

Transportation Safety Board
of Canada



Bureau de la sécurité des transports
du Canada

AVIATION INVESTIGATION REPORT

A07W0072



LOSS OF SEPARATION

NAV CANADA EDMONTON AREA CONTROL CENTRE

WESTJET AIRLINES

BOEING 737-800 C-GWSA

BOEING 737-600 C-GWSI

CALGARY, ALBERTA, 50 nm SSW

18 APRIL 2007

Canada

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

Aviation Investigation Report

Loss of Separation

NAV CANADA Edmonton Area Control Centre

WestJet Airlines

Boeing 737-800 C-GWSA

Boeing 737-600 C-GWSI

Calgary, Alberta, 50 nm SSW

18 April 2007

Report Number A07W0072

Summary

The WestJet Boeing 737-800, C-GWSA, flight WJA 42, was en route from Vancouver, British Columbia, to Calgary International Airport (CYYC), Alberta. A second WestJet aircraft, Boeing 737-600, C-GWSI, flight WJA 178, was en route from Comox, British Columbia, to CYYC. When the aircraft were in the vicinity of the OPALE intersection, southwest of the Calgary very high frequency omnidirectional radio range, air traffic control issued delaying radar vectors to both aircraft, accompanied by clearances for them to descend to flight level 260. Both aircraft were subsequently cleared direct OPALE intersection and at 2245:45 mountain daylight time, separation between them was reduced to 4.7 nautical miles (nm) laterally and 70 feet vertically where the required separation was 5 nm laterally or 1000 feet vertically. Both aircraft received traffic alert and collision avoidance system resolution advisories and performed avoidance manoeuvres. The air traffic control conflict alert system activated.

Ce rapport est également disponible en français.

Other Factual Information

The digital flight data recorder (DFDR) information from both aircraft was analysed, and the results were correlated with radar information, air traffic control (ATC) communications, and flight crew observations.

Due to poor weather conditions throughout the day at Calgary International Airport (CYYC), only one runway was available to most aircraft and the airport acceptance rate was reduced. To accommodate the reduced acceptance rate, ATC imposed flow control procedures that limited arrivals to 22 per hour by initiating a ground delay of flights at their departure points, and by metering inbound flights. Metering was accomplished by slowing aircraft, issuing holds at certain fixes and issuing delaying radar vectors. With traffic levels decreasing as the evening progressed, flow control was cancelled at 2230 mountain daylight time.¹ However, holding and vectoring delays were still required for some inbound flights.

The Calgary En route Specialty of the Edmonton Area Control Centre (ACC) comprised five sectors covering controlled airspace below flight level (FL) 290: Banff, Rocky Mountain House, Red Deer, Alsask, and Medicine Hat (see Figure 1). Overlying those sectors from FL 290 and above were three Alberta High sectors: Lethbridge, Drumheller, and Canmore.

Until 2230 on the day of the occurrence, the Alsask sector position controlled the south and east sectors of the specialty, with the Banff sector position controlling the north and west sectors. The Alsask and Banff controllers were also responsible for Alberta High sector airspace immediately above their sectors.

With normal levels of traffic and controller workload, all airspace in southern Alberta, except for terminal airspace, would routinely be combined into one position in the late evening, prior to commencement of the midnight shift at 2230. This southern Alberta airspace was designated as the Calgary En route Midnight Configuration. The midnight configuration was usually staffed by one radar controller and one data controller. Because of the workload imposed by flow control, two controllers from the evening shift agreed to extend their shift to augment the midnight shift staff.

