Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A05A0161

WING CONTACT WITH RUNWAY DURING LANDING

WESTJET AIRLINES
BOEING 737-700 C-GWJF
HALIFAX INTERNATIONAL AIRPORT, NOVA SCOTIA
25 DECEMBER 2005

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

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Summary

A WestJet Airlines Boeing 737-700 (registration C-GWJF, serial number 32766), operating as Flight 798 (WJA798), was on a scheduled passenger flight from Toronto, Ontario, to Halifax, Nova Scotia. Just before touchdown on Runway 14 in low-visibility conditions, the aircraft rolled right and moved toward the right side of the runway. The aircraft then rolled to the left, and the left wing struck the runway. None of the passengers or crew members were injured, and the aircraft taxied to the terminal. The incident occurred at 1924 Atlantic standard time, during the hours of darkness.

Ce rapport est également disponible en français.

Other Factual Information

The flight crew reported for duty in Regina, Saskatchewan, at 0910 Atlantic standard time[1] on the morning of 25 December 2005 to operate a series of flights from Regina to Calgary, Toronto, and Halifax, where their duty day would end. While on the ground in Toronto, the crew requested the latest runway visual range (RVR) report for Halifax, from the operator's dispatch personnel, through the aircraft communications addressing and reporting system (ACARS). They received a reply advising that the RVR at Halifax was 1100 feet, or 100 feet below the minimum approach ban[2] visibility of 1200 feet.

The report did not specify, nor did the crew ask for, the applicable runway or time of the RVR report. The RVR report was actually for Runway 14, and the RVR at the time on Runway 23 was 900 feet. There was no guidance for dispatchers in the company operations manuals on informing flight crews of the applicable runway or time for RVR reports.

The captain had requested that additional fuel be loaded on the aircraft because of the reported weather in Halifax. The captain's plan was to conduct a Category II instrument landing system (ILS) approach to Runway 23 at Halifax, if the visibility was at or above landing limits when they arrived. St John's, Newfoundland and Labrador, had been filed as the alternate airport if a landing in Halifax was not possible. The passengers were advised of the poor weather in Halifax, and of the possibility of not being able to land. The aircraft departed Toronto at 1748 with 132 passengers and 6 crew members on board. For this leg of the flight, the co-pilot, who was in the right seat, was the pilot flying (PF). The captain, who was in the left seat, was the pilot not flying (PNF).

While en route to Halifax, the crew requested and received another RVR report for Halifax through ACARS. The report indicated that the RVR at Halifax had improved to 1400 feet, or 200 feet above the minimum approach ban visibility. The report was for Runway 14, and again there was no indication of which runway the report referred to. The crew continued to assume that it was for Runway 23. This assumption was reinforced when the crew also received the automatic terminal information service (ATIS) report for Halifax, which indicated that the active runway was Runway 23. Based on the ATIS information, the crew planned for a Category II ILS approach for Runway 23 with an auto-land, and completed an approach briefing. The aircraft was being flown on autopilot, and it remained on autopilot until just before landing.

The crew requested and received descent clearance from the Moncton Area Control Centre. While in descent through 16 000 feet, the crew contacted Halifax terminal arrival control and informed the controller that they were planning the Category II ILS approach and landing on Runway 23. The controller informed the crew that the RVR for the approach end of Runway 23

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1 All times are Atlantic standard time (Coordinated Universal Time minus four hours).

2 Section 602.129 of the *Canadian Aviation Regulations* specifies that approaches are governed by RVR values only. With certain exceptions, pilots of aircraft are prohibited from completing an instrument approach past the final approach fix to a runway served by an RVR if the RVR values as measured for that runway are below 1200 feet.

was 1000 feet, and that the RVR for Runway 14 was 1200 feet. A short time later, because the RVR was below limits on Runway 23, the crew requested and received a clearance for the Category I ILS on Runway 14. This required the crew to reprogram the flight management system (FMS) computer, and re-brief for the new approach.

About 10 minutes before landing, the crew was advised that another aircraft had just landed on Runway 14, and that the pilots of that aircraft had reported that they had the runway lights visual at 250 feet above ground level (agl). This is 50 feet above the decision height (DH) for the ILS approach to Runway 14.

When WJA798 was established on final approach, the crew contacted the Halifax control tower and was informed that the wind was calm and that the RVR for Runway 14 was now 1400 feet. The tower controller cleared WJA798 to land.

