

AIRCRAFT EVACUATIONS - THE CANADIAN EXPERIENCE

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Abstract:

This paper provides an executive summary of *A Safety Study of Evacuation of Large, Passenger-Carrying Aircraft (SA9501)* conducted by the Transportation Safety Board of Canada. The objective of the study was to examine the Canadian experience, identify safety deficiencies and, where warranted, recommend remedial safety action. Twenty-one aircraft evacuations occurring between 1978 and 1991 were reviewed. The safety issues identified were fire, smoke and toxic fumes, exit and slide operation, communication and passenger preparedness. As a result of the study, the Board made five safety recommendations to the Department Transport. A brief account of Transport Canada's response and an update of the current situation in relation to those recommendations is included.

A brief overview of evacuation/survival hazards identified in occurrences post-1991 and a case study of one such accident will also be presented.

INTRODUCTION

Background

In 1995 the Transportation Safety Board of Canada published *A Safety Study of Evacuations of Large, Passenger-Carrying Aircraft (SA9501)*. For the purpose of the study, an evacuation was defined as the disembarkation (planned¹ or otherwise) of passengers because of an existing or perceived emergency. The term evacuation was used in a generic sense and included precautionary evacuations, abnormal deplanings, and emergency egress situations. The objective of the study was to examine the Canadian experience, identify safety deficiencies and, where warranted, recommend remedial safety action. The selection criteria for the study were aviation occurrences which resulted in an evacuation and took place between 1978 and 1991. Only large

¹Evacuations are commonly referred to as "planned" or "unplanned." In the case of a "planned" evacuation, cabin crew are advised that an evacuation is expected and some time is available to prepare the cabin and the passengers before the actual evacuation command is given. An "unplanned" evacuation is not expected and there is no time lapse between the decision to evacuate and the initiation of the evacuation.

Canadian- registered, passenger-carrying aircraft were considered Occurrences involving foreign-registered aircraft were also included if they happened in Canadian airspace.

The occurrence data were reviewed on a file-by-file basis. When information was not available in published reports, statements given by crewmembers, passengers, and airport personnel were considered.

Related studies conducted by foreign organizations were reviewed, as were foreign reports of occurrences involving remarkably successful or catastrophic evacuations. The proceedings of selected symposia and conferences, aviation journals, periodicals, and newsletters related to cabin safety were also reviewed.

Relevant Canadian regulatory documentation, as well as, corresponding regulatory documentation from the United States Federal Aviation Administration (FAA) and the Civil Aviation Authority (CAA) in the United Kingdom were reviewed. In addition, Canadian air carrier guidelines and procedures were consulted.

OVERVIEW OF THE CANADIAN EVACUATION EXPERIENCE

General

From 1978 through 1991 there were 18 evacuations of large, Canadian-registered, passenger-carrying aircraft. In addition, there were 3 evacuations of foreign aircraft in Canadian airspace. These 21 occurrences² involved 2,305 passengers and 139 crewmembers.

The most common lead events precipitating an evacuation were fire and engine failure. The phase of flight during which the lead events most commonly occurred was take-off and landing. The majority of evacuations were unplanned. There were no ditchings. In 14 of the 21 occurrences the time required to evacuate the aircraft was greater than 90 seconds.



² Please see Appendix A. for a listing of the occurrences reviewed in the evacuation study.

Lead Event	
Fire	8
Engine Failure	5
Runway Excursion	3
Component/System Failure	2
Miscellaneous	3
Phase of Flight	
Ground	1
Take-Off	6
En Route	5
Landing	9
Planned/Unplanned	
Planned	8
Unplanned	13
Land/Water	
Land	21
Water	0
Time To Evacuate	
More Than 90 Seconds	14
90 Seconds or Less	5
Unknown	2

Table 1 - General Data on Occurrences Studied

Injuries

Four occurrences resulted in fatalities. Non-fatal injuries were incurred in 15 occurrences, while six evacuations were injury-free. Table 2 summarizes the injuries recorded in the 21 evacuations.

