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REPORT

REDUCTIONS IN FATALITIES & SERIOUS INJURIES DUE TO EMERGENCY RESPONSE SERVICES AT CAR 303 AIRPORTS IN CANADA

Prepared for
Canadian Airports Council
Ottawa, Ontario, Canada

Prepared by
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FORWARD

Air transportation is, by an exceedingly wide margin, the safest mode of transportation. In performing transportation risk analyses, it is necessary to analyse data which invariably include the number of deaths and serious injury. In the case of air transportation this unavoidable "dehumanizing" can be particularly difficult to accept. In part because of the very small numbers of deaths and serious injuries, and in part because of the dramatic and tragic nature of aircraft accidents, a stronger emotional connection between the public (and aviation community) and victims is often established.

This report includes necessary data analysis and objective discussion. The overriding objective of the CAC in commissioning this report is to improve aviation safety. A review of the experiences of the past is a vital ingredient in determining the best course of action in preventing accidents in the future. The CAC recognises that behind the statistics there exists real human suffering and the tragic loss of loved ones, and it is not the intention of this report to in any way diminish the severity and importance of the accidents or dishonour the victims.

This report also recognises that airport emergency response services at Canada's airports are provided by airport firefighters and other professionals who are dedicated to aviation safety and the safety of the travelling public. Their commitment to ongoing education, training, and preparedness is beyond question. Airport emergency response plans are well developed and rehearsed, and the facilities and equipment are state of the art. Significant improvements in aviation safety, the very nature of aircraft accidents, and the need to be proactive in the quest to achieve further safety improvements, does however suggest we should be looking at more effective means of deploying resources to improve aviation safety.

Canadian Airports Council

I. INTRODUCTION

Background

The Canadian Aviation Regulations (CAR) Part III Subpart 303 sets out the requirements for providing Emergency Responses Services (ERS) at airports in Canada. Until mid-2008, ERS was required at "designated airports" but since that time the requirements are based on passenger traffic levels at the airport with airports having more than 180,000 E/D passengers per year required to provide ERS.

CARs do not require other less busy airports in Canada to provide ERS due to the lower frequency of traffic and accidents, and the high fixed costs of ERS. Prior to 1990, Transport Canada required ERS at 122 airports.

Approximately 28 airports were designated under CAR 303 in the period 1986 to 2008, and a similar number must provide ERS under the new passenger traffic requirement. However, the list of airports that now required it is different.

Exhibit I-1 summarizes the airports required to provide ERS since 1986 and encompasses both lists.

Exhibit I-1.
Airports in Canada Required by CAR 303 to Provided ERS, 1986-2009

Airport	Start/Period	Note	Airport	Start/Period	Note
Abbotsford	Jun-08	2	Quebec Int'l	< 1986	1
Calgary Int'l	< 1986	1	Regina	< 1986	1
Charlottetown	< 1986	1	Saint John	< 1986	1
Edmonton Int'l	< 1986	1	St. John's Int'l	< 1986	1
Fort McMurray	Jun-08	2	Saskatoon	< 1986	1
Fredericton	< 1986	1	Sault Ste. Marie	< 1986 - June 2008	3
Gander Int'l	< 1986	1	Sudbury	< 1986 - June 2008	3
Grande Prairie	Jun-08	2	Thunder Bay	< 1986	1
Halifax Int'l	< 1986	1	Toronto-Pearson Int'l	< 1986	1
Hamilton	<1986	1	Toronto City Centre	< 1986	1
Kelowna	< 1986	1	Vancouver Int'l	< 1986	1
London	< 1986	1	Victoria Int'l	< 1986	1
Moncton	< 1986	1	Windsor	< 1986 - June 2008	3
Montréal Trudeau Int'l	< 1986	1	Winnipeg Int'l	< 1986	1
Montreal Mirabel Int'l	< 1986	1	Yellowknife	< 1986	1
Ottawa Int'l	< 1986	1			
Prince George	< 1986	1	Iqaluit (Voluntary)	Mid'90s	4

Notes: 1 Designated Airport, started providing ERS prior to 1986
2. E/D passengers over 180,000, required to provide ERS starting in June 2008
3. Designated Airport but E/D passengers less than 180,000 and not required to provide ERS after June 2008
4. Not formally required to provide ERS, but anecdotally has provided at a level that would have been required by CAR 303 since the mid-1990s

In 1998 the government proposed regulations requiring non-designated airports (not covered under CAR 303) to provide a lower level of ERS that they termed emergence intervention services (EIS). The regulation was enacted, but suspended and eventually repealed due to the high costs of the service in comparison to the very low benefits based on a risk analysis.

ERS in Canada are state of the art. Airport firefighters and other ERS professionals are exceedingly well trained and dedicated professionals and are deeply committed to public safety. The ERS requirements under CAR 303 follow closely the ICAO Airport Rescue and Firefighting (ARFF) services Standards & Recommended Practices (SARPs) for the international airports required to provide ERS.

The primary role of airport ERS is stated in the CARs as follows:

"The principal objective in providing an aircraft fire-fighting service is to save lives in the event of an aircraft emergency on the airport or aerodrome. In this context, an aircraft fire-fighting service is a contingent resource tasked with the primary responsibility of providing a fire free egress route for the evacuation of passengers and crew following an aircraft accident". [1]

The same sub-paragraph of the regulation also states: *"This standard is not intended to limit the fire-fighting service from providing services in addition to that of aircraft fire-fighting at the airport or aerodrome, nor to prevent it from dealing with other occurrences."* The primary focus of ERS is preventing fatalities and injuries in aircraft emergencies: reductions in property damage are a secondary concern.

Airports play an important role in aviation safety by providing facilities and services which allow aviation users to operate safely at the airport. Airports must ensure that resources are directed at the areas of their operations where they have the highest probability of addressing and reducing real risks. As part of their safety requirements, airports in Canada are required to have a safety management system (SMS) in place to instill a safety management culture and provide details on safety systems and procedures at airports. The aim of SMS is to improve safety through proactive management rather than reactive compliance with regulatory requirements. ERS is one of many facilities and services available at an airport to improve safety. It should be considered in the context of all potential facilities and services that could improve safety at the airport and the amount that each contribute to the reduction in risk.

An important consideration in evaluating the various safety measures is that ERS is a reactive measure in that it can only reduce the risk in situations where a dangerous occurrence has already occurred on, or in the vicinity of, an airport and the specific circumstances of the occurrence are such that ERS can be effective in reducing fatalities and serious injuries. However, as other proactive non-ERS measures reduce the frequency of such occurrences, the frequency with which ERS can prevent fatalities and serious injuries is reduced. Proactive measures could include, for example, improved or upgraded landing navigation systems, airfield lighting, improved monitoring of aircraft and vehicles on the airport to reduce collisions and implementing measures to improve the safety culture.

1 CAR 323.03 General Requirements.

At some point it may become more effective to redefine the roles of ERS within the SMS to provide overall improvements in safety. A good understanding of the level of risk reduction that ERS is providing is required if changes are to be made to its role and to ensure resources are being allocated optimally within the SMS.

The Canadian Airports Council (CAC) contracted LeighFisher Canada to undertake a study of the reduction in risk due to ERS at CAR 303 airports in Canada. The study was also to provide an update on the risk reduction due to ERS previously determined in a 1988 study for Transport Canada using accident data between 1966 and 1985[2]. The current study focuses on quantifying the numbers of fatalities and serious injuries prevented by ERS based on historical experience using a risk analysis approach.

Objective of Study

The overall objective of the study is to determine the reductions in risk due to ERS as required by CAR 303 at airports in Canada. Reduction in risk is taken to be the degree to which ERS prevents fatalities and serious injuries in aviation accidents. The study determines for the study period:

- The number of aircraft accidents at, or in the close vicinity of the airport, by accident severity and estimates of the number and proportion of these accidents where ERS assistance was required and where ERS played a role in reducing the numbers of fatalities and serious injuries;
- Estimates of the numbers of fatalities and serious injuries prevented by the ERS in aircraft accidents; and
- The expected number of fatalities and serious injuries that ERS would prevent per year at airports with traffic levels ranging from 180,000 to 30 million E/D passengers per year.

Scope

The scope of the study includes airports in Canada which required ERS under CAR 303 and covers the 24-year period from 1986 to 2009. The start of the period corresponds to the end of the period used in the 1988 Transport Canada study.

Approach

The approach followed for determining the reduction in risk due to ERS was as follows:

- Review past studies of risk reduction due to ERS in Canada and the US;
- Examine trends in aircraft accident rates globally, in the USA, in Canada and at CAR 303 airports;

[2] Crash Firefighting and Rescue Services in Canada by Sypher:Mueller International prepared for Transport Canada, December 1988

- Review accident summaries and reports and identify accidents where ERS was involved and potentially reduced the fatalities or serious injuries;
- Examine the role of ERS in these accidents, and determine the probable and pessimistic outcome had ERS not been present; and
- Estimate the numbers of fatalities and serious injuries prevented by ERS per enplaned passenger and expected numbers per year at airports in Canada.

II. STUDIES OF RISK REDUCTION DUE TO ERS

Canadian Studies

The referenced 1988 study on airport crash firefighting and rescue services in Canada examined the benefits (in terms of fatalities, severe injuries and property damage prevented) and costs of ERS[4]. The risk analysis in that study was based on aircraft accidents at Canadian airports over the 20 years between 1966 and 1985[5]. The study found a total of 287 accidents occurred on, or in the vicinity of, airports in Canada during that period. Of these accidents, ERS appeared to contribute to a reduction in fatalities in 4 accidents.

The analysis found that:

- The expected number of lives saved by ERS was 4.35 per year;
- On average ERS saved 2.4 lives per 10 million enplaned passengers; and
- ERS could not be justified at all but the largest airports.

In 1998, the Air Transportation Association of Canada and the CAC commissioned a risk analysis as a result of newly proposed emergency intervention services at airports other than those already designated by Transport Canada. These non-designated airports were served primarily by turboprop and piston aircraft and most had a low frequency of scheduled passenger service. The study[6] found ERS did not prevent, or could not have prevented, any fatalities in accidents during the period 1976-1999 or reported incidents during the period 1992-1999 (incident data incomplete prior to 1992). The study did, however, find that ERS could likely have prevented a serious injury in one accident in the 23 year period.

US Studies

The National Academy of Sciences' Airport Cooperative Research Program (ACRP) published the findings of a six-month study of ARFF standards in July 2009. The study included an analysis of ARFF-related accidents in the US over an 11-year period between 1997 and 2007. The accidents were reviewed to determine if proposed new ARFF standards would have made any difference in the number of fatalities and looked at all fatal accidents in the US for Part 121 scheduled and non-schedule operations (aircraft with 10 or more seats) and all Part 135 commuter and air taxi operations (aircraft with 9 seats or less).

Only three of these Part 121 accidents were relevant to ARFF. In one (Little Rock, Arkansas, 1999, MD-82), the ACRP report indicated that ERS would have had to have been on the scene immediately for it to have potentially saved one life which was not possible. In the second (Charlotte, North Carolina, 2003, Beech 1900), all 21 occupants died on impact. In the third

[4] At that time ERS was referred to as Crash Fire Rescue services (CFR) in Canada

[5] An accident at Gander on July 13, 1986, was added to the accident set for completeness

[6] The Impact of Increased Emergency Service Requirements on Smaller Airports by Sypher:Mueller. International prepared for ATAC and CAC, Aug. 1999.