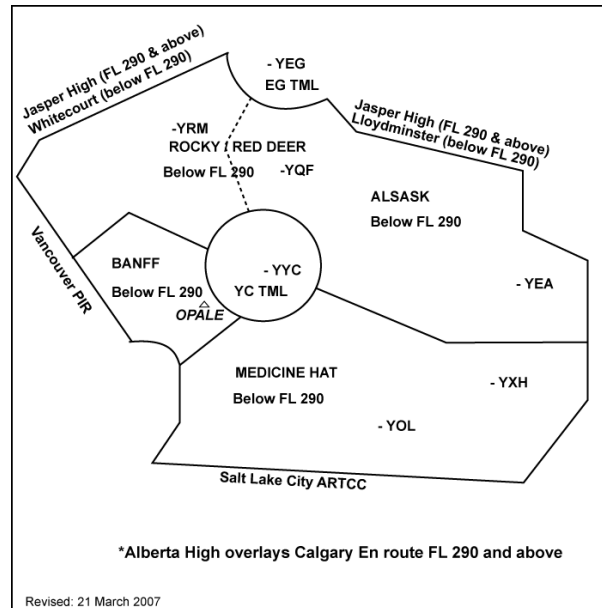


Figure 1. Calgary En route Specialty

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

The Edmonton ACC provided general guidelines for controllers, ACC shift managers, and team supervisors for the opening and closing of operating positions.² The guidelines indicated that the responsibility for opening and closing positions associated with combining and splitting of sectors rested with a team supervisor or shift manager. In the absence of a team supervisor or shift manager, this responsibility could be delegated to the controllers. In practice, shift managers were usually not involved in sector management, including combining and splitting of sectors. Controllers in the Calgary En route Specialty were not provided with specific training on applying these guidelines.

On the day of the occurrence, due to the workload associated with the Calgary flow control, a controller was appointed as acting team supervisor for the evening shift. In the Calgary En route Specialty, a team supervisor was not regularly scheduled for the midnight shift and the acting supervisor ended his shift at 2215.

At 2230 on the day of the occurrence, the sectors were still split due to the weather and flow control into CYYC. At 2234, the Alsask and Banff controllers, who were handling both radar and data functions at their individual positions, made the decision to combine their sectors based on their individual workloads.

When the relieving controller arrived to begin his midnight shift, he was informed that the sectors were in the process of being combined. He took the radar position at the Alsask sector console. The Banff sector controller brought his data strips to the Alsask console and the previous Alsask sector controller assumed the combined configuration data position. The Banff controller briefed the relieving controller and the data controller on the traffic in the combined sector. The relieving controller then became responsible for the Calgary En route combined radar position. This resulted in the two Calgary En route midnight configuration controllers being responsible for all southern Alberta En route controlled airspace.

Although the requirement for flow control had just ended, the traffic level was considered to be moderate. The complexity was higher than normal for the time of day due to the flow control. In the 12 minutes preceding the sector combination, the Alsask and Banff controllers conducted an average of 6.0 and 6.2 communications per minute respectively, with each peaking at 11 per minute. After the sectors were combined, the relieving controller conducted an average of 11.7 communications per minute, peaking at 17 per minute (see Figure 2). When the relieving controller took his position, he was responsible for 20 aircraft in the combined sector.

² Operations Letter, Edmonton Area Control Centre No. 04/013, 24 March 2004.