	Fatal	Serious	Minor/None	Total
Crew	7	6	126	139
Passengers	84	72	2149	2305
Total	91	78	2275	2444

Table 2 - Injuries

! Thirty-six fatalities occurred during the evacuation process, while 13 resulted from impact. The cause of death was not documented for 42 passengers.

! Eight serious injuries occurred during the evacuation process. The cause of injury was not recorded for 52 occupants who suffered serious injuries.

! Six passengers were known to have been injured when they exited via over-wing exits.

! Minor injuries were also sustained by passengers using the evacuation slides.

Fire, Smoke and Toxic Fumes

The presence of fire, smoke, and/or toxic fumes created evacuation difficulties in 11 of the evacuations reviewed and was lethal in three of four occurrences where fatalities were incurred. Smoke inhalation or burns was the primary cause of death for 36 of the 49 fatalities where cause of death was recorded. Although the cause of death for 42 passengers was undocumented, it is suspected that a large number of these deaths were also fire-related as they occurred in accidents where there was a fire in the aircraft cabin.

In addition, fire, smoke, and/or toxic fumes threatened the probability of a successful evacuation by restricting visibility, hampering flight attendants ability to shout evacuation commands, reducing the number of available exits, affecting passenger behavior, and decreasing occupants' mental and physical capacities.

At the time the study was conducted, there was no regulatory requirement in Canada to provide cabin attendants, other than those working on combi- aircraft, with protective breathing equipment (PBE). Nevertheless, there was legislation (ANO Series VII No. 2, Section 45, "Emergency Procedures Training") which clearly implied that all cabin attendants were expected to fight cabin fires.

There was no regulatory requirement to provide passengers with PBE. In 1987, an international feasibility study addressing the safety benefit of providing "smoke hoods"³ for passengers concluded that the number of lives saved by smoke hoods each year would be "modest" (179 lives over 20 years, or approximately 9 lives per year world-wide) and that the time required to don the

³"Smoke hoods are protective head coverings that prevent wearers from breathing the smoke, particulates and toxic gases generated in a fire. ... two general types of smoke hoods have evolved in the marketplace: one has a self-contained source of breathable oxygen, and the other filters ambient air for breathing." Flight Safety Foundation, "Getting Out Alive - Would Smoke Hoods Save Airline Passengers or Put Them At Risk?" Cabin Crew Safety, January/February 1994.

apparatus might increase the time required to evacuate an aircraft, thereby causing a greater loss of life. Mandatory carriage of smoke hoods, as passenger safety equipment was not recommended.⁴

There remained the question of voluntary carriage of passenger PBE, by carriers or by individuals. In Canada, *The Transportation of Dangerous Goods Act*, prohibited, and continues to prohibit, passengers from bringing smoke hoods, which provide oxygen from a cylinder of compressed gas on board an aircraft. They were/are viewed as a hazard in the event of an in-flight fire. Passengers were/are permitted to carry filtration-type smoke hoods on board aircraft but they are not as effective as smoke hoods which have a self-contained source of breathable oxygen.

Escape/Evacuation Slides

Slides were deployed in 15 of the evacuations. There were problems related to the slides in seven occurrences. The two most common problems were the angle of the slide and deployment. Both problems occurred five times each. As a result of problems with deployment of slides or their angle of inclination exits were rendered inoperable, use of specific exits was delayed and injuries were incurred when slides that were too steep were used for passenger egress. In cases where the angle of the slide was too steep to be used safely, or the slide did not reach the ground, either the main aircraft landing gear or the nose gear had collapsed, altering the normal attitude of the aircraft at rest.

Airworthiness Standard 528.810,(a)(I)(iii) addresses deployment of evacuation slides and states, in part, that the slide must be of sufficient length such that, if any of the landing gear has collapsed, the slide will reach the ground at an angle which allows for a safe evacuation of the aircraft occupants.