(Lexington, Kentucky, 2006, CRJ-100), the accident site was 1,800 ft from the runway and it took ARFF 11 minutes to reach the scene. Only one of the 50 people on board survived and ARFF were not directly responsible for saving his life[7]. Most passengers died on impact but some survived the impact and died of smoke inhalation or thermal injuries. The NTSB notes that it could not be determined exactly how long these passengers survived or whether they could have been save if the ARFF was on the scene earlier. NTSB did note that the ARFF was timely and well coordinated under the circumstances. Of the 13 accidents involving Part 135 operations, none were at airports requiring ARFF. Thus, in none of the accidents identified in the ACRP study did ARFF prevent any fatalities or serious injuries.

7 The first officer suffered serious injuries, including multiple broken bones, a collapsed lung, and severe bleeding. The Lexington-Fayette and airport police officers pulled him from the wreckage.

III. TRENDS IN AVIATION ACCIDENT RATES

An aviation accident is defined in the Convention on International Civil Aviation, Annex 13, as an occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight and all such persons have disembarked, in which a person is fatally or seriously injured, the aircraft sustains damage or structural failure, or the aircraft is missing or is completely inaccessible.

ERS is a reactive safety measure in that it can only reduce the severity of an occurrence, it does not prevent the occurrence in the first place. As the level of safety improves, the frequency with which ERS can prevent fatalities and serious injuries is reduced as the number of occurrences (opportunities) is reduced. The aircraft accident rate, the fatal accident rate and the fatality rate are the most common measures for tracking aviation safety. The changes in these rates were examined to provide an indication of how aviation safety has improved, particularly in relation to the period on which the 1988 study was based.

Canadian Accident Rates

Overall Accident Rates

The Transportation Safety Board (TSB) publishes the numbers of aircraft accidents and fatal accidents by operator type and total numbers of hours flown in aviation statistical summary reports on its web site for the years 1989 to 2009, and for January to July 2010. These, and the accident rates overall operator types, are presented in Exhibit III-1[8].

The numbers of accidents and numbers of fatal accidents have declined over the 20-year period despite the increase in the numbers of hours flown. The reductions in accidents and fatal accidents have occurred for Airliner, Commuter and other operator types. The decline in overall accident and fatal accident rates since 1976[9] are shown graphically in Exhibit III-2. The decline in accident rates from around 13 in 1989 to 5.9 in 2009 represents a 55% reduction, and a similar decline occurred in the fatal accident rate.

Exhibit III-1
Accidents and Fatal Accidents by Operator Type, Total Hours Flown and Overall Accident and Fatal Accident Rates, 1989 to 2009

	Accidents			Fatal Accidents			Hours	Rate per 100,000 hours	
Year	Airliners	Commuter Aircraft	Other	Airliners	Commuter Aircraft	Other	Flown ('000)	Accident	Fatal Acc.
1989	13	8	465	5	1	54	3,737	12.9	0.016
1990	3	12	484	0	2	45	3,411	14.6	0.014
1991	11	6	439	3	1	61	3,301	13.7	0.020
1992	7	10	418	0	1	45	3,308	13.1	0.014

8 Slightly different classifications were report prior to 1989

9 The detailed breakdown shown in Exhibit III-1 is not available for years prior to 1989 but overall rates are and so an earlier start date is reflected in the Exhibit III-2

Exhibit III-1 (Cont'd.)

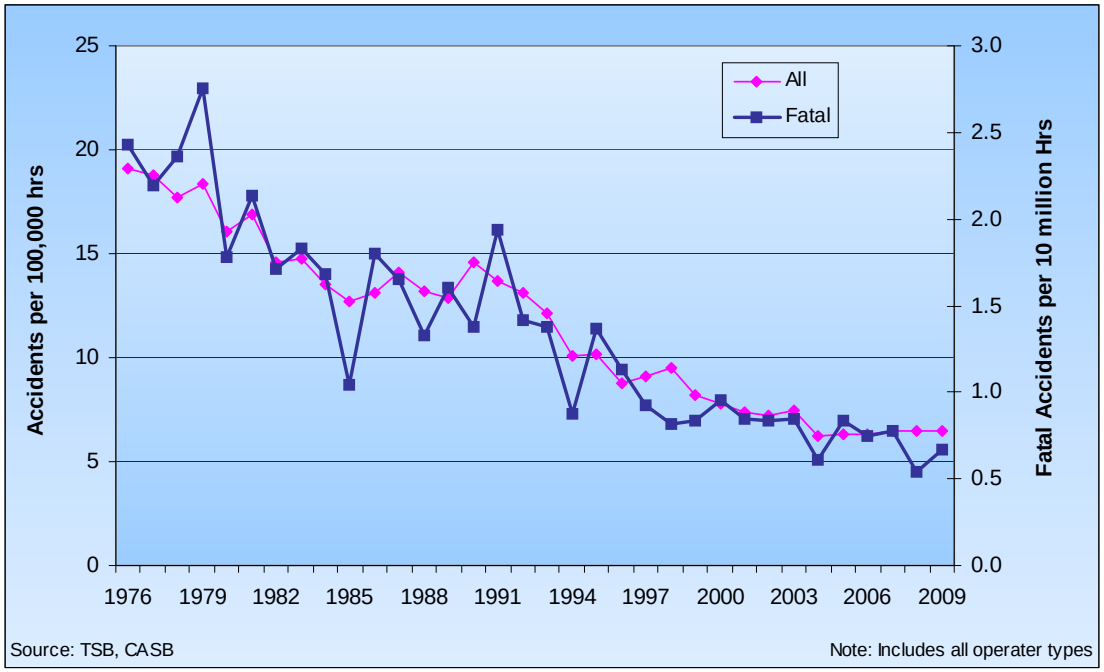
Accidents and Fatal Accidents by Operator Type, Total Hours Flown and Overall Accident and Fatal Accident Rates, 1989 to 2009

	Accidents			Fatal Accidents			Hours	Rate per 100,000 hours	
Year	Airliners	Commuter Aircraft	Other	Airliners	Commuter Aircraft	Other	Flown ('000)	Accident	Fatal Acc.
1993	14	9	403	3	0	45	3,490	12.1	0.014
1994	6	8	371	0	2	31	3,776	10.1	0.009
1995	7	19	369	1	2	52	3,810	10.2	0.014
1996	5	12	325	1	1	42	3,900	8.8	0.011
1997	8	14	339	0	0	37	3,900	9.1	0.009
1998	14	10	368	0	1	32	3,931	9.5	0.008
1999	6	13	328	1	2	33	4,046	8.2	0.009
2000	9	4	310	1	1	36	3,982	7.8	0.010
2001	5	8	285	0	1	33	3,885	7.4	0.009
2002	6	6	264	0	0	32	3,713	7.2	0.009
2003	7	9	282	0	0	33	3,790	7.5	0.009
2004	3	1	252	0	0	24	3,961	6.2	0.006
2005	5	6	253	0	1	33	4,079	6.3	0.008
2006	7	4	257	0	0	32	4,161	6.3	0.008
2007	5	4	278	0	1	33	4,266	6.7	0.008
2008	8	6	241	0	0	26	4,432	5.7	0.006
2009	2	5	246	0	0	28	4,171	5.9	0.007
7Mths 2010	4	2	140	0	0	16			

Source: TSB

Exhibit III-2.

Overall Accident and Fatal Accident Rates, 1976 to 2009



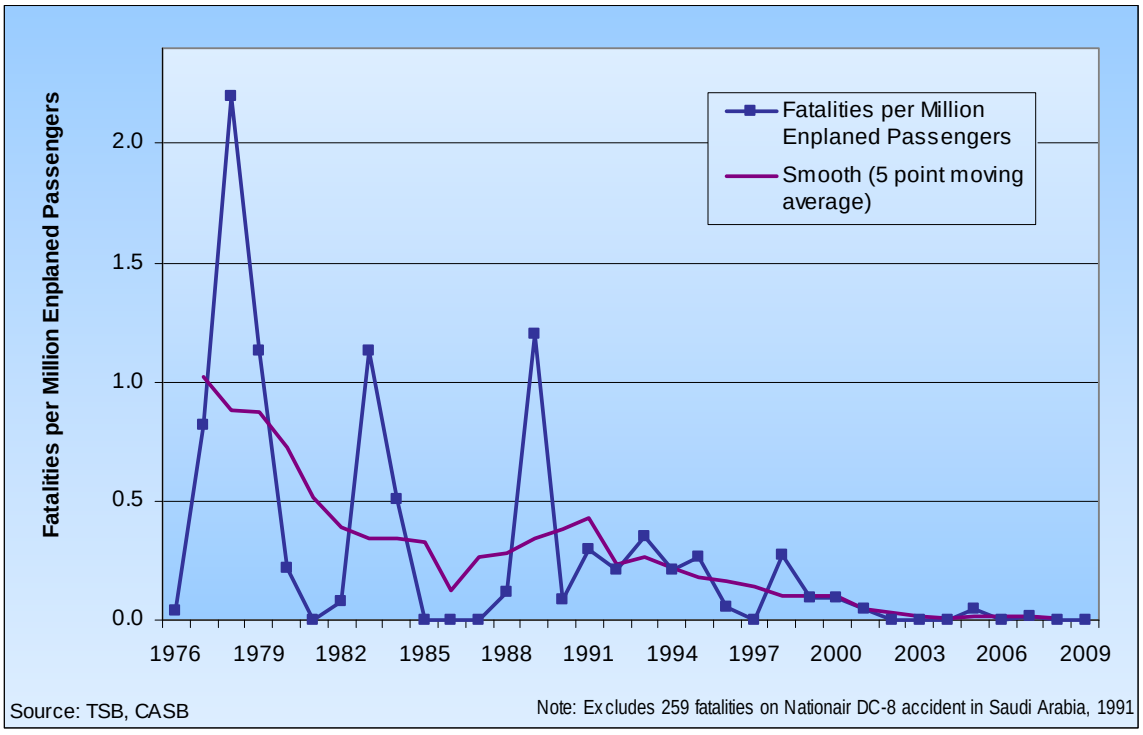
Air Carrier Accident Rates

The fatality rate per million enplaned passengers for Canadian based airlines and commuter air carriers for accidents in North America is presented in ExhibitIII-3. There was one fatal accident outside North America involving a Nationair DC-8 in Saudi Arabia in 1991 with 259 fatalities. This accident shows how dependent fatality rates can be on a single event and why fatality rates based on small number of fatal accidents involving large aircraft can be misleading. Long term trends in fatality rates in large similar aviation countries (e.g., the US) or trends in fatal accident rates, provide a better measure of changes in safety. Notwithstanding this, not only was the Nationair accident not at a Canadian airport, but it occurred off-airport and was of such severity that ERS would not have had any influence on the outcome. The accident is not relevant from the point of view of ERS at Canadian airports.

