: Birkhäuser, pp. 177-188.

In addition to working memory, fatigue reduces cognitive abilities such as cognitive processing speed. The speed with which a controller can identify important information, process and react to it is a function of cognitive processing speed. Cognitive processing speed is reduced by fatigue. [9]

NAV CANADA Fatigue Management

A risk of fatigue-induced human performance decrements is inherent in all 24-hour operations. To address this risk, NAV CANADA developed a fatigue management program (FMP) which is integrated into its safety management system. The FMP includes a number of components such as controller education, preventative and operational strategies, controller scheduling practices, and the concept of shared responsibility. All operational controllers, including those involved in this occurrence, receive information on fatigue management during their basic and recurrent training.

The goal of the training is to encourage controllers to use operational and preventative strategies to help manage the risk of fatigue and related decrements in human performance. Preventative strategies are used before shifts to properly manage sleep-wake patterns and reduce the likelihood of fatigue. Operational strategies are used during a shift to maintain alertness and performance levels. These strategies include consuming caffeine, taking short physical activity breaks and changing the environmental conditions of the workplace.

One of the preventative strategies included is a questionnaire designed to assess whether or not a person is fatigued (see Appendix A). A set of questions is asked to draw attention to fatigue risk factors such as: personal fatigue signs and symptoms, acute sleep loss, cumulative sleep debt, time of day, circadian effects and hours of continuous wakefulness. If the answer is yes to the presence of any one of the risk factors, then the person may be fatigued. Use of the questionnaire is not mandatory. This questionnaire is briefly introduced during the training on fatigue. No instructions regarding when it should be used and by whom it should be used are provided. No other fatigue assessment is performed by either controllers or NAV CANADA.

In addition to the voluntary use of the questionnaire, the FMP relies on controllers to monitor their own fatigue and performance. The relationship between subjective levels of fatigue (i.e. how a controller feels) and estimates of future performance is complex and not completely understood.[10] Research seems to indicate that if a person notices that he or she feels some level of fatigue, he or she may be able to correctly estimate that they will not be able to do their job optimally.[11] However, research also shows that if a person is in a stimulating environment [12]

(b) Galy, E., Mélan, C., & Cariou, M. (2008). *Investigation of task performance variations according to task requirements and alertness across the 24-h day in shift workers*. Ergonomics, 51(9), pp. 1338-1351.

9 See previous note.

10 Rogers, N., & Dinges, D. (2003). *Subjective surrogates of performance during night work.* Sleep, 26, pp. 790-791.

11 Dorrian, J., Lamond, N., & Dawson, D. (2000). *The ability to self-monitor performance when fatigued*. Journal of Sleep Research, 9, pp. 137-144.

12 Yang, C., Lin, F., & Spielman, A. (2004). *A standard procedure enhances the correlation between subjective and objective measures of sleepiness*. Sleep, 27, pp. 329-332.

they may not notice that they are fatigued and may not be able to predict that performance may be impaired.

There is currently no agreed upon, reliable and valid standard for assessing subjective fatigue that correlates well with objective measures of fatigue and risk of accidents. The relationship between subjective fatigue questionnaires and objective measures of fatigue is unclear. Some subjective estimates of fatigue (e.g. Visual Analogue Scale (VAS) and Stanford Sleepiness Scale (SSS)) do not correlate well with objective measures of fatigue (e.g. Multiple Sleep Latency Test (MSLT) and number of lapses during a tap test).[13]

Analysis

The satellite controller was unable to create and maintain a complete mental image of POE249's position and predicted flight path with that of the arriving flight path of POE406 in working memory. When validating POE249's departure, the satellite controller did not remember that POE406 had been cleared for an unrestricted visual approach and, as a result, likely did not anticipate the conflict with POE406. This is supported by the fact that the satellite controller later informed POE406 that it would receive an approach clearance and frequency change shortly.

The vector to POE406 and subsequent reference to company traffic suggests the satellite controller did eventually recognize the potential conflict. However, it took time before the satellite controller understood that the conflict had progressed to the point where action had to be taken. Because of the relative lateness of the communication transfer of POE249 and its proximity to POE406 and other workload, the satellite controller did not have time to issue appropriate avoidance instructions.