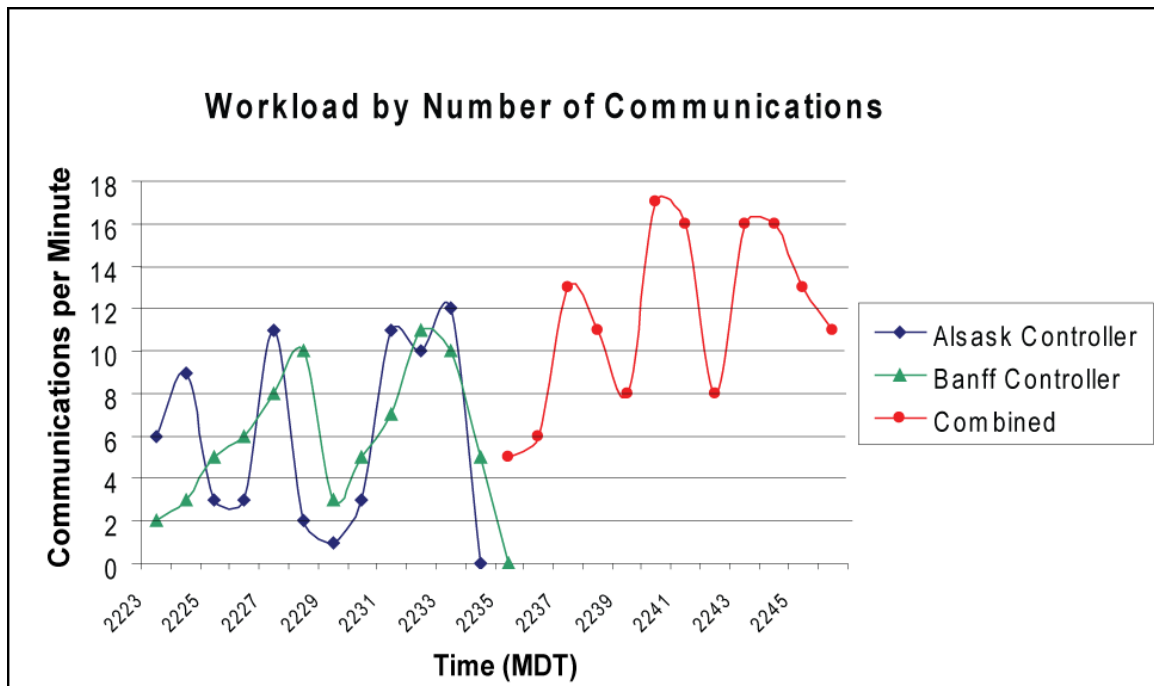


Figure 2. Workload by number of communications

The position handover briefing was recorded (by digital audio) in accordance with the NAV CANADA *Air Traffic Control Manual of Operations (ATC MANOPS)*. However, the recording was incomplete because part of it was done in open air conversation. For the same reason, the details of the sector consolidation briefing were not recorded.

Upon taking his position in the combined configuration, the relieving controller's attention was divided between Calgary arrivals, departures, and overflights in the eastern and western portions of the combined sector. In addition to dealing with metering tactics, the controller had to spend time dealing with confusion over the intentions of an overflight in the eastern portion of his airspace.

Five aircraft were inbound to CYYC from the west, in trail, about 12 nm apart on Airway J 504. KFA 274 was in the lead, followed by JZA 8525, WJA 42, WJA 178, and JZA 8556. To space arrivals, Calgary Terminal Control issued specific aircraft fix crossing times to the en route sector controllers. The crossing times for OPALE intersection³ were the times the aircraft were to depart the fix and join the OPALE 8 standard arrival route (STAR) into Calgary.

³ OPALE intersection was a fix with a published holding pattern near the eastern edge of the Banff sector, located 45 nm west of the Calgary very high frequency omnidirectional radio range (VOR) on Airway J 504.

An OPALE crossing time of 2240 for the first aircraft in the stream had been issued by Calgary Terminal Control. Before transferring the sector to the relieving controller, the Banff controller cleared the flight to hold at OPALE as published.⁴ The Banff controller informed the other four aircraft that there would likely be a hold at OPALE before proceeding to Calgary; however, no holding clearances were issued. In the sector handover briefing, the relieving controller was informed of the holding clearance for the first aircraft, but not of the specific holding status of the remaining four eastbound aircraft. The Banff controller had implied that all five inbound aircraft had been issued holding clearances at OPALE, and the relieving controller was under that impression. In fact, the first aircraft was the only aircraft that had been given such a clearance. At 2237:09, the first aircraft (KFA 274) called entering the hold, and the relieving controller cleared the aircraft for one orbit before proceeding to CYYC.

Before entering the Edmonton ACC airspace, WJA 42 and WJA 178 were cruising at FL 390 with 13 nm lateral separation. Both flights had been cleared to descend by the Banff controller before turning the flights over to the relieving controller.

When the crew of WJA 178 called the relieving controller level at FL 290 and inquired about a hold at OPALE, they were informed that all aircraft would be given vectors. At 2238:42, WJA 178 was instructed to turn right to 130°magnetic (M). After the second aircraft (JZA 8525) had proceeded past OPALE at 2239:50 without entering a hold, the relieving controller was informed by the observing Banff controller that the aircraft did not have a holding clearance.