Excluding the Nationair accident, there has been a significant downward trend in the fatality rate of Canadian airlines since 1976 as is evident from the smoothed accident rate shown in Exhibit III-3. Air carrier fatality rates for the period of the previous study (1976-1985) were thirty times higher than during the past 10 years:

- 1976-1985 0.60 per million enplanements
- 1989-1999 0.29 per million enplanements
- 2000-2009 0.019 per million enplanements

Exhibit III-3.
Air Carrier Fatality Rates, 1976 to 2009



Accident Rates at CAR 303 Airports

The accident rates at CAR 303 airports were derived based on the numbers of accidents at the CAR 303 airports identified from the TSB occurrences database using the selection criteria outlined later in Chapter IV. Note that occurrences as defined by TSB include both aviation accidents and incidents. The numbers of accidents and fatalities and the accident rate per 100,000 flights and fatality rate per million enplaned passengers is summarized in Exhibit III-4. The accident rate is 14% lower during the last 10 years, 2000-2009 compared to the earlier period 1986-1999. The fatality rate has declined more, but is based on only 3 fatal accidents (1995, 1998 and 2004) and the difference is not statistically significant.

Exhibit III-4.
Summary of Numbers and Rates of Accidents and Fatalities at CAR 303 Airports for Aircraft over 5.67 Tonne, 1986 to 2009

Period	Large >30 t	Medium 9-30 t	Small 5.67-9 t	Total	Exposure Measure	Accident/ Fatality Rate
Numbers of Accidents					Flights	Accidents per 100,000 flights
1986-1999	15	3	6	24	18,157,120	0.132
2000-2009	8	4	3	15	13,215,890	0.113
Numbers of Fatalities					Enplaned Pass.	Fatalities per Million Enplaned Passengers
1986-1999	3	0	11	14	482,502,981	0.029
2000-2009	7	0	0	7	458,154,168	0.015

Source: TSB and Statistics Canada
Note: Includes occurrences where the take-off or landing airport at the time of or after the initial occurrence Airport had ERS under CAR 303. This is sometimes different from the Occurrence location category given by TSB

Looking further back, accident and fatality rates at CAR 303 airports were not given in the referenced 1988 report. However, the report identified 16 accidents during the period 1976-1985 at CAR 303 airports involving aircraft over 5.67 tonne where ERS could possibly have reduced the risk in the accident. The total number is likely higher as there are some accidents where ERS would not have any possible benefit. The report gives the total number of commercial movements at Canadian airports in the period to be 10.45 million (5.45 million flights) airports and it is estimated that 80% of these are at CAR 303 airports and involve aircraft over 5.67 tonne. The accident rate is estimated to be 0.38 per 100,000 flights, much higher than the 0.11 observed during the past 10 years.

US Accident Rates

The NTSB publishes information on aviation accident and fatality rates in the US. The accident rates for aircraft on commercial passenger service (classified as Part 121 operations) are presented in Exhibit III-5. There does not appear to be a trend in the accident rate, but the fatal accident rate is trending downwards.

Exhibit III-5.
Accident and Fatal Accident Rates for Aircraft on Commercial Passenger Service (CFR 121) in the US, 1982 to 2009

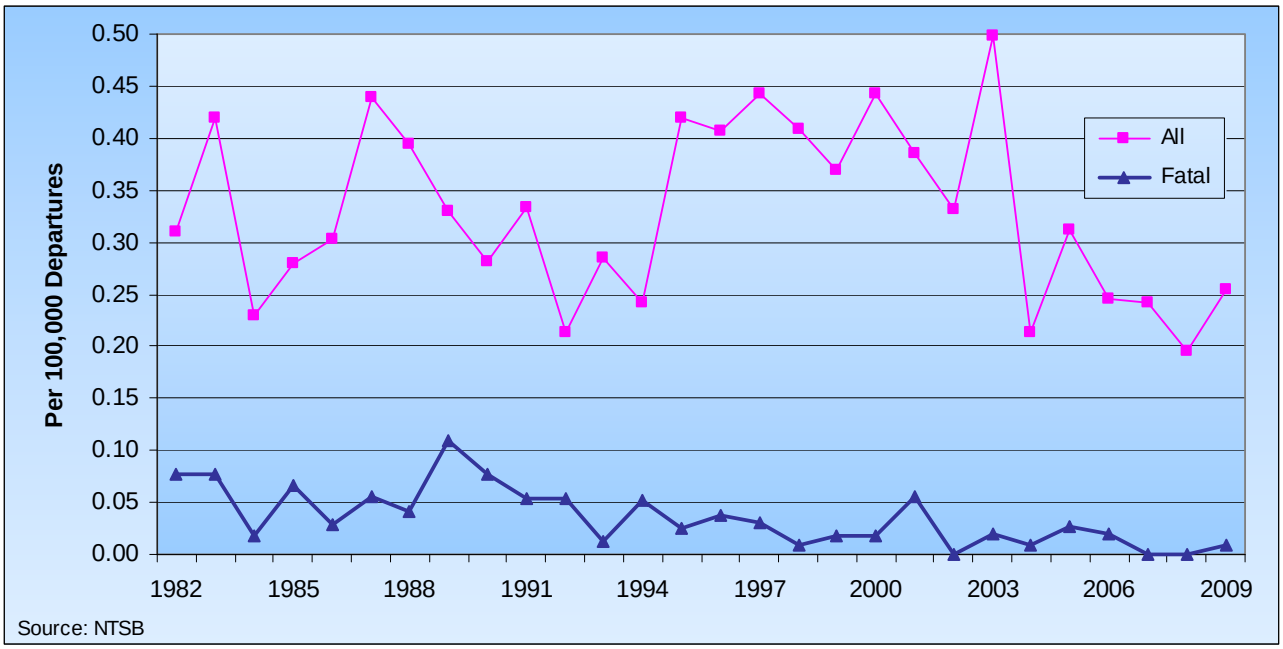


Exhibit III-6 presents the average accident rates per 100,000 departures for commercial passenger services for the three time periods: 1982-1989, 1990-1999 and 2000-2009. The average accident rate over the most recent 10-year period was marginally less than during the 1982-1989 period, while the recent fatal accident rate is less than a third of the earlier rate.

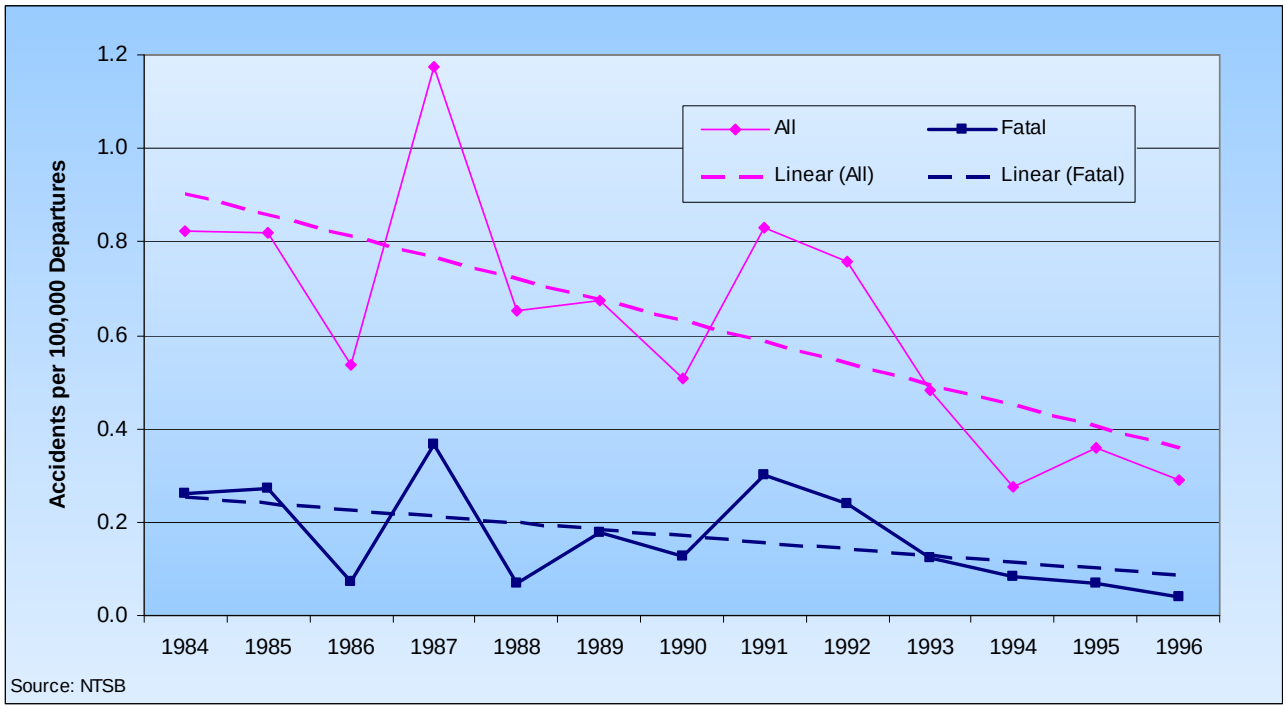
Exhibit III-6.
Average Accident and Fatal Accident Rates for Aircraft on Commercial Passenger Service (Part 121) in the US, 1982 to 2009

Period	Accident Rates per 100,000 Departures	
	All	Fatal
1982-1989	0.341	0.059
1990-1999	0.347	0.035
2000-2009	0.312	0.016

However, because of changes in the class of airplane operation captured part way through the period, the picture is somewhat distorted. Prior to 1997, scheduled commuter (Part 135 with 9 seats or less) operations were classified separately from Part 121 operations. Since the Part 135 scheduled commuter operations have a higher accident rate than Part 121, their inclusion since 1997 with Part 121 operations lead to an increase in the Part 121 accident rate. The effect was estimated to be an increase in the accident rate of approximately 0.05 after 1996. The accident rate for Part 121 operations excluding the previously classified scheduled Part 135 operations would be approximately 0.26 in the 2000-2009 period, or 23% less than the comparable rate for the 1982-1989 period.

The accident rates of the scheduled commuter Part 135 operations were trending downwards prior to their incorporation with Part 121 operations as is clearly shown in Exhibit III- 7.