Public Address Systems

Inoperable/inaudible public address (PA) systems put passenger safety at risk in at least six emergency situations where evacuations were required. As a result, in four occurrences cabin crew and /or passengers did not hear the captain=s initial command to evacuate. Use of the PA system by the flight crew involved in these occurrences was in accordance with emergency operating procedures. In two occurrences emergency situations developed en route (in-flight fire, double engine flame out due to fuel exhaustion). Therefore, in accordance with emergency

⁴Members of the aviation industry who continue to promote passenger smoke hoods fault the model on which the above-referenced study was based and maintain that the probability of a successful evacuation (increased survivability) will be enhanced as passengers will not be incapacitated by smoke and toxic fumes. Smoke hoods are perceived as particularly beneficial in the event of an in-flight fire where passengers may be exposed to a potentially lethal environment for a relatively long period of time.

procedures, the in-charge flight attendants proceeded to give the passengers a full emergency briefing using the PA system. In one case the PA system was inoperable, in the second it was inaudible because of an inadequate power supply and a design-induced decrease in volume. In both cases many passengers were unable to hear critical safety information.

Crew Communication/Co-ordination

Ineffective crew communication was seen to have jeopardized, or potentially jeopardized, the likelihood of a successful evacuation in several occurrences. Difficulties encountered included the use of improper terminology leading to inaccurate assumptions on the part of other crew members, delays in transmitting critical safety information to the flight deck from the cabin crew, lack of confirmation of receipt of information, total lack of communication etc.

Passenger Behaviour/Preparedness

In 11 occurrences, inappropriate passenger behaviour was encountered. Faced with an unexpected life-threatening situation, passengers typically reacted in one of two ways: overt panic (screaming, crying, hysteria, aggressiveness) or negative panic (inaction, freezing). There were occasions when it appeared that passengers had not perceived the danger they were in and therefore reacted in an inappropriate manner. In many occurrences passengers stopped to retrieve carry-on baggage and attempted to take it with them as they exited the aircraft, this despite having been specifically told not to by the cabin attendants. Passengers often insisted on exiting the aircraft via the same door they entered. There were also several occasions when passengers seemed to be fixated on a particular exit and made no attempt to look for an alternative escape route. In at least one occurrence passengers exhibited competitive behavior as they attempted to evacuate the aircraft. Behavior exhibited by passengers suggested that they were not adequately prepared to assume a certain level of responsibility for their own safety in an emergency situation such as an evacuation.

In addition, there was some evidence to suggest that passengers may be least prepared to evacuate an aircraft when an emergency happens following landing. Ironically, emergencies leading to an evacuation occur more often during the "landing" phase of flight than during any other phase of flight⁵: such was the case in the Canadian experience.

At the time this study was being prepared, TC was proposing that a pre-landing safety briefing be required on all flights of four hours duration or more. The briefing was to include the location of emergency exits and exit location signs.

⁵Fifty-five (35%) of 156 evacuations identified in the International Civil Aviation Organization data bank (1970-1993) followed an emergency which occurred during the landing phase of flight.

SAFETY DEFICIENCIES - TSB RECOMMENDATIONS - TC RESPONSE

In the course of the study the Board identified four areas of concern; protective breathing equipment for cabin crew and passengers, slide operation, crew communication/co-ordination and passenger preparedness. In the Board's opinion, certain safety deficiencies in each of these areas required remedial action. As a result, six safety recommendations were issued.

Protective Breathing Equipment - TSB Recommendation A95-01 & A95-02

In the context of the actual evacuation process, there was no direct evidence that a lack of PBE for cabin crew resulted in fatalities or injuries during evacuations. Yet, there was a paradox in that cabin attendants were expected to fight cabin fires, but, in many cases, they were not provided with PBE in the aircraft cabin. Ready access to portable PBE could have improved their ability to fight fires and had the effect of reducing the risks faced by occupants during an evacuation. Therefore, the Board recommended that:

The Department of Transport requires that sufficient portable, protective breathing equipment units with full-face masks be carried in the passenger cabins of transport aircraft for cabin crew. A95-01

In addition, given the number of fatalities that occurred when fire, smoke, and/or toxic fumes were present, the Board believed that further research was required to determine whether passengers should be given the opportunity to carry appropriate protective breathing equipment. Accordingly, the Board recommended that:

The Department of Transport re-evaluate research regarding protective breathing equipment (PBE) for passengers with a view to determining the feasibility of the carriage of appropriate protective breathing equipment, on a voluntary basis. A95-02

TC Response to TSB Recommendations A95-01 & A95-02

TC concurred with the recommendation A95-01 that called for PBE for flight attendants and proposed a regulation to address the identified deficiency. Currently, Canadian Aviation Regulation (CAR) 705.71 Protective Breathing Equipment requires that a PBE unit is available for each flight attendant designated as minimum crew.