The relieving controller then issued the second aircraft a vector to 170°M, with subsequent instructions to continue the turn to take the aircraft directly to the HANDA fix for the arrival procedure. At 2240:40, when it was 2 nm west of OPALE, WJA 42 was instructed to turn right to 160°M. When WJA 42 called level at FL 280 at 2241:37, the flight was cleared to FL 260. At 2243:16, WJA 178 was instructed to turn left direct to OPALE and was also cleared to FL 260. WJA 42 was then instructed to turn right, direct to OPALE.

At 2245:18, WJA 178 was descending through FL 265 and the Banff controller, who was still monitoring the position, drew the relieving controller's attention to the impending conflict. The relieving controller instructed the flight to climb to FL 270 and did not give a reason nor imply any degree of urgency in the first call. Although the crew members of WJA 178 did not acknowledge this instruction, they began the process of initiating a normal climb. Seven seconds after the first call, the controller repeated the instruction. The crew acknowledged the second call by 2245:28. Before the crew could arrest the descent and begin a climb, the aircraft reached FL 261. At 2245:30, WJA 42, which was level at FL 260, was instructed to descend immediately to FL 250. The controller made two more calls before the crew of WJA 42 acknowledged the instruction.

At 2245:33, when the aircraft were separated by 6.6 nm laterally and 350 feet vertically, the traffic alert and collision avoidance system (TCAS) in both aircraft generated simultaneous resolution advisories (RAs). WJA 42's TCAS issued a "do not descend" RA that was followed

⁴ To simplify clearances for holding procedures at fixes, information is published in NAV CANADA charts depicting holding orientation relative to the fix and direction of turns. The published hold at OPALE featured an inbound track of 055° with right-hand turns.

immediately by a “climb” RA (see Appendix A). The captain, who was the pilot flying, disconnected the autopilot and obeyed the RA. Eight seconds after the “climb” RA, the WJA 42 TCAS command changed to a “descend” RA. The captain obeyed that advisory while tightening the right turn in response to the position of WJA 178 appearing on his TCAS display.

An aural bank angle warning occurred in WJA 42 when the bank angle exceeded 35° and 40°. ⁵ This alert and an autopilot disconnect aural alert occurred at approximately the same time the controller was calling WJA 42 with instructions to descend. The crew was occupied with responding to the RAs, controlling and monitoring the aircraft, and cancelling the aural warnings.

At the same time that WJA 42 received the initial TCAS RA to climb, WJA 178 received an RA to descend. Within six seconds and coinciding with the WJA 42 “descend” RA, the WJA 178 RA changed to “climb.” Five seconds later, at 2245:45 the WJA 178 TCAS again commanded a descent. It is normal for TCAS to adjust commands as it recalculates changing position and altitude trends of conflicting aircraft. The controller was not informed of the TCAS RAs by the flight crews until after separation was regained.

The controller received a traffic alert at 2245:38, followed by a conflict alert at 2245:48. At that time, WJA 42 was on a heading of 201°M at FL 261, and WJA 178 was on a nearly reciprocal heading of 012°M at FL 261 (see Appendix B). The conflict ended at 2245:57 when separation increased to 3.5 nm laterally and 1200 feet vertically, with the aircraft on diverging tracks and altitudes.

Conflict Alert System

The conflict alert system is a function of the radar data processing system, which examines radar tracks for potential conflicting traffic. Based on three-dimensional predicted positions, tracks are evaluated to determine if separation standards will be violated within a specified time. Alerts are generated and sent to the displays in two stages. Sixty seconds before loss of separation is predicted, a traffic alert is generated. A conflict alert is generated after separation is lost. ATC conflict alerts in the airspace where the occurrence took place were set at separation parameters of less than 5 nm laterally and 800 feet vertically.