Exhibit III-7.
Accident Rates of Scheduled Commuter Part 135 Operations, 1984 to 1996



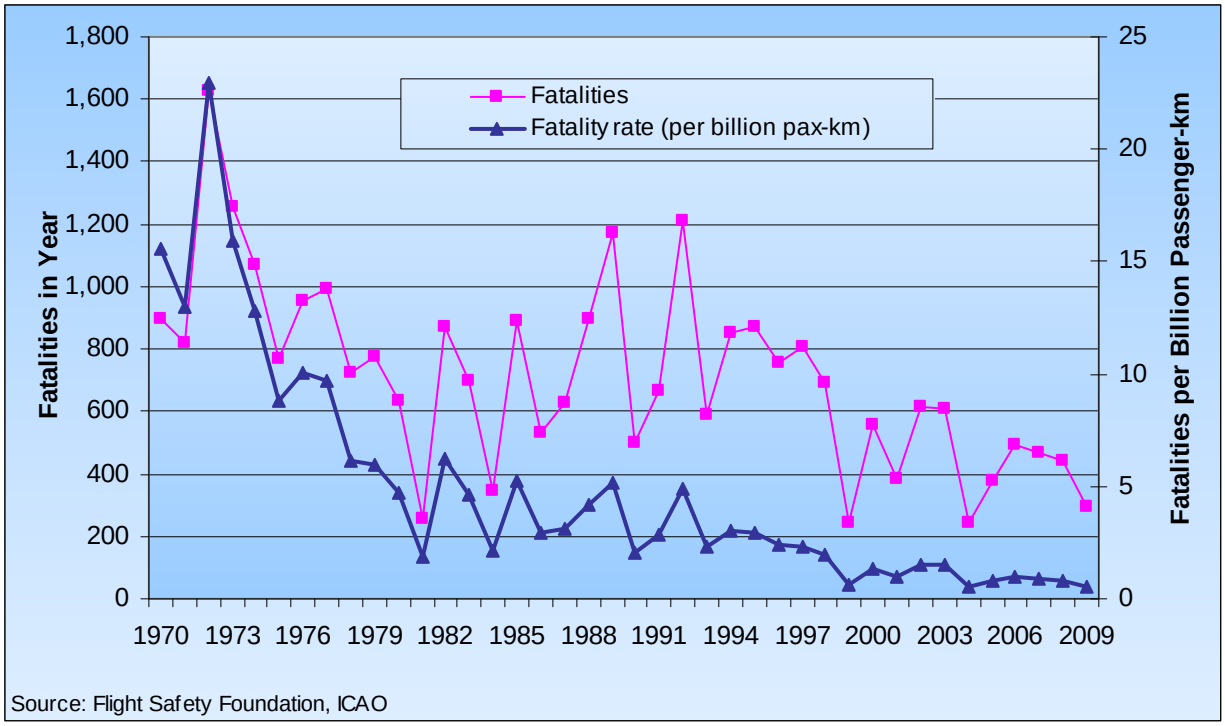
World-wide Accident Rates

The Flight Safety Foundation tracks the number of fatal hull-loss airliner accidents worldwide. Their definition of airliner includes "Commercial multi-engine airplane which, in certificated maximum passenger configuration, is capable of carrying 14 or more passengers". Accidents include: "An occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, in which a person on the airplane is fatally injured and the airplane is damaged beyond repair." They also classify the accidents by phase of flight and the accidents where the phase was take-off, landing, initial climb or approach were selected as these are the categories most relevant to ERS.

Accident rates were estimated using the Flight Safety Foundation accident data and world annual traffic data reported by ICAO[10]. The numbers of fatal hull-loss airline accidents and the corresponding accident rate for the years 1970 to 2009 are presented in Exhibit III-8.

10 Fuel Economy and ICAO Role During Previous Crisis by Narjess Teyssier, Chief Economic Analyses & Database Section, ICAO, Presentation to the GIACC / 4, 25 May 2009.

Exhibit III-8.
Numbers of Fatalities and Fatality Rates in Fatal Hull-loss Airliner Accidents at or Near Airports Worldwide, 1970 to 2009



Note: Includes accidents where the phase of flight was take-off, landing, initial climb or approach

The numbers of fatal accidents and fatalities and the average fatality rates for the past four decades are presented in Exhibit III-9. The numbers of fatalities and fatal accidents have both decreased by factor of 2 since the 1970s, but with the increase in traffic, the fatality rate has decreased by a factor of 12 since the 1970s and factor of 4 since the 1980s.

Exhibit III-9.
Worldwide Numbers of Fatal Hull-Loss Airliner Accidents and Fatalities at or Near Airports and Fatality Rate During each Decade, 1970 to 2009

Period	Number of Accidents	Number of Fatalities	Passenger-km (Billion)	Fatality Rate*
1970-1979	372	9,872	887	11.1
1980-1989	276	6,926	1,721	4.0
1900-1999	301	7,189	2,941	2.4
2000-2009	181	4,475	4,714	0.9

* Fatality rate per Billion Passenger Kilometers

Note: Includes accidents where the phase of flight was take-off, landing, initial climb or approach

Comparison with Other Modes

When considering safety in aviation, it is worthwhile considering how it compares with other modes of transport. The numbers of fatalities per year in Canada by various modes are presented in Exhibit III-10. By far the most fatalities are by road motor vehicles with 2,767 in 2007, while commercial passenger air services averaged less than one fatality per year between 2000 and 2009.

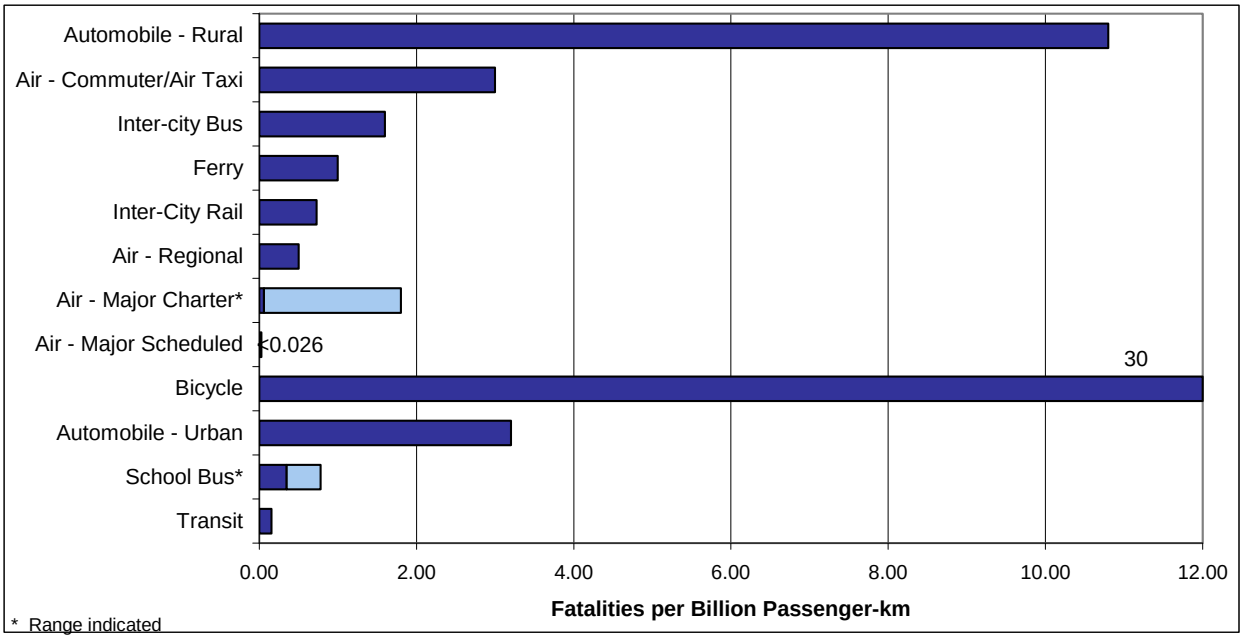
Exhibit III-10.
Annual Fatalities in Canada by Mode of Transport

Mode	Segment	Fatalities per year	Notes
Air	All segments (incl. GA)	52	Average per year 2000-2009 (TSB, 2010)
	Commercial passenger	0.9	
Rail	Crossing, Trespass & Other	91	Average per year 2004-2009 (TSB, 2010)
Motor vehicle		2,767	Canada, 2007 (Statistics Canada, 2010)
Bus		53	Canada 1987-1997 (Transport Canada, , Review of Bus Safety Issues)

Considering the distance travelled, scheduled air passenger service is by far the safest mode of travel. Exhibit III-11 presents the average fatality rates of various modes of travel for the period 1990 to 1999. The fatality rate for air was less than 0.026 per billion passenger kilometer[11], while for rural automobile travel it was 10.8 per billion passenger kilometer, 400 times greater than by air, and for inter-city bus was 1.6 per billion passenger kilometer, 60 times higher than by air.

[11] Rate was zero for period 1990-1999, but extending period to 1983 to 1999 the rate was 0.026 per billion-km

Exhibit III-11.
Average Fatality Rates for Different Modes of Travel



Source: Canadian Urban Transit Association, Transit's Safety and Security Record, STRP Synthesis S3, Nov. 2000
Notes: Rates based on 10-year period 1990-1999 for Canada, except air 1983-1999; inter-city bus 1988-1997; and bicycle, 5 years UD data.
Transit excludes walking to and from the bus stop
School bus range due to inclusion/exclusion of pedestrian accidents
Air major charter range due to inclusion/exclusion of one catastrophic accident in Saudi Arabia by a Canadian registered aircraft

Summary

Aircraft accident rates have decreased greatly over the past 40 years and are currently significantly lower than during the period of the data used in the referenced 1988 study. Due to the small number of accidents in Canada involving large aircraft, it is difficult to be confident of the improvement in safety, but trends in larger aviation markets, particularly the US, provides a good indication of the levels of improvement. Based on the analyses for Canada, the US, and to a less extent, worldwide, the accident rate for large commercial passenger aircraft has declined by over 20%, while the fatal accident rate and the fatality rate have decline much more, likely in the order of 70-80%. The accident rate of private/GA operations has declined by over 60%.

The number of fatalities for commercial passenger air service is very low compared to other modes of travel and the fatality rate per billion passenger kilometers for scheduled air service is less than 100th that of other modes.

IV. EXAMINATION OF ROLE OF ERS IN PAST ACCIDENTS

Occurrences (accidents or incidents) at airports with ERS as required by CAR 303 were examined to determine the role played by ERS in reducing the risk associated with the occurrence. Incidents were examined in addition to accidents as ERS may have prevented the incident from becoming more serious. Information on occurrences was obtained from the Transportation Safety Board.

Role of ERS in Reducing Fatalities & Serious Injuries

The primary role of ERS is to prevent fatalities and injuries in aircraft accidents by providing a fire-free egress route for the evacuation of passengers and crew following an aircraft accident. Where circumstances allow, they may also rescue passengers from an aircraft, although they must consider the risks to themselves in undertaking such a role. The main benefits of airport ERS are related to their ability to respond quickly in an emergency and extinguish or prevent aircraft fire. ERS also provides first aid to seriously injured passengers and other less critical assistance at the crash site.

The role of ERS is often limited by various factors:

- Accident is not survivable;
- Aircraft does not end up at or in vicinity of the airport;
- Aircraft is difficult to locate due to, for example, fog, mist, heavy rain or blowing snow which are often a contributory cause of the occurrence;
- Aircraft is difficult to reach (deep snow, in ravine, forest, etc);
- There is no fire or risk of a fire; and
- Evacuation is complete or underway by time ERS arrives.

ERS is regularly called to be on standby when an aircraft is coming to land at an airport and an emergency situation exists. In determining the effectiveness of ERS in reducing the risk based on past aviation occurrences, being on standby only reduces the risks in those occurrences where it actually performs firefighting and/or other actions which prevent fatalities or serious injuries. It should be noted that the benefits of ERS under CAR 303 achieved following ERS being on standby would often be achievable with a less stringent response time requirement. For example, in many cases where ERS is on standby the call to go on standby is made at least five minutes prior to landing. Thus, an alternate form of ERS with less stringent response time requirements would be able to standby at the required time for those occurrences.

Each one of the identified occurrences was examined to determine the possible role of ERS in preventing fatalities and serious injuries. A critical question in determining their role is, *what would the likely outcome have been if ERS had not arrived or not arrived until much later (say 10 minutes).*

The factors examined when identifying ERS's role included:

- Condition of the aircraft, passengers and crew when aircraft finally came to rest, how many people on board were seriously injured and would have had difficulty evacuating the aircraft;
- Existence of post-crash fire and type of fire(s), or risk of fire due to smoke, very hot components and/or fuel spill;
- Location and intensity of the fires, especially if near emergency exits;
- The deployment and inflation of the evacuation slides or other emergency exits;
- The success of flight attendants in evacuating passengers, and whether the fire prevented or significantly slowed down the evacuation;
- The numbers of people on-board the aircraft when ERS arrived on the scene and when ERS started extinguishing the fire or taking effectual action;
- The availability and use of required ERS equipment;
- The actions and timeliness of actions taken by ERS to extinguish the fire or reduce the risks of the fire becoming severe or of an explosion; and
- Assistance provided by non-ERS personnel at the crash site.