TC did not concur with recommendation A95-02, addressing voluntary carriage of appropriate passenger PBE by individual passengers or carriers. The Board continues to monitor the occurrence data and any new research in this area.

Escape Slides - TSB Recommendation A95-03

Since 7 of 15 evacuations were hindered as a result of problems related to deployment and/or angle of inclination of slides, it appeared that the intent of the current Airworthiness Standard was not being achieved. Given that the use of effectively deployed escape slides may be critical to the success of an aircraft evacuation, the Board recommended that:

The Department of Transport, in concert with industry, re-evaluate the performance of escape slides on all large passenger-carrying aircraft registered in Canada, to confirm that they can be functionally deployed in accordance with the criteria of the Airworthiness Standard. A95-03

TC Response to TSB Recommendation A95-03

TC did not concur with recommendation A95-03. They responded that airworthiness standards applicable to emergency exit assist means have been upgraded over the years and that TC Aviation, the FAA and industry were in the process of rewriting TSOC69 which addresses aircraft escape slides. Issues cited as being addressed included slide strength, rate testing and slide illumination.

Despite historical improvements to applicable airworthiness standards, problems with slide deployment and angle of inclination continue to occur. It is noted that, certain aircraft do not have to meet the referenced airworthiness standard as they were type certified prior to promulgation of the standard. Regarding the rewrite of TSOC69, it does not appear that the specific deficiencies identified in the study, i.e. deployment and angle of inclination are issues that are being addressed.

TC went on to say that from an operational perspective TCA standards require flight attendant training programs to include procedures that describe the different aircraft attitudes possible as a result of accidents/incidents, such as gear collapse. Flight attendants' abilities to determine whether a slide is useable in an emergency situation was never a question. When a flight attendant correctly determines that a slide is not useable because the angle is too steep, or because the slide does not reach the ground, that does not change the fact that the performance of the slide did not meet the criteria of the Airworthiness Standard and that as a result passengers had one less exit available to them in an emergency egress situation.

The Board continues to monitor the occurrence data and any research/development in this area.

Public Address Systems - TSB Recommendation A95-04

The Board was concerned that, as a result of inoperable or inaudible PA systems, some cabin crew and/or passengers were unable to hear the captain's initial command to evacuate and/or

passenger safety briefings given over the PA system in a planned emergency. At the time the study was being written, the Board was investigating another occurrence where emergency announcements made by the captain on the PA system were inaudible by the cabin attendant and the passengers. Since it appeared that cabin crew and passengers continued to be placed in a position of increased risk of delay in evacuations due to inaudible commands or instructions, the Board recommended that:

The Department of Transport reviews the adequacy of power supplies and standard operating procedures for PA systems in an emergency for all Canadian operators of large passenger aircraft.

A95-04

TC Response to TSB Recommendation A95-04

TC responded that airworthiness standards for large passenger aircraft did not contain requirements for PA systems power supplies until amendments were introduced in 1989 and 1993 and that these amendments applied to *new* large passenger aircraft *designs only*.

From an operational perspective TC responded that flight attendants are trained not to rely on aircraft power during an emergency requiring an evacuation. Flight attendants are trained to direct passengers in emergency situations by the use of shouted commands. While it is agreed that shouted commands are an effective method of communication during the actual evacuation, flight attendants are trained in a prepared, emergency-landing situation to prepare the passengers for the evacuation by making specific announcements using the PA system.

TC did not address the issue of *unheard initial commands* to evacuate made by the flight crew using the PA system. It is noted that, in a recent evacuation occurrence (A97H0011 - investigation ongoing) when the captain gave the command to evacuate over the PA, as per procedure, the system was inoperative. Fortunately, in that occurrence the need to evacuate was obvious and the In-Charge flight attendant did not wait for the captain's command before initiating the evacuation. Under other circumstances where the need to evacuate is not obvious an inoperative PA system could result in delaying initiation of an evacuation.