The final approach on autopilot was stabilized and uneventful. The PNF observed the approach lights at 200 feet agl (the DH for the approach), and the PF transitioned from monitoring the flight instruments to acquiring visual references for the landing. After passing the approach lights, the runway environment appeared very dark and the visibility was such that finding visual cues was difficult for the PF.

The aircraft remained aligned with the runway and on the ILS glide path until, at 67 feet agl,[3] the PF disconnected the autopilot. Immediately after, the PF unintentionally rotated the control column approximately 30 degrees clockwise towards right-wing-down, and also moved it slightly aft. This resulted in the aircraft rolling to the right and levelling off. The aircraft went above the glide path, and deviated three degrees from the runway heading to a heading of 147 degrees.

At 22 feet agl, the PF unintentionally depressed the take-off/go-around (TOGA) switch on the throttles instead of the auto-throttle disconnect switch. This was followed by immediate selection of the auto-throttle disconnect. The operator's standard operating procedures (SOPs) require that the auto-throttles be disconnected at no lower than 50 feet agl. The aircraft deviated to the right of the runway centreline. The PF attempted re-alignment using rapid and aggressive left and right control wheel movement. The captain gave verbal instructions to descend and turn left almost immediately after the deviations from the approach path, indicating that he had sufficient visual cues to correctly assess the aircraft's displacement.

The aircraft touched down firmly on the left main landing gear at about 2500 feet from the runway threshold, between the centreline and the right edge of the runway, with 16 degrees of left bank. Concurrently, the left wing contacted the runway surface for approximately one-half second. The left main landing gear strut then extended to nearly full length, and the left bank increased to 18 degrees. The wing contacted the runway again for approximately two seconds, and simultaneously, the aircraft heading deviated left to 136 degrees, or 8 degrees left of the runway heading.

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[3] The operator's standard operating procedures (SOPs) state that, when carrying out a Category I approach, the autopilot must remain coupled until at least DH and be disconnected by no lower than 50 feet agl for a manual landing.

The aircraft settled onto both main landing gears five seconds after the left main gear made contact, approximately 3550 feet beyond the runway threshold. After the nose gear touched down, heavy wheel braking was used to slow the aircraft. Eight seconds after nose gear touchdown, after being prompted, the PF applied reverse thrust on both engines. Deployment of reverse thrust occurred approximately 5300 feet beyond the runway threshold. The aircraft slowed to taxi speed with approximately 500 feet of runway remaining. The aircraft taxied uneventfully to the assigned gate at the terminal.

The engines were shut down at the gate. During normal ground inspection of the aircraft, it was determined that the left wing tip, outboard leading edge flap, aft position light, and outboard flap canoe tail cone had been damaged. The aircraft was removed from service until repairs could be affected.

There were no other discrepancies or malfunctions found with the aircraft systems. The flight data recorder (FDR) and cockpit voice recorder (CVR) were removed and sent to the TSB Engineering Laboratory for analysis. High-quality data was recovered from both recorders. The CVR circuit breaker had not been pulled after the damage was discovered, and as a result, only the final five minutes of the approach and landing were captured on the two-hour recording. The CVR continued to operate after the aircraft had landed resulting in occurrence information being overwritten; therefore, the investigation team was deprived of possible important information relative to the occurrence.

There have been at least eight other occurrences where the CVR had been overwritten because of the limited duration of recording and/or the recorder had been allowed to run after the occurrence without recognition that data were being lost (see Appendix B for details). The TSB recently issued an Aviation Safety Advisory (A060008-1) with respect to cockpit voice recorder duration. In addition to increased CVR recording duration, there needs to be enhanced awareness by flight crew and maintenance personnel of the potential safety information loss if a CVR is allowed to continue to record after a significant safety event.

Halifax International Airport is served by two runways: 23/05 and 14/32. Runway 14 is 7700 feet long by 200 feet wide and has a Category I ILS approach with a simplified short approach lighting system with runway alignment lights. Runway 23 is 8800 feet long by 200 feet wide and has a Category II ILS approach. The approach and runway lighting system on a Category II runway is superior to a Category I system in that it has an enhanced approach lighting system along with centreline and touchdown zone lighting embedded in the runway surface. These enhanced visual aids assist the pilot in visually aligning the aircraft with the runway centreline.

The DH on the Category I and II approaches are 200 and 100 feet agl respectively. Both runways are served by RVR transmissometers, and therefore, the approaches to the runways are subject to approach ban limits. The ban prohibits pilots from conducting an approach to either a Category I or II serviced runway when the RVR is below 1200 feet.