Occurrences Where ERS Could Potentially Have Had a Role

The occurrences where ERS could potentially have had a role were selected from the TSB database based on a search of various accident categories and the textual summary of the occurrence. Occurrences meeting any one of the following criteria were selected:

- Event Category: FIRE/SMOKE/EXPLOSION, or TAKE-OFF/LANDING EVENT, or TAKE-OFF EVENT, or LANDING EVENT, OR
- ATS related event: EMERGENCY/PRIORITY HANDLING , OR
- Phase of Flight Category: AT TAKE-OFF, or ON APPROACH, or ON LANDING, or AIRCRAFT STANDING, OR
- The summary includes the words: "ERS", or "CFR", or "EMERGENCY RESPONSES SERVICES", or "SERVICES D'URGENCE DEMANDES"; or "FIRE" and "EVACUATION"

In addition, only those occurrences on or after January 1, 1986, and those where the aircraft maximum take-off weight was greater than 5.67 tonnes (12,500 lbs), or the weight was not specified, were selected. The aircraft weight category is not complete for many occurrences and the set of flights provided by TSB included many occurrences involving small aircraft. The role of ERS in these occurrences was also reviewed, but results are only presented for the aircraft

over 5.67 tonne as the occurrence set for the smaller aircraft was incomplete. ERS in Canada is only required for commercial operations of aircraft with 20 or more seats (CAR 303.04(2)), although, if available and on duty at the airport, ERS would respond to occurrences involving other aircraft. All aircraft on commercial service in Canada with 20 or more seats weigh over 5.67 tonnes and are therefore included in the analysis.

The full occurrence reports given on the TSB web site and occurrences examined in a study on evacuations by TSB were cross-checked with the occurrences identified in the database search to ensure that no potentially important occurrences were missed.

TSB provide the long-form summary report for all occurrences meeting these criteria. These long-form summaries were examined and where further information was required, the full occurrence reports were also examined where they were available (TSB does not do a full report for all occurrences). In total, long-form summaries were provided for 184 accidents and 155 incidents. These included many occurrences for aircraft under 5.67 tonnes and occurrences at non-CAR 303 airports.

The TSB database includes a field for "Location" which is usually an airport. However, when the first event occurred en-route, the field is often not an airport even though the emergency still existed when the aircraft landed at an airport and ERS was on standby. In these situations the airport where the aircraft landed was taken as the location relevant to ERS. Occurrences not occurring at or in the vicinity of an airport (taken to be less than 2 miles) were assumed to have no ERS benefit and were excluded. For the other incidents the identified airport was used to determine if ERS under CAR 303 was available at the airport. The date of the occurrence was taken into account as the provision of ERS has changed over time (particularly after June 2008).

General Aviation and Small Commercial Aircraft

In the 1988 study of all accidents at or in the vicinity of airports in Canada and the 1998 study of occurrences at non-designated airports in Canada, ERS was found to have not prevented fatalities in any occurrences involving small aircraft less than 5.67 tonne. There are a number of reasons for this. Firstly, small aircraft generally have much lower take-off and landing speeds and accidents on take-off and landing tend to be less severe. Secondly, accidents involving small aircraft seldom involve fire so the need for ERS to provide firefighting is unusual. Thirdly, evacuation is easier on a small aircraft and the small number of crew and passengers can usually evacuate before ERS reaches the crash site.

The current study focuses on the role of ERS in occurrences involving larger commercial aircraft. The cut off of 5.67 tonnes was used as aircraft over 5.67 tonnes are classified as Transport Category aircraft and typically carry more passengers. Almost all GA aircraft weigh less than 5.67 tonnes. Commercial aircraft under 5.67 tonnes are typically air taxi (9 or less seats) or non-passenger operations such as cargo or aerial photography. Almost all aircraft over 5.67 tonnes have 10 or more passenger seats, are either jet or turboprop aircraft and are used in commuter size or larger air carrier or corporate operations.

While the search of the TSB database was geared to identifying aircraft over 5.67 tonne, 87 accidents and 9 incidents involving aircraft less than 5.67 tonnes were identified due to the weight field not being completed[12]. These occurrences were reviewed to determine the role played by ERS in reducing the risks. In the 20 occurrences at CAR 303 airports, ERS was found to not have prevented any fatalities, and in the 67 occurrences at non-CAR 303 airports, availability of ERS would not have prevented any fatalities. These findings were consistent with the role of ERS in occurrences involving small aircraft found in the previous studies.

Thus, while it is possible that ERS may have prevented fatalities or serious injuries in occurrences involving small aircraft not considered in the study, the likelihood is extremely low. Also, as small aircraft typically only have one to four people on board, the numbers of lives saved even in the most optimistic scenario (for ERS assistance) would be low.

Summary of Occurrences

A total of 339 occurrences were examined and classified first by whether the airport had ERS as required by CAR 303 and the size of aircraft involved. An initial assessment was made of whether the occurrence was on or in the vicinity of the airport and, if off-airport, the distance to the crash site from the airport boundary (or closest runway end).

Thirty-nine accidents and 123 incidents were identified to be at or in the vicinity of a CAR 303 airport involving an aircraft over 5.67 tonnes. These accidents and incidents are summarized separately below.

Accidents

The numbers of accidents by accident category and numbers of injuries by category are presented in Exhibit IV-1 broken down by three weight classes. Only three accidents were fatal with a total 21 fatalities. Most (81%) of the accidents had no injuries. Large aircraft over 30 tonne accounted for most of the accidents and over half the fatalities and serious injuries.

ERS responded in 24 of the 39 accidents of the accidents, was not called in 7, or was on standby but not required in 8 of the accidents (see Exhibit IV-2).

The evacuation assistance provided by ERS is summarized in Exhibit IV-3. In most of the accidents (31) there was no evacuation or the evacuation was complete by the time ERS arrived. This occurred, for example, when all on board evacuated before ERS arrived, the fire was extinguished by crew, or substantial damage to the aircraft occurred but it landed safely without incident. In six accidents there was an evacuation while ERS was present, but the risks were minimal. Examples of this include situations where an evacuation took place but there was no fire. In one occurrence ERS arrived at the crash site after all but the seriously injured were evacuated. Two of the accidents were deemed to be un-survivable by the TSB.

[12] The weights for these aircraft were determined using the aircraft type information.

Exhibit IV-1.
Numbers of Accidents and Injuries by Category at CAR 303 Airports 1986 to 2009

	Small 5.67-9 tonne	Medium 9-30 tonne	Large >30 tonne	Total
Accident Category				
Fatal	1		2	3
Serious Injury(s)		1	2	3
Minor Injury(s)			2	2
No Injuries	8	6	17	31
Total	**9**	**7**	**23**	**39**
# of Injuries				
Fatal	11		10	21
Serious Injury(s)		9	13	22
Minor Injury(s)			13	13
Total	**11**	**9**	**36**	**56**

Exhibit IV-2.
ERS Role at Accidents at CAR 303 Airports, 1986 to 2009

ERS Role	Small 5.67-9 t	Medium 9-30 t	Large >30 t	Total
Responded	6	4	14	24
Standby only	3	2	3	8
Not called		1	6	7
Grand Total	9	7	23	39

Exhibit IV-3.
ERS Evacuation Assistance at Accidents at CAR 303 Airports, 1986 to 2009

ERS Evacuation Assistance	Small 5.67-9 t	Medium 9-30 t	Large >30 t	Total
Not Required or assisted after evacuation	6	5	20	31
Assisted, minimal risk	2	1	2	5
Un-survivable	1		1	2
Late, assisted evacuation of seriously injured (1)		1		1
Total	9	7	23	39

Note: 1. Fredericton Air Canada CRJ Accident

The firefighting assistance provided by ERS in the 39 accidents at CAR 303 airports is summarized in Exhibit IV-4. In most accidents there was no fire or the fire was extinguished by the crew. In four accidents ERS extinguished the fire, but in two of these the passengers had already evacuated and in one the risks were low (small fire around hot brakes). In two accidents

ERS was unable to extinguish the fire, in one all on board had evacuated before ERS arrived and the other was un-survivable.

Exhibit IV-4.
ERS Firefighting Assistance at Accidents at CAR 303 Airports, 1986 to 2009

ERS Firefighting Assistance	Small 5.67-9 t	Medium 9-30 t	Large >30 t	Total
No fire	7	7	17	31
Fire, extinguished by ERS after evacuation	1		1	2
Unable to put out fire			2	2
Extinguished fire quickly	1			1
Extinguished small fires around hot brakes			1	1
Fire, appears to have been extinguished by crew			1	1
Smoke, no fire			1	1
Total	9	7	23	39

Incidents

There were 123 incidents identified at or in the vicinity of a CAR 303 airport involving aircraft over 5.67 tonnes. Incidents do not involve any serious or fatal injuries and damage to the aircraft was either minor or none. However, it is possible that the actions of ERS may have prevented the incident becoming more severe.

ERS responded to 55 of the 123 incidents, and was on standby but not required in another 27. In 39 cases they were either not called or not required, while for two the role of ERS could not be determined (see Exhibit IV-5). In 19 of the incidents there was a risk of collision on the airport or a loss of separation on approach or climb near the airport, but there was no actual collision and thus no role for ERS. A further 17 incidents provided by TSB (not included in the 123 incidents) involved a risk of collision/loss of separation on approach or climb.

Exhibit IV-5.
ERS Role at Incidents at CAR 303 Airports, 1986 to 2009

ERS Role	Small 5.67-9 t	Medium 9-30 t	Large >30 t	Total
Responded		10	45	55
Not called/required		5	34	39
Standby	1	8	18	27
Unknown			2	2
Grand Total	1	23	99	123

The evacuation assistance provided by ERS in these incidents is summarized in ExhibitIV-6. In over 85% of incidents there was no evacuation or evacuation assistance was not required. In 16

incidents there was an evacuation while ERS was present, but the risks were minimal. There were three incidents where ERS was extinguishing a fire while the evacuation took place and possibly assisted in the evacuation, and in another ERS arrived at the crash site while the evacuation was underway.

Exhibit IV-6.
ERS Evacuation Assistance at Incidents at CAR 303 Airports, 1986 to 2009

ERS Evacuation Assistance	Small 5.67-9 t	Medium 9-30 t	Large >30 t	Total
No evacuation/ ERS not required	1	20	80	101
ERS assisted, but risk minimal	0	3	13	16
Evacuation by crew, ERS not required	0	0	2	2
ERS assisted, fire present	0	0	3	3
Evacuation underway when ERS arrived	0	0	1	1
Total	1	23	99	123

The firefighting assistance provided by ERS in the 39 incidents at CAR 303 airports is summarized in Exhibit IV-7. In 77% of incidents there was no fire. A fire occurred in 28 of the incidents and in another 17 there was smoke or a risk of fire (smell of smoke, very hot brakes, fire warning activation), but no fire. However, in the majority of incidents with fires, the fire either dissipated by itself or was extinguished by the crew. Only in five incidents was the fire extinguished by ERS and in one of these their role was limited to after the evacuation. In one minor fire in the landing gear the role of ERS was not given in the occurrence reports. ERS was found to play a role in extinguishing or preventing fire and reducing the risk in 4 or possibly 5[13] of these incidents.