The Board will continue to monitor occurrence data in relation to use of public address systems in evacuation occurrences.

Crew Communication/Co-ordination - TSB Recommendation A95-05

Ineffective crew communication/co-ordination created an environment in which passengers and crews were exposed to unnecessary risks during the evacuation process in several occurrences examined.

Notwithstanding Transport Canada's efforts to promote effective crew communication by encouraging air carriers to implement joint crew training, the Board believed that lack of, or ineffective, crew communication continued to place the lives of aircraft occupants at risk during evacuations of large passenger-carrying aircraft. In view of the Canadian accident experience and demonstrated problems in crew coordination on a global basis, the Board recommended that:

The Department of Transport requires that air carriers implement an approved, joint-crew emergency training program with emergency simulations for all aircrew operating large passenger-carrying aircraft.

A95-05

TC Response to TSB Recommendation A95-05

TC concurred with the recommendation. Today, Crew Resource Management training, which includes annual, hands-on, joint-crew training in safety and emergency procedures, is mandatory. Reference Commercial Air Services Standards 725.124 (39).

Passenger Behavior/Preparedness

While the Board applauded Transport Canada's initiative to require a standard pre-landing, safety briefing on certain flights, there was concern that safety information found only on the safety features card, such as exit operation, recommended brace positions, floor proximity emergency path lighting, use of the escape slides and location and donning of life jackets would not be reinforced prior to landing. Since most emergency evacuations are unplanned and occur during the landing phase, the Board recommended that:

The Department of Transport encourage carriers to include sufficient detail in their pre-landing briefings to prepare passengers for an unplanned emergency evacuation.

A95-06

TC Response to TSB Recommendation A95-06

TC responded that the issue of pre-landing safety briefings had been thoroughly reviewed and was discussed extensively during the Canadian Aviation Regulation Advisory Council (CARAC) process. Although no change regarding the content of the briefing would be required, staff advised that air carriers would be encouraged to include sufficient detail in their pre-landing safety briefings.

Current requirements for pre-landing safety briefings are outlined in CASS 725.43 (1)(d).

EVACUATIONS POST 1991

General Overview

Since 1991, at least 13⁶ occurrences with evacuations have been investigated by the TSB. The most common lead event, fire and/or smoke, frequently occurred during the take-off phase (25%). All of the evacuations were conducted on land.

Seven of the 13 occurrences were injury-free and there were no fatalities. Twenty minor and nine serious injuries were incurred.

Numerous evacuation/survival hazards were identified:

I Inappropriate passenger behavior - passengers retrieved their carry-on-baggage and attempted to take it with them as they exited the aircraft.

I Carry-on-baggage - access to a primary exit was blocked by carry-on-baggage.

I Slides - rendered unusable by wind, partially deflated, escape slide/raft cover did not retract as designed and obstructed exit door.

I Crew co-ordination - lack of co-ordination between cabin crew and flight deck crew in an emergency situation - crews had not participated in joint crew emergency procedures training.

I Communication - operable interphone system not used to relay critical safety information in a timely manner.

I Human error - flight attendant seated in an aft facing jump seat confused left/right side of aircraft and evacuated passengers from the wrong side of the aircraft.

I Flight attendant emergency procedures training - did not reflect emergency equipment used on the aircraft.

I Standardization between flight deck and cabin crew manuals - discrepancy between emergency procedure as written in Flight Operations Manual and Flight Attendant Manual.

⁶ Aviation Occurrence Reports: A97H0011, A96Q0083, A95Q0232, A95C0255, A95H0015, A95P0138, A94P0285, A94O0271, A94O0163, A94C0034, A94C0009, A93Q0242, A93P0131.

I Post-evacuation survival - passengers not adequately dressed for survival in harsh climate, lack of passenger control following egress.

I Despite meeting the FAR flammability standards for cabin interior materials, the passenger service blanket material (polyester) supported fire when folded flat.