The observed airport weather conditions at Halifax at the time of the incident were as follows: surface wind calm; ground visibility ⅛ statute mile in fog; vertical visibility 100 feet; temperature 1°C, dew point 1°C; and RVR Runways 23 and 14, 1000 feet and 1200 feet, respectively. There had been very little change in the weather for several hours before the incident.

The captain had a total of 11 000 hours of total flying experience with 3200 hours on the Boeing 737. The co-pilot had approximately 6570 hours of total flying experience of which 620 were on the Boeing 737. The flight crew were certified and qualified for the flight in accordance with existing regulations.

The following table represents the flight crew experience and workload in hours.

	Captain	First Officer
Total Time (all times are in hours)	11 000	6570
Time on Type	3200	620
Flight Time in Last 90 Days	88	170
Flight Time in Last 30 Days	28	25
Flight Time in Last 24 Hours	6	6
Hours on Duty Prior to Occurrence	10	10
Hours off Duty Prior to Occurrence	11	11
Hours Awake Prior to Occurrence	11	12
Duration of Last Sleep	7	6

The following is an extract from the operator's SOPs with respect to Category I approaches:

> MONITORED APPROACH
>
> GENERAL
>
> Low visibility CAT I approaches are required to be flown using the autopilot and monitored approach procedures.
>
> A Monitored Approach Procedure shall be utilized during:
> A CAT I precision approach anytime reported RVR is reported below 2600 feet or, in the absence of RVR, prevailing visibility is below ½ sm.
>
> Prior to commencing the approach the First Officer assumes control of the aircraft and the Captain will monitor the approach. To facilitate the transfer of control, the Captain will position his hand at the base of the thrust levers no later than 1000 feet AGL. The Captain will assume control of the aircraft

> prior to landing and the First Officer will monitor the flight instruments for the duration of the approach, landing and rollout. If a go around is required after the Captain assumes control of the aircraft the Captain will fly the missed approach and the First Officer will monitor the flight instruments.
>
> In order to maintain the flow of the Monitored Approach, all callouts shall be completed at the appropriate altitudes regardless of when the runway environment is encountered.
>
> The First Officer controls the autopilot until DA(H) where the Captain calls for control if the required visual reference for landing is met.
>
> The autopilot remains coupled until at least Decision Altitude and no later than 50 feet.
>
> If, at DA(H), the Captain makes no callout or calls "GO AROUND" the First Officer shall carry out a go-around.
>
> If the Captain elects to land, the First Officer will continue to monitor his flight instruments until touchdown and callout any deviations.

This technique balances the cockpit workload at a critical stage of the approach (transition to landing), and improves decision making with respect to continuing for a landing or abandoning the approach. It usually also results in the more experienced flight crew member landing the aircraft when the weather conditions are at minimums. The crew did not brief for, or carry out, a monitored approach.

A number of occurrences have been investigated by the TSB in which inadequate visual references during the final stages of an approach contributed to an accident. These occurrences share a number of commonalities. All were conducted during darkness with visibilities less than those recommended on the *Canada Air Pilot* (CAP) approach plate to runways served by a Category I ILS system. In these occurrences, the crew had sight of the runway environment at minimums and elected to land, but subsequently had difficulty acquiring sufficient visual references to maintain aircraft alignment with the runway.

The Transportation Safety Board of Canada has previously identified safety deficiencies associated with conducting approaches in low visibilities, and has made recommendations to Transport Canada that could mitigate the deficiencies. The Safety Action section of this report identifies the current initiatives by Transport Canada to address these recommendations.

Analysis

There were no discrepancies found with the aircraft, airport facilities, or air traffic services. This analysis will focus on those aspects of the flight that were considered causal, contributing, or were identified as presenting a potential safety risk.

From the outset of the flight from Toronto, the crew was anticipating a Category II approach to Runway 23 at Halifax. This anticipation was based on the ACARS reports from the operator's dispatch and the ATIS information at Halifax. It was only during the descent into Halifax that the crew became aware that they would be unable to conduct the approach to Runway 23. This change required the crew to re-program the FMS, conduct another approach briefing for Runway 14, and also expedite the descent because of the reduced distance to fly to reach Runway 14. All of these elements increased the crew workload, and may have contributed to the inadvertent omission of the required monitored approach procedure.

The crew did not brief for nor carry out a pilot monitored approach (PMA), which disabled a critical safety defence established by the company to effectively manage low-visibility conditions. The cockpit workload during the transition to visual conditions is shared during a PMA, thus improving the decision making with respect to continuing for a landing. Flying a PMA would also have resulted in the more experienced flight crew member landing the aircraft in the reduced visibility conditions.