Exhibit IV-7.
ERS Firefighting Assistance at Incidents at CAR 303 Airports, 1986 to 2009

ERS Firefighting Assistance	Small 5.67-9 t	Medium 9-30 t	Large >30 t	Total
No fire	1	17	72	90
Smoke or risk of fire, but no fire	0	4	13	17
Fire in engine, dissipated without ERS action	0	0	5	5
Fire in engine, extinguished by crew	0	1	4	5
Fire in engine, extinguished by ERS	0	0	4	4
Fire in engine, extinguished after evacuation	0	1	0	1
Fire in landing gear, ERS role not stated	0	0	1	1
Total	1	23	99	123

[13] Uncertain of exact role of ERS in one incident due to limited information in the occurrence report

Occurrences where ERS Possibly Reduced the Risks

In the 20-year period 1966-1985 the referenced 1988 study identified four serious accidents where ERS was found to have likely contributed to the reduction in fatalities. In contrast, the current study found no occurrences in the more recent 24-year period, 1986-2009, where ERS was likely to have prevented fatalities or serious injuries. Nonetheless, to ensure all possible life saving benefits of ERS were included, a conservative risk management approach was used. The review of occurrences identified 10 where ERS **may possibly** have prevented fatalities or serious injuries. These occurrences were:

Accidents

- 27 June 1995, Vancouver, DC-9-32, Air Canada
- 13 May 2002, Toronto-Pearson, B767-300, Air Canada
- 16 Dec 1997, Fredericton, CRJ, Air Canada
- 19 Oct 1995, Vancouver, DC-10-30, Canadian Airlines International

Incidents

- 10 Oct 1994, Toronto-Pearson, B727, American Airlines
- 13 July 1986, Gander, L-1011, American Trans Air
- 10 Dec 2004, Vancouver, B747-400, China Airlines
- 22 May 2008, Saskatoon Int'l, B737-200, Canadian North
- 24 Dec 1999, Calgary Int'l, A320-200, Air Canada
- 19 July 2000, Edmonton Int'l, B737-200, Canadian Airlines International

There have been a number of other high profile accidents in the past 24 years where ERS did not prevent fatalities or serious injuries. These accidents, summarized below, illustrate the nature of serious accidents and the ineffectiveness of reactive safety measures:

- Accident: 2 Aug. 2005, Toronto-Pearson, A340, Air France - the aircraft overran on landing in a heavy rain storm and crashed in a ravine. Passengers evacuated the aircraft within 2 minutes. ERS arrived at the crash site within the required three minute period, but after all passengers had evacuated the aircraft[14]. ERS worked to extinguish the fire but were unsuccessful. They also carried one lady with a broken leg on a stretcher up the bank away from the crash site. All passengers and crew would have survived without ERS present.

14 Confirmed with TSB investigator (Glen Freison, personal communication, Nov. 19, 2010).

- Propair Metro at Montreal-Mirabel in 1998 – 11 fatalities, accident un-survivable, ERS on scene immediately and extinguished fire, but all onboard were dead;
- MK Airlines B747-200 freighter at Halifax in 2004 – all 7 crew died, aircraft struck an embankment, there was a severe post crash fire, TSB: "the accident was not survivable"; and
- Air Ontario F-28 at Dryden in 1989 – 24 fatalities, not CAR 303 airport, accident off-airport.

The 10 occurrences where ERS may possibly have prevented fatalities or serious injuries are discussed below. The full set of occurrences is summarized in Appendix A.

Estimation of Expected Fatalities and Serious Injuries Prevented by ERS

In order to evaluate the effectiveness of airport ERS, it was necessary to quantify deaths resulting from (or potentially resulting from) aviation accidents and incidents. While this is a statistical analysis, one should not ignore the human tragedy involved. It is therefore all the more important to fully understand the risks involved and determine ways to reduce this personal loss.

The expected number of fatalities prevented by ERS was estimated by considering what would likely have happened to the passengers and crew had ERS not been present. The number of fatalities prevented is dependent on the numbers of passengers and crew on board the aircraft when ERS started fighting the fire or taking preventative action. We first considered how frequently would an occurrence in the given circumstances have resulted in at least one fatality had ERS not been present. We then considered the numbers of people on board when ERS arrived and the proportion that would have likely died without ERS firefighting and evacuation assistance.

The expected numbers of fatalities prevented is then calculated by:

No_Fatal_Prev = Pr_Acc_Fatal x No_at_Risk x Pr_Onboard_Die

where

No_Fatal_Prev	is the expected numbers of fatalities prevented by ERS in occurrence
Pr_Acc_Fatal	is the probability that the occurrence would have been fatal had ERS not been present
No_at_Risk	Number on board at the time ERS started taking action to reduce the risk (e.g., started extinguishing fire)
Pr_Onboard_Die	Proportion of those on board at risk that would have died without ERS given accident had been fatal

The estimated expected numbers of fatalities prevented by ERS in occurrence can be interpreted as the average number over many incidents with similar characteristics and ERS responses. In some similar situations the fire may have got much worse and resulted in fatalities, but in others

all the crew and passengers may have been able to evacuate safely. The expected number typically results in non-integer values and may be less than 1 for occurrences where there was a low probability of a serious fire.

Any assessment of the benefits of ERS will be subjective as the outcome of the occurrence at CAR 303 airports without ERS is unknown. In the occurrences examined, there were none where it is clear cut that without ERS people would have died. The use of the probabilistic approach described above allows estimates to be derived even when the role of ERS may be more preventive than the definitive role of clearing a fire-egress route during an evacuation.

The assessment of probabilities and number of people on board at risk is based on evidence presented in the occurrence reports and takes into account experiences at other accidents/incidents, especially what happens when there was no ERS, or ERS arrived late at the crash site due to difficulty location or accessing the site. Reports on occurrences at non-CAR 303 airports were also reviewed to better understand what happens when CAR 303 level ERS is not available. Due to the subjective nature of the assessment, a "most likely" and a "high" estimate of the numbers of fatalities prevented by ERS are provided.

The number of serious injuries prevented by ERS is particularly hard to estimate. Serious injuries in aircraft accidents usually occur due to impact injuries at the time of the crash. ERS could prevent serious burns by creating a fire-egress route and may prevent serious injuries due falls during panicked evacuation from the aircraft. The number of seriously injured without ERS at the scene would be expected to be of a similar order of magnitude, on average, as the number of fatalities prevented, and are assumed to be equal in the analysis.

Each of the 10 accidents and incidents where ERS was identified as possibly reducing the numbers of fatalities and serious injuries is discussed below and values of the parameters for estimating the expected numbers of fatalities prevented by ERS are provided. The following case studies are ordered by the positive contribution that ERS had on the outcome, with the highest contribution listed first.

Accident: 27 June 1995, Vancouver, DC-9-32, Air Canada

An engine failure occurred on start-up while the aircraft was on the ramp. The crew activated the fire extinguishers and evacuated the aircraft. ERS responded and applied foam to left engine. There were 72 passengers and 5 crew members on board the aircraft. The TSB report states:

"While the pilots were completing the engine shut-down procedures [after unsuccessful attempt to start engines], they were informed by ground personnel and the crew of a passing aircraft that black smoke and flames were visible in the vicinity of the left engine. There were no cockpit indications of fire, but, based on these external reports, the captain activated the engine fire extinguisher bottle No. 1, and informed the flight-attendant-in-charge. A short time later, the pilots received a second report of fire from personnel working near the aircraft. The captain immediately activated the engine fire extinguisher bottle No. 2, and, because the aircraft had already been pushed back from the terminal gate, he ordered an emergency evacuation through the two forward doors. The flight attendants deployed the two forward escape slides and began the emergency evacuation. During the evacuation, the

right-side escape slide partially deflated, but it remained sufficiently firm for the evacuation. There were four minor injuries during the evacuation, and the aircraft was not damaged."

"The emergency rescue services (ERS) responded without delay and applied foam to the left engine. The evacuation was reportedly completed in a timely and orderly fashion, and was supported by the RCMP, ERS crews, ramp attendants, and Air Canada ground personnel."

ERS responded quickly and were on the scene and extinguishing the fire as passengers evacuated. ERS may have prevented a serious occurrence, particularly further asset loss, but most likely all on board would have evacuated safely without ERS present.

Based on the assessment of risks, the likely and high values for calculating the fatalities prevented by ERS were as follows:

Probability occurrence would have been fatal without ERS: Likely: 1/20, High: 1/10

Number on board at the time ERS started to reduce the risk: Likely 30, High: 50

Proportion on board at risk that would have died: Likely: 20%, High: 30%

Expected numbers of fatalities prevented by ERS in occurrence: Likely: 0.30, High: 1.5

Accident: 13 May 2002, Toronto Int'l, B767-300, Air Canada

A fire occurred in-flight in the cargo bay and extinguishers were deployed by the crew. The aircraft landed safely, ERS inspected the aircraft and found significant amount of smoke. The number of passengers and crew on board was not stated, but was likely 110-150. The TSB report states:

"The Air Canada Boeing 767-300 was conducting an IFR approach to runway 06l at Toronto LBPIA. At approximately 10 miles on final approach, the flight crew received a cargo fire warning. The flight crew followed QRH procedures, activated the cargo bay fire extinguishers and declared an emergency. The flight landed and stopped on the runway to allow airport ERS to inspect the aircraft for fire. No external fire damage was observed but the flight and cabin crew noticed a significant smoke odour in the cabin. The flight crew taxied to the terminal but stood off from the gate at a distance of approximately 40 feet. ERS personnel opened the C2 and bulk cargo compartments and discovered a significant amount of smoke in both areas."

TSB did not do a full investigation of the accidents and no occurrence report was produced. The exact role of ERS in reducing the risk of a fire and in evacuating passengers unknown, although a full investigation and accident report would likely have been done if the risks were great. ERS may have prevented a serious occurrence, but extremely likely all would have evacuated safely without ERS present.

Based on the assessment of risks, the likely and high values for calculating the fatalities prevented by ERS were as follows:

Probability occurrence would have been fatal without ERS: Likely: 1/100, High: 1/20

Number on board at the time ERS started to reduce the risk: Likely 200, High: 200

Proportion on board at risk that would have died: Likely: 10%, High: 10%

Expected numbers of fatalities prevented by ERS in occurrence: Likely: 0.20, High: 1.0

Accident: 16 Dec 1997, Fredericton, CRJ, Air Canada

The aircraft crashed after a rejected landing. Because of poor visibility due to fog, it took ERS 15 minutes to locate the aircraft. All passengers and crew except for 7 seriously injured trapped passengers evacuated the aircraft without ERS assistance. There were 39 passengers and 3 crew members on board the aircraft. The TSB report states:

"With visibility 1/8 of a mile in fog, the crew conducted a Category I ILS approach to Runway 15 and elected to land. On reaching about 35 feet, the captain assessed that the aircraft was not in a position to land safely and ordered the first officer, who was flying the aircraft, to go around. As the aircraft reached its go-around pitch attitude of about 10 degrees, the aircraft stalled aerodynamically, struck the runway, veered to the right and then travelled - at full power and uncontrolled - about 2100 feet from the first impact point, struck a large tree and came to rest. ERS took about 15 minutes to locate the crash site. An evacuation was conducted without ERS; however, seven passengers were trapped in the aircraft until rescued. A portable jaws-of-life from the CFB Gagetown fire department was used to assist in the extraction of the trapped passengers. Of the 39 passengers and 3 crew members, 9 were seriously injured and the rest received minor or no injuries."