Case Study - Post 1991 Evacuations

A recent occurrence from the post-1991 evacuations has been chosen to present in greater detail. A brief synopsis of the occurrence, hazards identified, safety action issued by the TSB and proposed remedial action by the appropriate parties will be included.

A97H0011

Synopsis:

On 16 December 1997, at the Fredericton Airport, Air Canada Flight 646, a Canadair CL600-2B19 Regional Jet (CL-65) struck the runway while attempting a go-around in low visibility conditions. When the aircraft struck the runway it then traveled - at full power and uncontrolled - about 2100 feet from the first impact point, struck a large tree and came to rest. An evacuation was conducted: however, seven passengers were trapped in the aircraft until rescued. Of the 39 passengers and 3 crewmembers, 9 were seriously injured. The accident occurred at 2348 hours. Flight 646 was an approved single cabin crew operation.

Hazards & Associated Risk Identification:

During the course of the investigation it was determined that neither flight crewmember had received the required, practical training on operation of aircraft doors. While the operation of emergency exits by the flight deck crew was not called for in this occurrence, there is a risk that in other circumstances a lack of practical training could adversely affect their ability to open emergency exits in a timely and effective manner and thereby delay evacuation of the aircraft. This risk is considered particularly significant for single cabin crew operations.

A second hazard related to flight crew knowledge and emergency procedures training was also identified. Neither flight crewmember was aware that there was a pry bar on the aircraft. The flight crew indicated that had they known one was available they would have used it. There is a risk that lack of knowledge by flight deck crew concerning the existence and location of emergency equipment, in this occurrence a pry bar, could result in undue injury to passengers and other crew members.

The third hazard uncovered related to post-egress survival. Emergency response personnel were

unable to visually locate the aircraft because of dense fog. The only emergency equipment on board the aircraft that could be used to visually signal distress and hence the location of the aircraft were flashlights. Although the flight attendant, and subsequently a passenger, repeatedly signalled rescue personnel using a flashlight, given the dense fog, it was not an effective signalling tool and they were not successful. Only after a passenger walked from the wreckage to the runway where he encountered airport personnel was the aircraft finally located; this was approximately 15 minutes after the accident had occurred. There was no requirement for carriage of on board survival equipment that provides a means for visually signalling distress on Flight 646. Any circumstance or situation that impedes, or does not facilitate, a timely response by emergency rescue personnel is hazardous in that it creates a potentially unacceptable risk in relation to passenger and crew survivability. As evidenced by this occurrence, effective signalling equipment is essential even when an accident occurs at, or near, an airport.

Finally, the fourth hazard pertained to location of the emergency flashlights. It was noted that the emergency flashlights were stored in the same general area of the aircraft: three were in the flight deck and one was just outside the flight deck in the storage area under the flight attendant=s seat. In these locations they were readily accessible by the crew during an emergency. However, locating all of the emergency flashlights in close proximity within an aircraft increases the risk that all of them may be destroyed or inaccessible if that portion of the aircraft is damaged during an accident. Flashlights are a necessary piece of emergency equipment particularly if an accident occurs at night, if the fixed emergency lighting system is not operable, if there is smoke inside the aircraft and for survival following an evacuation. Lack of flashlights could hamper the flight and cabin crew=s ability to carry out their emergency/survival duties.

Proposed Safety/Remedial Action:

The TSB informed Transport Canada and the air operator of the hazards and associated risks identified. As a result, both Transport Canada and the air operator have proposed remedial action. A brief summary of their intended remedial action plan follows:

- § TC will develop Commercial & Business Aviation Advisory Circulars (CBAAC) for air operators and Policy Letters for Commercial & Business Aviation Inspectors responsible for the approval of flight crew member training programs. These documents are being developed to clarify the intent of the “emergency exits” training requirement, as well as, the training requirements for the location and use of emergency equipment, including practical training. Amendments to the associated CASSs will be proposed by TC.
- § TC will develop a CBACC for air operators to recommend that, on aircraft types where only one flight attendant is carried and the flight attendant seat

is located forward, an additional flashlight be carried on that aircraft and that it be located in the aft of the aircraft.