Source: Adapted from NAV CANADA Conflict Alert DSC Manual, version 3.1

The aircraft were clear of cloud at the time of the occurrence. The crew members of WJA 178 saw WJA 42 pass in front of them from right to left and slightly below them during the second TCAS RA. The crew of WJA 42 did not see WJA 178. As a result of the vectoring, the order of the aircraft on the inbound leg to Calgary was reversed, with WJA 178 leading WJA 42.

⁵ The ground proximity warning system in the Boeing 737-800 provides the aural alert “Bank Angle, Bank Angle” when the roll angle exceeds 35 degrees, 40 degrees, and 45 degrees. Once sounded, the alert is silent for that bank angle until the system is reset by decreasing the bank angle to 30 degrees or less.

The relieving controller was licensed in September 2005 and all of his experience was in the Calgary En route Specialty. He was beginning the final day of a seven-day work period. The previous day, he was in training until 1415 and was off duty for 32.25 hours before reporting for the midnight shift at 2230 on the evening of the occurrence. He was considered to be well rested.

The Banff controller was licensed in 2005 and had two years' experience in the Calgary En route Specialty. This was his second shift after returning from two days off.

The Alsask controller, who occupied the data position in the combined configuration, had 10 months of experience as a controller in the Calgary En route Specialty. He also had 14 years of foreign ATC experience. This was his second shift following two days off; he reported for duty after 24 hours off since ending his previous shift.

The NAV CANADA ATC MANOPS had guidelines for phraseology which air traffic controllers should use to impart a level of urgency to an instruction, such as the wording "immediately."

As a delaying tactic for flow control, vectoring of aircraft usually involves a higher communications workload compared to issuing clearances for a published hold at a fix. The vectoring controller assumes ongoing responsibility for aircraft navigation, lateral spacing, and terrain clearance. A holding clearance generally involves a lower controller workload because the pilot maintains responsibility for navigation. The controllers in the Calgary En route Specialty, including those involved in the occurrence, generally preferred to issue vectors for delays of three minutes or less. For longer delays, holds on a fix or 360-degree turns would be used.

Analysis

The following factors formed a chain of safety-significant events leading to the loss of separation:

- WJA 42 and WJA 178 were vectored on converging courses;
- the two aircraft were cleared to the same altitude;
- the two aircraft were turned towards each other for their return to OPALÉ;
- the Calgary En route sectors were combined prematurely; and
- the two vectored aircraft were not adequately monitored by the Calgary En route radar controller.

There was no team supervisor in the Calgary En route Specialty at the time the airspace was combined into the midnight configuration. Controllers in the specialty were routinely allowed to combine sectors without management approval; the on-duty shift manager was not consulted about the combination as stipulated in NAV CANADA policy. Therefore, there were no checks on the decision by the three specialty controllers to combine their sectors. Their decision was based on their individual workloads and adherence to an established routine in the specialty of going to the midnight configuration by 2230. The residual traffic level and complexity arising

from the Calgary flow control was not consistent with normal levels for combining the sectors. Therefore, combining the Calgary En route Southern Alberta airspace into the midnight configuration was premature.

Although the relieving controller's communication workload was reduced to some degree by having a data controller in position, his overall workload in the combined airspace was nearly equal to the total of the two split-sector controllers. He was dealing with a complex traffic situation over a wide geographic area that included several aircraft in the eastern portion of the combined airspace. This required splitting his attention and affected his monitoring of the inbound traffic from the west. Before the loss of separation occurred, one of the aircraft ahead of WJA 178 had already overflowed OPALE and was nearly in Calgary terminal airspace before the controller issued a delaying vector.

When the relieving radar controller took the handover for the combined sector, the Banff sector controller did not clearly indicate what specific flow control instructions had been issued to the five aircraft inbound from the west. The relieving controller believed all the flights had been issued holding clearances at OPALE. Only the first aircraft in the stream inbound to OPALE had a specific OPALE crossing time. Although the Banff controller had indicated to the other four aircraft crews that holds were planned, no clearances had been issued. When the first aircraft called entering the hold at OPALE, the relieving controller's impression that all aircraft would hold at OPALE was reinforced. However, when WJA 178 inquired about a hold, the controller realized that holding clearances were not issued. He was forced to devise a plan to meter the remaining four eastbound flights and his decision was to vector all of the aircraft.