There was no fire either before or after the aircraft crashed"

There was no fire, and the role of ERS was limited to attending to seriously injured passengers before community fire department brought a portable "jaws of life" and freed them. ERS may have provided life saving assistance to the serious injured, but very likely all would have survived without ERS present. Note that most CAR 303 airports now have portable "jaws of life", but the outcome would have been the same in this accident if ERS had such equipment.

Based on the assessment of risks, the likely and high values for calculating the fatalities prevented by ERS were as follows:

Probability occurrence would have been fatal without ERS: Likely: 1/10, High: 1/5

Number on board at the time ERS started to reduce the risk: Likely 7, High: 7

Proportion on board at risk that would have died: Likely: 20%, High: 30%

Expected numbers of fatalities prevented by ERS in occurrence: Likely: 0.14, High: 0.42

Accident: 19 Oct 1995, Vancouver, DC-10-30, Canadian Airlines

An engine failure occurred on take-off. The pilot aborted the take-off and aircraft overran runway by 400 ft. ERS responded and extinguished small fires around brakes. There were 243 passengers and 14 crew members on board the aircraft. The TSB report states:

"The Canadian Airlines DC-10 with a crew of 14 and 243 passengers on board was on its take-off run at Vancouver International airport in day VMC. About two seconds after the v1 call 164 kts, the crew heard a loud bang; the captain rejected the take-off at 172 knots. The aircraft ran about 400 feet off the end of Runway 26. The nosewheel collapsed as the aircraft rolled through the soft ground off the end of the runway. There was no fire. The aircraft was evacuated quickly and the ERS responded; 6 passengers received minor injuries during the evacuation."

"Small grease-type fires occurred around the hot wheels some time after the evacuation and were extinguished by fire-fighters."

The exact role of ERS evacuating passengers is unknown, but there was no fire during the evacuation and their firefighting role was limited to extinguishing small grease-type fires around the brakes after the evacuation and applying foam in case of a possible fuel spill. ERS assisted passengers after the evacuation and likely reduced the fire damage to the aircraft.

ERS may have prevented a serious occurrence, but it is extremely likely that all would have evacuated safely without ERS present. Based on the assessment of risks, the likely and high values for calculating the fatalities prevented by ERS were as follows:

Probability occurrence would have been fatal without ERS: Likely: 1/100, High: 1/20

Number on board at the time ERS started to reduce the risk: Likely 261, High: 261

Proportion on board at risk that would have died: Likely: 5%, High: 10%

Expected numbers of fatalities prevented by ERS in occurrence: Likely: 0.13, High: 1.31

Incident: 10 Oct 1994, Toronto Int'l, B727, American Airlines

During touchdown the tires blew and caught on fire. The crew initiated an emergency evacuation. ERS responded and arrived in 3 minutes. The number of passengers and crew on board not stated, but was likely 100-150. The TSB report states:

"During the touchdown on runway 24R with the wind from 330 degrees magnetic at 8 knots, the main landing gear tires blew and the aircraft began to veer to the left. The aircraft began to slide sideways down the runway until it came to a stop. The crew was advised by the control tower of flames emitting from the starboard landing gear and ordered an evacuation. The captain advised the flight attendants to avoid using the overwing and starboard exits."

"ERS was called out by the tower and were on scene in approximately 3 minutes. During the evacuation five passengers received minor injuries."

There was no detailed investigation of the occurrence by TSB and a full occurrence report was not produced. The exact role of ERS in extinguishing fire and evacuating passengers is unknown. However, if the incident had posed a serious threat to life the occurrence would likely have been investigated further.

ERS may have prevented a serious occurrence, but it is very unlikely as all transport category aircraft are required to demonstrate that a brake/wheel fire will not result in penetration of the fuel tanks or passenger cabin. Most likely all on board would have evacuated safely without ERS present. Based on the assessment of risks, the likely and high values for calculating the fatalities prevented by ERS were as follows:

Probability occurrence would have been fatal without ERS: Likely: 1/20, High: 1/10

Number on board at the time ERS started to reduce the risk: Likely 135, High: 135

Proportion on board at risk that would have died: Likely: 10%, High: 20%

Expected numbers of fatalities prevented by ERS in occurrence: Likely: 0.68, High: 2.7

Incident: 13 July 1986, Gander, L1011, American Trans Air

On engine start-up there was a muffled explosion in one engine and it caught fire. Captain discharged extinguishers and called for an evacuated. ERS responded and extinguished the fire. There were 344 passengers and 12 crew on board the aircraft. The TSB report states:

The engines were being restarted after an approximate one-hour shutdown during a scheduled refuelling stop. The number two (rear) engine was started first and was being used to provide pressure air to start the number one (left) engine. As fuel and ignition were introduced during the start sequence on the left engine, the flight crew felt the aircraft shake and thought that the aircraft had been struck by a service vehicle. There was a muffled explosion in the number one engine, and it was on fire. Flames were shooting out both the front and the rear of the engine. The flight crew could not see the engines from their position, and the engine fire warning did not activate. They were informed of the fire by the cabin crew, the ground marshaller, and the tower controller. The captain called for evacuation from the right side of the aircraft. All slides were used, except for the one at the rear door position, which did not deploy. The engine fire extinguishers were discharged, but the fire continued until it was extinguished by the airport emergency response vehicles.

The source of the fire was a pool of fuel that had accumulated in the combustion and turbine area of the engine after the engine had been shut down.

The occurrence report did not provide any details on the timing of the arrival of ERS and the evacuation of passengers and little information on the fire. If the fire was serious and the passengers at serious risk, the report would likely have included more details on the fire and the evacuation.

ERS may have prevented a serious occurrence, but given the strict certification requirements regarding engine fire protection[15], most likely all would have evacuated safely without ERS present. Based on the assessment of risks, the likely and high values for calculating the fatalities prevented by ERS were as follows:

Probability occurrence would have been fatal without ERS: Likely: 1/20, High: 1/10

15 CAR 525.863 to 525.869

Number on board at the time ERS started to reduce the risk: Likely 200, High: 300

Proportion on board at risk that would have died: Likely: 10%, High: 20%

Expected numbers of fatalities prevented by ERS in occurrence: Likely: 0.50, High: 4.0

Incident: 10 Dec 2004, Vancouver Int'l, B747-400, China Airlines

The pilot rejected take-off just below V1 speed following a birdstrike in an engine. Strong braking resulted in smoke and fire from all four main wheels. ERS responded and extinguished the wheel fires. No evacuation was necessary. The number of passengers and crew on board is unknown, but is likely 300-400. The TSB report states:

During the take-off roll on runway 08R, the captain saw a large water bird pass under the aircraft's nose from left to right. This was followed by a loud bang, a yaw to the right, and momentary fluctuation of the number 4 engine instruments. The captain rejected the take-off at 120 knots (v1 was 154 knots). The captain was able to bring the aircraft almost to a full stop before the end of the runway, and exited at the D5 taxiway. The aircraft was just below its MATOW and smoke and fire was coming from all four main wheel bogies. He stopped the aircraft, requested ERS, started the APU, and shut down the engines. ERS responded and extinguished the brake fires. There was no evacuation.

A full investigation of this incident was not undertaken and there is no full occurrence report. While wheel fires caused by strong braking rarely result in serious fires, ERS may have prevented a serious occurrence, but extremely likely there would have been no fatalities or serious injuries without ERS present.

Based on the assessment of risks, the likely and high values for calculating the fatalities prevented by ERS were as follows:

Probability occurrence would have been fatal without ERS: Likely: 1/100, High: 1/20

Number on board at the time ERS started to reduce the risk: Likely 350, High: 380

Proportion on board at risk that would have died: Likely: 10%, High: 20%

Expected numbers of fatalities prevented by ERS in occurrence: Likely: 0.36, High: 1.4

Incident: 22 May 2008, Saskatoon Int'l, B737-200, Canadian North

During approach an engine failed and caught fire. The pilot landed the aircraft and passengers and crew evacuated aircraft. ERS responded and extinguished the engine fire. The number of passengers and crew on board not stated, but likely 70-120. The TSB report states:

"The Boeing 737-217 was on final approach when the right engine failed. The crew carried out the checklist items for an engine failure and declared an emergency. They reconfigured the aircraft for a flaps 15 landing and landed on runway 15. The aircraft was shutdown on the runway and a fire in the right engine was extinguished by ARFF. Crew and passengers carried out a rapid deplanement via the aircraft forward (l1) airstairs without injury."

"There was no cockpit indication of an engine fire and the fire bottles were not discharged. After the aircraft came to a stop on the runway, the airport firefighters approached the right engine and noticed flames inside the engine exhaust. Fire suppressant was applied to the front and rear of the engine. The engine continued to smoke and thermal imaging was used to identify hot spots. Fire suppressant was then applied a second time."

"The fire was found to be contained within the engine and the fire warning detection system was not compromised [did not activate]".

The occurrence report did not provide any details on the timing of the arrival of ERS and the evacuation of passengers. If the fire was serious and the passengers at serious risk, the report would likely have included more details on the fire and the evacuation.

ERS may have prevented a serious occurrence, but very likely all would have evacuated safely without ERS present. Based on the assessment of risks, the likely and high values for calculating the fatalities prevented by ERS were as follows:

Probability occurrence would have been fatal without ERS: Likely: 1/20, High: 1/10

Number on board at the time ERS started to reduce the risk: Likely 85, High: 115

Proportion on board at risk that would have died: Likely: 10%, High: 20%

Expected numbers of fatalities prevented by ERS in occurrence: Likely: 0.43, High: 2.3

Incident: 24 Dec 1999, Calgary Int'l, A320-200, Air Canada

An engine failure occurred in-flight and further problems occurred in descent. An emergency was declared, ERS was on standby and extinguished an engine fire after the aircraft stopped. The number of passengers and crew on board was not stated, but was likely 100-140. The TSB occurrence report states:

"AFF vehicles were called and were in position by the time the aircraft was two miles from the runway. After touchdown, an AFF vehicle followed the aircraft down the runway and noticed a 10-foot flame emanating from the No. 2 engine. The aircraft exited the runway and stopped on the taxiway. At this time, AFF told the ground controller that the No. 2 engine was on fire. The pilot commanded an evacuation and activated the fire bottles for both engines. Five of the six slides were used for the evacuation. The right over-wing exit was not used. AFF personnel applied foam to the exhaust cone of the No. 2 engine to extinguish the flames. Twenty minutes after evacuation, buses arrived to transport the passengers and the crew, all of whom were in the terminal 40 minutes after the evacuation commenced. There were no reported injuries and no external damage to the aircraft."

There were issues with communications between the crew and ERS and ERS did not know the aircraft was being evacuated until the escape slides deployed. Further information on the fire was obtained from the TSB. There are different types of engine fires, some much more serious than others. In this incident the fire was a tail pipe fire, caused by some extra oil in the part of the engine which is meant to be very hot, and is not considered a serious fire. The TSB indicated that the fire would likely have gone out once the engine was spooled down and stopped. They

also indicated that had there been direct communication with the flight crew, the fire would have been identified as a tail pipe fire and there would likely not have been an evacuation.