The controller was moderately busy working the combined sectors with multiple overlapping transmissions. This likely reduced the opportunity for the satellite controller to recognize the conflict and take earlier action to resolve the conflict.

Fatigue results in working memory and cognitive processing impairments. In complex information systems, such as air traffic control, a reduced cognitive processing speed can cause a delay in realizing that a potentially dangerous situation exists. Impaired working memory can also result in difficulty maintaining a complete mental image of complex situations such as aircraft departures, approaches, flight paths and separation distances. These impairments are consistent with the events observed in this occurrence.

A normal nightly sleep requirement is about 8 hours. The satellite controller had been operating with roughly 6 hours of sleep per night for about 5 months. The satellite controller was chronically sleep-deprived and was, therefore, fatigued at the time of the occurrence. This fatigue likely resulted in the impaired working memory and reduced cognitive processing speed of the satellite controller.

Dinges, D. & Graeber, R. (1989). *Crew fatigue monitoring. Flight Safety Foundation*: Flight Safety Digest, October, 65-75.

13 Johnson, L., Freeman, C., Spinweber, C., & Gomez, S. (1988). *The relationship between subjective and objective measures of sleepiness.* Report No. 88-50, Naval Health Research Center: San Diego, CA

NAV CANADA's Fatigue Management Program (FMP) relies partly on controllers to monitor their own fatigue and performance. The fatigue questionnaire was voluntary and was not used by the satellite controller. In addition, the stimulation of the work environment likely prevented the controller from noticing his level of fatigue. Therefore, unacceptable levels of fatigue and performance decrements while on duty may not always be identified.

Findings as to Causes and Contributing Factors

1. The satellite controller did not initially recognize the potential conflict between the POE249's departure and POE406's arrival when validating POE249's departure.

2. The satellite controller did not remember that an approach clearance without restriction had already been issued to POE406.

3. The controller was moderately busy working the combined sectors which contributed to the late recognition of the conflict. There was insufficient time to take corrective action, resulting in a risk of collision.

4. The satellite controller was fatigued, thus resulting in working memory and cognitive processing impairments.

Finding as to Risk

1. Reliance on controllers monitoring their own level of fatigue may not always effectively identify unacceptable levels of fatigue.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 22 December 2011.

Visit the Transportation Safety Board's website (www.bst-tsb.gc.ca) for information about the Transportation Safety Board and its products and services. There you will also find links to other safety organizations and related sites.

Appendix A

NAV CANADA Fatigue Questionnaire

When you become fatigued, you lose the ability to judge your own level of alertness. Typically, you overestimate your level of alertness when fatigued. Despite this decreasing accuracy as you become fatigued, you can teach yourself to better recognize your personal signs of fatigue and to recognize personal factors in yourself and others. Use the following checklist to help you better assess your current level of alertness and fatigue.

PERSONAL FATIGUE SIGNS & SYMPTOMS *Yes* *No*

(Write in your personal fatigue signs and symptoms below)
1. Example: My eyes are red and itchy
2. ___________ _______ _______
3. ___________ _______ _______
4. ___________ _______ _______
5. ___________ _______ _______

PERSONAL FACTORS

Acute Sleep Loss

6. Have you gotten 2 hours less sleep than your body requires in the last 24-hours? (For example, if you need 8 hours of sleep each 24-hours, did you get less than 6 last night?) _______ _______

Cumulative Sleep Debt

7. Have you been unable to get 2 consecutive nights of at least 8 hours of sleep in the past 5 days? _______ _______

Time of Day/Circadian Effects

8. Are you in a period of internal body clock / circadian low between 3-5 am or 3-5 pm? _______ _______

Hours of Continuous Wakefulness

9. Have you been awake for longer than 16 hours? _______ _______

If you answered “No” to all of the questions above, you are probably well rested. The more questions to which you answered “Yes”, the less likely you are to be well rested. A “Yes” answer to any of the question above is an indication that you may be fatigued.