Issuing delaying vectors would have injected a higher level of complexity into the controller's traffic situation. When the controller was developing a plan to ensure the required spacing of aircraft over OPALE, the controller cleared WJA 178 and WJA 42 to the same altitude - flight level 260. The controller did not notice that this created the potential for the loss of separation that eventually occurred. His workload could have been reduced by clearing the eastbound flights to hold as published at OPALE. A momentary lapse of attention to holding aircraft at stacked altitudes would have been less likely to generate a loss of separation due to converging aircraft.

When the controller became aware of the impending conflict, his first climb instruction to WJA 178 did not indicate a degree of urgency. The crew's initial response was therefore not as timely as the situation warranted; the vertical separation between the aircraft was possibly affected by this.

When the crew members of WJA 42 responded to the initial RA, their attention was focussed on flying the aircraft and monitoring the aural alarms for bank angle and autopilot disconnect alerts. Although they responded to their TCAS RAs, they did not acknowledge the controller's first two instructions to descend. Both flight crews responded correctly by following the commands of the RAs rather than following conflicting ATC instructions.

The following TSB Engineering Laboratory report was completed:

LP 038/2007 - FDR Analysis

This report is available from the Transportation Safety Board Canada upon request.

Findings as to Causes and Contributing Factors

1. While WJA 42 and WJA 178 were manoeuvring on converging vectors, the aircraft were inadvertently turned toward each other at the same altitude and a loss of separation resulted.
2. The Alsask and Banff sector controllers combined all the individual sectors prematurely, resulting in a high workload for the combined airspace radar controller. This adversely affected his monitoring of WJA 42 and WJA 178 while they were on delaying vectors and resulted in the loss of separation.
3. The handover briefing for the relieving controller did not clearly indicate what flow control provisions had been established for all aircraft inbound from the west. This affected his awareness of the traffic situation and increased his workload by requiring him to develop a traffic-metering plan for four inbound aircraft in a relatively short period of time.

Finding as to Risk

1. The relieving controller did not impart urgency to the initial instruction for WJA 178 to climb in response to the impending loss of separation. It is possible that the resulting delay in the crew's reaction affected the vertical separation of the two aircraft.

Other Findings

1. The complete handover briefing between the Banff controller and the relieving controller was not in accordance with the *Air Traffic Control Manual of Operations* (ATC MANOPS). This affected the evaluation of the briefing.
2. Clearing eastbound flights to hold, as published at OPALE, would have reduced the combined sector workload.