The co-pilot flown transition became destabilized after the autopilot was disconnected, and this situation became more difficult when the TOGA mode was activated. When the aircraft was being manoeuvred to correct the situation, the aircraft wing contacted the runway. Reverse thrust was not selected until eight seconds after the nose gear was on the runway. These actions were likely a result of limited experience on type and the relatively high-stress, high-workload environment, exacerbated by the dark, low-visibility conditions.

The captain had sufficient visual references to assess correctly the aircraft's position and direct corrective action to the first officer. The captain did not take control or command a go-around after the transition became destabilized because he believed that the co-pilot was correcting back toward the centre of the runway and the landing was salvageable.

The aircraft settled on both main landing gear at 3550 feet from the threshold of Runway 14. The touchdown position, in conjunction with the delay in the application of reverse thrust, led to the aircraft slowing to taxi speed with only approximately 500 feet of runway remaining. With even a lightly contaminated runway, the risk of a runway overrun would have been increased.

The fact that the CVR continued to operate after the aircraft landed resulted in occurrence information being overwritten, depriving the investigation team of potentially important information relative to the occurrence. This is an ongoing problem with CVR–equipped aircraft, and a solution must be found.

Findings as to Causes and Contributing Factors

1. The crew did not carry out a pilot monitored approach in accordance with company procedures and therefore disabled a critical safety defence established to manage landing safely in the low-visibility conditions.

2. The transition from the approach to the landing phase became destabilized when the co-pilot disconnected the autopilot, resulting in the aircraft wing contacting the runway when the aircraft was being manoeuvred to correct the situation.

3. The co-pilot's inability to keep the aircraft stabilized during the transition to landing and his selection of the take-off/go-around (TOGA) mode were likely the result of his limited experience on type and the stress from the low-visibility and relatively high-workload conditions.

4. The captain did not take control or command a go-around once the transition became destabilized.

Finding as to Risk

1. The touchdown point, in conjunction with the delay in application of reverse thrust, increased the risk of a runway overrun.

Other Finding

1. Significant data were lost to the investigation because the cockpit voice recorder (CVR) was not shut down after it was determined that the aircraft wing had struck the ground, depriving the investigation team of possible important information.

Safety Action Taken

WestJet Airlines

The flight crew were given simulator training in low-visibility approaches, and completed line checks with a company check pilot.

A memorandum was issued to all dispatch personnel advising them that, when passing runway visual range (RVR) information to flight crew, they must also include the applicable runway along with the time and date. The memorandum will be included in the next Flight Dispatch Operations Guide revision. Guidance on the required information will be given during training for dispatch personnel.

Revisions to flight crew training procedures have been introduced that place additional emphasis on hazards associated with low-visibility transition to visual references during instrument approaches, and on the requirement to use monitored approach procedures in these conditions. In addition, training will involve discussion of procedures to be carried out in the event of loss of visual reference below decision height (DH), such as missed approach/rejected landing procedures.

The approach procedures for Category I and II instrument landing system (ILS) approaches are being harmonized to make both procedures as similar as possible.

Amendments to the operator's company operations manual have been issued outlining the changes to the approach ban limits.

The operator has completed an internal risk assessment and has entered into discussions with NAV CANADA, Transport Canada, and other industry organizations to explore the possibility of conducting auto-landings on Category I ILS approaches.

Transport Canada

Aviation regulations have been amended to prohibit commercial aeroplane operators from beginning an approach when visibility is so poor that a successful approach to a landing is unlikely.

The regulations will establish, for all runways where visibility is reported, the minimum visibility for the crew to begin an approach in what is termed an Approach Ban.

The amendments will also extend the requirements to runways where conditions are reported by an instrument-rated pilot or qualified person rather than a sensor. In addition, the regulations will help harmonize Canadian regulations with international standards and respond to recommendations from the TSB.

These changes came into force 01 December 2006 and affect commercial operators. The most significant changes to the Approach Ban affect commercial operators holding operating certificates under the Subparts 702, 703, 704 and 705 of the *Canadian Aviation Regulations* (CARs) operating aeroplanes in instrument flight rules (IFR). Minimal changes to the approach ban affect IFR commercial helicopter, and IFR aircraft operations by private operators and general aviation.

For more information regarding the new "Approach Ban" regulations, visit the Transport Canada web site. The following table provides an overall summary of the present approach ban minima, and the minima that will apply after the new regulations come into force.