- § Air Canada will be installing a second flashlight at the rear of their CL-65 Regional Jet aircraft.
- § TC advised that they will be establishing a working group to review the current survival equipment regulation and all associated issues and concerns; The TSB's concern regarding a means for visually signaling distress will be included.

Conclusion

The hazards/safety deficiencies related to aircraft evacuations and passenger survivability identified from the evacuation study and from individual aircraft accident investigations are not unique to Canada. The lethal effect of fire, smoke and toxic fumes, ineffective crew communication/co-ordination, inappropriate passenger behavior, etc., continues to place the lives of passengers and crew at risk, globally.

	EVACUATION STUDY										
			INJURIES								
DATE	OCCURRENCE NUMBER	LOCATION	AIRCRAFT	FATAL	SERIOUS	MINOR/NONE	FIRE/SMOKE PRESENT	SLIDES USED	PLANNED	LEAD EVENT/REMARKS	
11-Feb-78	A78H0001	Cranbrook, B.C.	B-737	42	5	2	YES	NO	NO	Go-around, obstruction on runway	
26-Jun-78	A78H0002	Toronto, Ont.	DC-9-32	2	47	58	NO	YES	NO	Tire failure on take-off roll/Runway excursion	
29-Dec-81	A81A0039	Sydney, N.S.	HS-748	0	1	18	NO	NO	NO	Hydraulic failure, no braking/Taxing to ramp	
	A82H0001	Sault Ste. Marie, Ont.	B-737	0	0	122	NO	YES	NO	Hard landing	
12-May-83	A83H0005	Regina, Sask.	DC-9-32	0	0	62	NO	YES	NO	Gear collapsed on landing	
2-Jun-83	A83F0006	Cincinnati, Kentucky	DC-9-33	23	3	20	YES	YES	YES	In-flight cabin fire	
23-Jul-83	A83H0006	Gimli, Man.	B-767	0	0	69	YES	YES	YES	Fuel exhaustion/forced landing	
22Mar84	A84H0003	Calgary, Alta.	B-737-200	0	4	115	YES	YES	NO	Uncontained engine failure on take-off	
20-Apr-86	A86Q4036	Montreal, Que.	DC-9-32	0	0	89	NO	YES	YES	Smoke in cockpit/enroute	
13-Jul-86	A86A4936	Gander, Nfld.	L1011-100	0	0	356	YES	YES	NO	Engine fire	
14-Jul-86	A86P4053	Kelowna, B.C.	B737-275	0	0	81	NO	YES	NO	Runway excursion/hydroplaning	
20-Jul-86	A86A0024	Wabush, Nfld.	B737-200	0	1	63	NO	YES	NO	Engine failure/rejected take-off	
12-Dec-86	A86H4902	Goose Bay, Nfld.	B747-131	0	0	328	YES	NO	YES	Fire warning in cargo hold/enroute	
17Jan88	A88H0001	Vancouver, B.C.	B737-200	0	0	38	YES	YES	NO	Engine failure/rejected take-off	
18Jan89	A89P0018	Vancouver, B.C.	B737-217	0	0	65	YES	YES	YES	APU fire/after landing	
10Mar89	A89C0048	Dryden, Ont.	F-28	24	17	28	YES	NO	NO	Ice on wing on take-off	
5-Jun-89	A89O0249	Toronto, Ont.	F-28	0	0	69	NO	NO	YES	Smoke in cabin/during climb	
22-Jun-89	A89C0115	Saskatoon, Sask.	B737-217	0	0	78	NO	YES	YES	Runway excursion on landing/Improper procedures	
7-Aug-90	AAIB EW/C1174	Gatwick, England	B747-200	0	0	456	YES	YES	YES	Tail-pipe fires on three engines	
18-May-91	A91W0088	Edmonton, Alta.	B767	0	0	122	NO	YES	YES	Acrid fumes in cockpit/enroute	
29Nov91	A91H0012	Riviere-Aux-Saumons, Que.	HS-748	0	0	36	YES	NO	NO	Engine failure/rejected take-off	

Appendix B.
Photo from A98H0011