Safety Action Taken

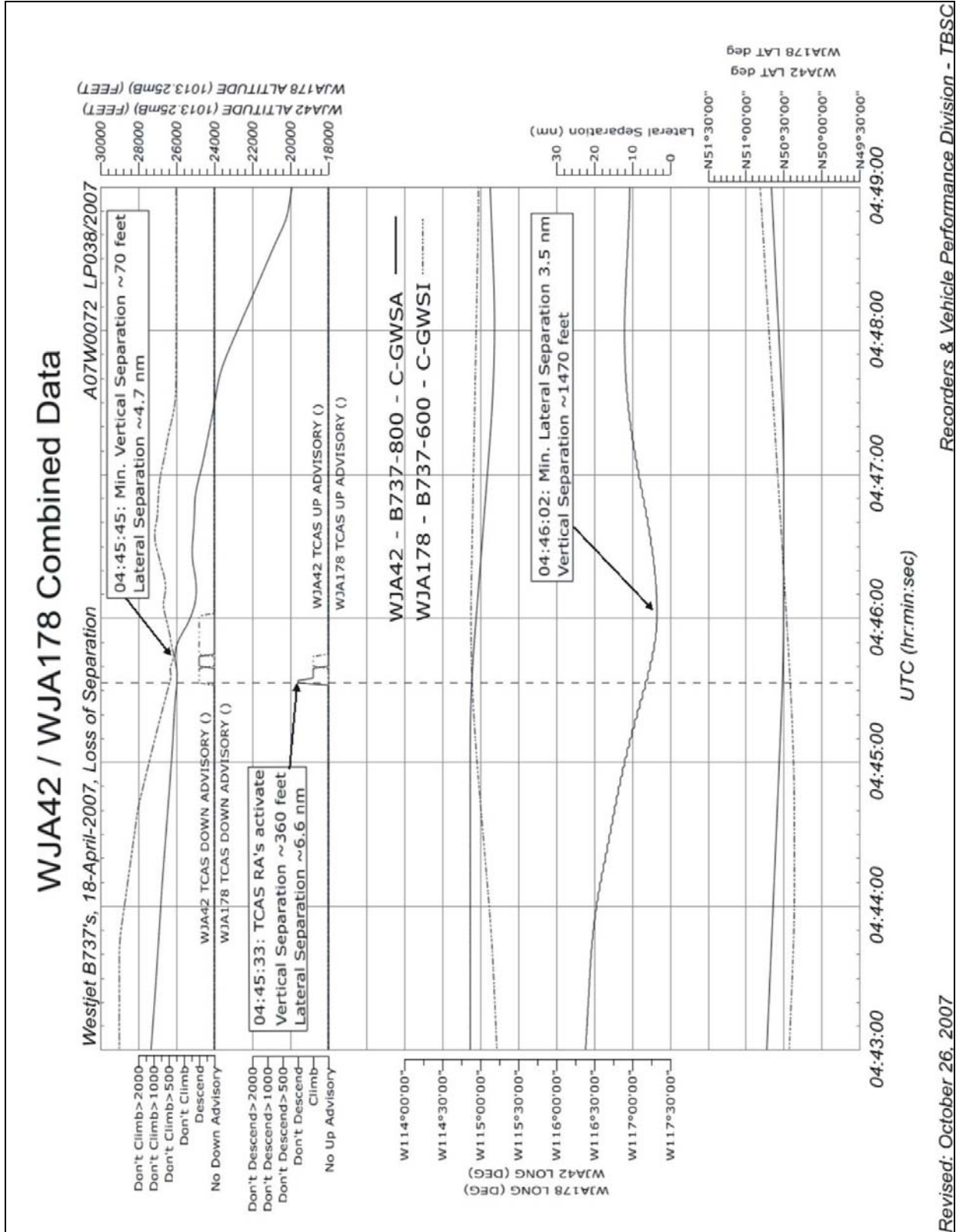
NAV CANADA notified the TSB that the following actions have been taken in response to this occurrence:

- The relieving controller underwent a post-operating irregularity recertification that included attention to sequencing procedures and phraseology.
- NAV CANADA issued Operations Bulletin 08/063 (12 March 2008) reminding controllers of the content of the *Air Traffic Control Manual of Operations* (ATC MANOPS) 507 Safety Alert, which provides direction, phraseology samples, and a discussion regarding advice to aircraft of unsafe conditions.
- The Edmonton Area Control Centre began a project on 12 March 2007 to vertically split airspace over Alberta and Northern British Columbia, resulting in a new specialty – Alberta High, controlling flight level 290 and above. At the time of the occurrence, Calgary En route still controlled the airspace over the Banff, Rocky-Red Deer, and Alsask sectors.
- As of 04 January 2008, this airspace was transferred to Alberta High, achieving a full high-low airspace split. This has resulted in reduced workload, frequency congestion, and complexity.
- All airspace over Alberta in the Calgary En route midnight configuration, excluding the two terminal control areas, would previously have been controlled by two controllers. As of 18 April 2008, a minimum of three controllers will provide traffic services during the midnight configuration.
- NAV CANADA re-issued Operations Bulletin No. 04/013 (12 March 2008) as Operations Letter No. 08/015, containing guidelines for opening and closing sectors.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 27 May 2008.

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Appendix A – Combined Digital Flight Data Recorder Data, WJA 42 / WJA 178



Appendix B – Plan View of Flight Paths, WJA 42 / WJA 178