<table>
<tr><th>Reg</th><th>Present</th><th colspan="2">Changed Approach Ban
General | Ops Spec**</th></tr>
<tr><td>602
Gen Avn</td><td rowspan="2">Aeroplane
RVR 12/6

Helicopter
RVR 12</td><td rowspan="2">Aeroplane: RVR12/6

Helicopter: RVR 12</td><td rowspan="2">Not Applicable</td></tr>
<tr><td>604
Pvt Opr</td></tr>
<tr><td>700
General</td><td>CAT III
RVR 6</td><td>Aeroplane: ~75% CAP vis*
Helicopter: RVR 12</td><td rowspan="3">Not Applicable</td></tr>
<tr><td>701
Foreign</td><td colspan="2">According to foreign auth, but not less than Canadian regs/minima</td></tr>
<tr><td>702
Aerial W</td><td></td><td></td></tr>
<tr><td>703
Air Taxi</td><td rowspan="3">See 602
above</td><td rowspan="3">See 700 above

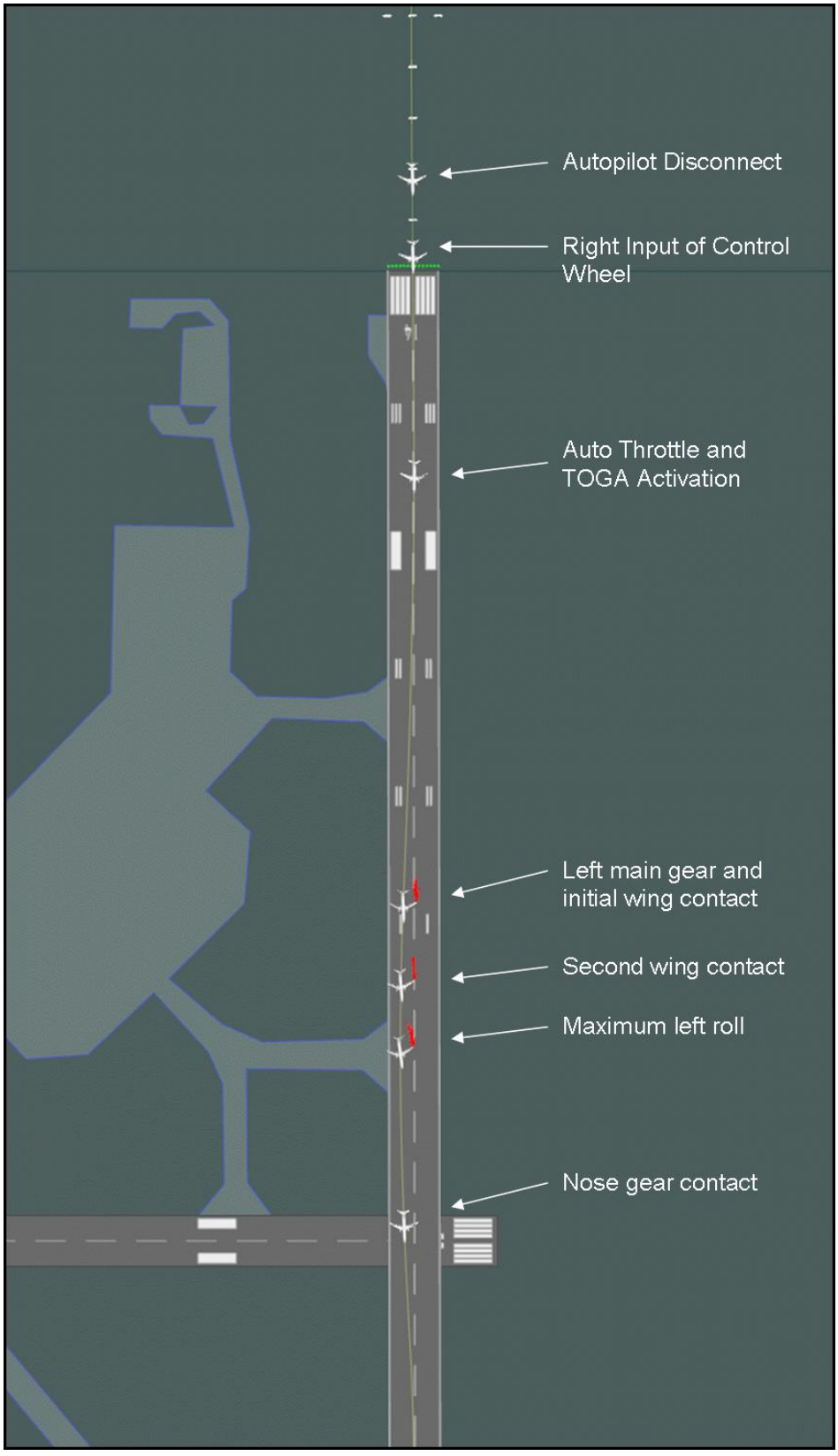
CAT II RVR 12/6
CAT III RVR 6

*ground vis does not apply an approach ban north of 60ºN lat</td><td rowspan="3"><u>Aeroplane</u> (**Conditions apply)
Ops Specs 019, 303 & 503
~50% CAP vis*</td></tr>
<tr><td>704
Commtr</td></tr>
<tr><td>705
Airline</td></tr>
</table>

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 28 March 2007.

*Visit the Transportation Safety Board's Web site (**www.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 – Sequence of Events Illustration



Appendix B – Cockpit Voice Recorder Operations

A96A0035

A Boeing 767-375 landed at Halifax. The aircraft crossed the runway threshold about 20 feet above ground level (agl) and touched down 200 feet past the threshold. The tail of the aircraft struck the runway, causing substantial damage to the tail skid and rear fuselage.

The cockpit voice recorder (CVR) recording of the accident was overwritten after the aircraft was parked because power to the CVR was not removed.

A97A0136

During a landing attempt, as the Super Puma helicopter was about to touch down, the crew realized that the helicopter was lower than normal and that the landing gear was still retracted. The crew began to bring the helicopter into a hover; however, as collective pitch was applied, the nose of the helicopter contacted the runway surface. Once the hover was established, the landing gear was lowered and the helicopter landed without further incident.

Although not required by regulation, the aircraft was equipped with a digital flight data recorder and a CVR. By the time the operator was advised of the need to examine the recorder data and the units were submitted for analysis, the information pertaining to the occurrence flight had been overwritten by the recording of a subsequent flight.

A97F0059

Shortly after the Boeing 767 commenced the take-off roll, at about 20 knots, there was a loud explosion and the aircraft yawed sharply to the left. The take-off was rejected; there was a fire warning on the left engine. The crew performed necessary drills. The aircraft was shut down and towed to the terminal.

The CVR recording was overwritten because the 30-minute CVR had not been secured following the occurrence. As a result, no useful information pertaining to the occurrence was obtained from the CVR.

A00A0185

A Fokker F-28 MK 1000 aircraft was on a scheduled, night passenger flight. After landing, the aircraft overran the end of the runway.

The CVR and the flight data recorder (FDR) were shipped to the TSB Engineering Laboratory. Playback of the CVR revealed that it continued to operate for more than 30 minutes after the occurrence, overwriting the occurrence information.

A01W0117

A Boeing 737 landed hard at Yellowknife, Northwest Territories, touching down three times. The aircraft sustained substantial damage. The CVR was overwritten, and there was no recorded data related to the occurrence.

A03A0012

On landing, the pilot lost directional control of the aircraft after touchdown. The aircraft drifted to the left of the runway centreline, with the left wheel near the edge of the runway, before the captain regained directional control. After the incident, passengers were deplaned normally at the assigned gate.

The aircraft's CVR was sent to the TSB Engineering Laboratory for analysis. The CVR had not been secured after the occurrence, and all information relative to the occurrence had been overwritten.

A03P0259

While executing a visual approach to the Kelowna Airport, the captain misidentified the Vernon Airport as the Kelowna Airport and executed a visual approach to the Vernon Airport, descending to 730 feet above ground level (agl) before executing a go-around. Shortly after the go-around was initiated, a TCAS (traffic alert and collision avoidance system) traffic advisory, generated by a Cessna 152 aircraft in the circuit, was received. The aircraft, an Airbus A320, then continued to the destination airport, about 15 miles away.

The CVR data was not secured after landing, and the pertinent section of the CVR tape was overwritten.

A04A0057

A Boeing 727-225 freighter was a night cargo flight. The en route portion of the flight to Moncton was uneventful. On arrival at destination, the flight crew conducted two unsuccessful approaches in darkness and poor weather conditions before landing on the third approach.

The FDR and CVR were removed from the aircraft and sent to the TSB Engineering Laboratory for analysis. The CVR had recorded 30 minutes of good quality audio; however, all in-flight information was overwritten when the CVR continued to operate after the final landing. The CVR did record crew comments after this landing.