Thus, while ERS may have prevented a serious occurrence, but very likely there would have been no injuries or fatalities had ERS not been present. Based on the assessment of risks, the likely and high values for calculating the fatalities prevented by ERS were as follows:

Probability occurrence would have been fatal without ERS: Likely: 1/100, High: 1/50

Number on board at the time ERS started to reduce the risk: Likely 120, High: 135

Proportion on board at risk that would have died: Likely: 10%, High: 20%

Expected numbers of fatalities prevented by ERS in occurrence: Likely: 0.12, High: 0.54

Incident: 19 July 2000, Edmonton Int'l, B737-200, Canadian Airlines

An engine failure occurred on the take-off run. The pilot rejected the take-off and stopped the aircraft on the runway. ERS responded and with smoke from the very hot engine, the pilot activated the engine fire extinguisher and ERS applied water to the engine to reduce the risk of fire. The number of passengers and crew on board not stated, but likely 80-120. The TSB report states:

The Boeing 737-200 was at about 80 knots on the take-off roll on runway 12 when the crew heard a loud "bang" and the aircraft swerved to the right. The crew rejected the take-off roll and came to a stop 3 000 feet down the runway. The crew advised tower that they could not exit the runway as they thought they had experienced a right tire/wheel malfunction. Tower observed smoke from the right side of the aircraft and dispatched the ERS vehicles. When ERS contacted the flight crew, the fire chief advised that the right engine (P&W JT8D) was very hot. The pilot activated the fire bottle for the right engine and the ERS vehicles applied water to the engine. After consulting the fire chief and determining that the threat of fire had been minimized, the flight crew performed a rapid deplanement out the front main exit via the built in air stair. Severe contained damage was evident in no. 2 engine, with the runway out of service for several hours while the debris was swept up. There were no injuries, and no damage to the aircraft other than no. 2 engine.

A full investigation of this incident was not undertaken and there is no full occurrence report. While there was no fire, ERS by their preventative action may have prevented a fire from starting and the incident becoming more serious. However, it is very likely there would have been no fatalities or serious injuries without ERS present.

Based on the assessment of risks, the likely and high values for calculating the fatalities prevented by ERS were as follows:

Probability occurrence would have been fatal without ERS: Likely: 1/100, High: 1/20

Number on board at the time ERS started to reduce the risk: Likely 100, High: 115

Proportion on board at risk that would have died: Likely: 5%, High: 10%

Expected numbers of fatalities prevented by ERS in occurrence: Likely: 0.05, High: 0.58

Summary of Expected Fatalities and Serious Injuries Prevented by ERS

Frequency ERS Prevents Fatalities

Exhibit IV-8 summarizes the expected number of fatalities prevented by ERS at CAR 303 airport over the 24-year period 1986 to 2009. The number of enplaned passengers at CAR 303 airports was determined based on reported passengers by airports, or Statistics Canada, for the years that the airport had ERS under CAR 303. The number of crew on board averages approximately 5% of the number of passengers on board. Over that period ERS is estimated to have prevented 3 fatalities, averaging 0.13 per year and just 0.003 per million enplaned passenger plus crew. Thus, while there were no occurrences where ERS **likely** prevented fatalities, when considering the all the occurrences where ERS may possibly have prevented fatalities and the probabilities of life saving response and numbers on board at risk, it is estimated that ERS likely prevented 3 fatalities over the 24-year period.

Exhibit IV-8.

Estimated Expected Number of Fatalities Prevented by ERS at CAR 303 Airport, 1986 to 2009

Year	Airport	Aircraft	Airline	Most Likely				Pessimistic/ High
				Prob. ERS Prevented Fatal Acc. (a)	# Lives at Risk (b)	Proportion Lives Saved By ERS (c)	Expected Lives Save (d=axbxc)	ERS Benefit Expected Lives Save
Accidents								
1995	Vancouver	DC-9-32	Air Canada	0.05	30	0.2	0.30	1.50
2002	Toronto/Lester	CRJ	Air Canada	0.01	200	0.1	0.20	1.00
1997	Fredericton	CRJ	Air Canada	0.10	7	0.2	0.14	0.42
1995	Vancouver	Metro	International	0.01	261	0.05	0.13	1.31
Incidents								
1994	Toronto Intl	727	American Airlines	0.05	135	0.1	0.68	2.70
1986	Gander	L-1011	American Trans Air	0.05	100	0.1	0.50	4.00
2008	Saskatoon/John	737-200	Canadian North	0.05	85	0.1	0.43	2.30
2004	Vancouver Intl	747-400	China Airlines	0.01	350	0.1	0.35	1.52
1999	Calgary Intl	A320-200	Air Canada	0.01	120	0.1	0.12	0.54
2000	Edmonton Intl	737-200	Canadian Airlines	0.01	100	0.05	0.05	0.58
Total Fatalities Prevented Over 24 years							2.9	15.9
Average per Year							0.12	0.66
Total enplanements & Crew at CAR 303 Airports over 24 years (Million)							990	990
Average per Million enplanements							0.003	0.016

The table also gives the estimated fatalities prevented by ERS for the High Case (or pessimistic accident outcome without ERS). The High Case for a particular occurrence represents a possible, but relatively unlikely outcome. The chance that all 10 occurrences results in the High Case for ERS benefits is extremely unlikely and the total of 16 fatalities prevented should be considered a Very High Case. In this Very High Case, the fatalities prevented by ERS average 0.66 per year or 0.016 per million enplanements.

Comparison with 1988 Study

The estimated fatalities prevented by ERS during the past 24 years is compared with the values found in the referenced 1988 study for the period 1966 to 1985 in Exhibit IV-9. The rate of fatalities prevented per million passengers plus crew has declined dramatically since the previous study. The rate was 75 times greater for the earlier period for the most likely estimates, and 37 times greater for the High Case estimates, equivalent to declines of 99% and 97% respectively. The current High Case value is also less than the previous most likely value by a factor of 14. These declines in estimated fatalities prevented are significantly higher than the declines in fatal accident rates for commercial passenger aircraft in North America of 70-80%. The greater decline in occurrences where ERS prevented fatalities could be due to a number of reasons including improvements in engine technology and maintenance and almost a total elimination of the use of avgas for commercial passenger carrying ops (avgas is far more volatile than jet fuel) resulting in fewer fires, and improvements in flammability standards that make it much less likely that a fire will spread and toxic fumes be released.

Exhibit IV-9.
Comparison of Fatalities Prevented by ERS During the Two Periods 1966-1985 and 1986-2009

	Study Period		%
	1966-1985	1986-2009	Change
Number of years	20	24	
Enplaned passengers & crew	377	988	
Total fatalities prevented			
Most likely	87	2.9	
High Case	167	15.9	
Fatalities prevented per year			
Most likely	4.35	0.12	-97%
High Case	11.1	0.66	-94%
Fatalities prevented per million enplaned passengers & crew			
Most likely	0.23	0.003	-99%
High Case	0.59	0.016	-97%

Source: 1966-1985 – 1988 TC study of Crash Firefighting & Rescue Service in Canada
1986-2009 – Current study by LeighFisher Canada

Frequency ERS Prevents Serious Injuries

As discussed previously, the expected number of serious injuries prevented by ERS is estimated to equal to the number of fatalities prevented, that is, 0.003 per million enplaned passengers plus crew on board.

Frequency ERS Prevents Occurrences from Being Fatal

The expected number of fatal accidents prevented by ERS over the 24 year period was estimated to be 0.35[16] with a High Case value of 0.79. In the same period, 1986 to 2009, there were approximately 21 million flights departing from CAR 303 airports involving aircraft over 5.67 tonne. Thus the probability of life saving benefits of ERS is estimated to be:

0.35 /21,000,000 flights

= 0.016 fatal accidents prevented per million flights

The corresponding High Case value is 0.037 per million flights.

The 1988 study found the corresponding rate of 0.19 fatal accidents prevented per million flights[17], over 10 times higher than the rate found for the period 1986-2009.

Confidence Intervals

Statistical confidence intervals were determined as described in Appendix B. Approximate 95% confidence intervals of the fatal accident and fatality prevention rates are as follows:

- Number of fatal accidents prevented by ERS per million departures: 0.002 to 0.21 with most likely value of 0.016; and
- Number of fatalities prevented by ERS per million enplaned passengers and crew: 0.0003 to 0.038 with a most likely value of 0.003.

The upper ends of the confidence intervals are approximately 10 greater than the "most likely" values. The large difference is due to the small number of accidents where ERS benefits were realized.

The high (upper end of confidence interval) value of the number of fatal accidents prevented by ERS per million departures was close to the "Most Likely" value found for the 1966-1985 period (0.21 verses 0.19). However, the high (upper end) value for the number of fatalities prevented by ERS per million enplaned passengers and crew was much less than the "most likely" value found for the 1966-1985 period (0.038 verses 0.23).

16 Found by summing the probabilities that ERS prevented the occurrence from being a fatal accident over the 10 occurrences in Exhibit IV-8

17 Reported value was 3.83 events per 10,000,000 movements

V. EXPECTED RISK REDUCTION AT CAR 303 AIRPORTS

In 2009 there were 2.0 million movements (1.0 million flights) of jet and turboprop aircraft at CAR 303 airports. At this level of traffic, based on the experience over the past 24 years, ERS (under CAR 303) would be expected to prevent fatalities in 0.016 occurrences per year. The *High* value is 0.037 fatal accidents prevented per year. This corresponds to once in every 27 to 60 years in Canada. Again at this level of traffic, ERS would be expected to prevent 0.15 fatalities per year, with a *High* value of 2.0 per year.

Exhibit V-1 presents the expected numbers of fatal accidents and fatalities prevented by ERS at airports in a year for a range of annual traffic levels. At an airport such as Toronto-Pearson with 200,000 departing flights per year, ERS could be expected to perform a life saving role an average of 0.0033 times per year, with a *High* value of 0.0074 times per year. This is equivalent to once in every 135 to 300 years (with traffic remaining at that level). At the smaller airports it is once in every 1,000 years or more.

Exhibit V-1.
Expected Numbers of Fatal Accidents and Fatalities Prevented by ERS in a Year for a Range of Traffic Levels

E/D Passengers	Jet + Turboprop Movements	Expected # of Fatal Accidents Prevented		Expected # of Fatalities Prevented*	
		Most Likely	High	Most Likely	High
100,000,000	2,000,000	0.016	0.037	0.153	2.02
30,000,000	400,000	0.0033	0.0074	0.046	0.60
16,000,000	253,000	0.0021	0.0047	0.025	0.32
10,000,000	166,000	0.0014	0.0031	0.015	0.20
6,000,000	118,000	0.0010	0.0022	0.009	0.121
4,000,000	91,000	0.0007	0.0017	0.0061	0.081
3,000,000	70,000	0.0006	0.0013	0.0046	0.060
2,000,000	54,000	0.0004	0.0010	0.0031	0.040
1,000,000	37,000	0.0003	0.0007	0.0015	0.020
800,000	29,000	0.0002	0.0005	0.0012	0.016
600,000	26,000	0.0002	0.0005	0.0009	0.012
400,000	20,000	0.0002	0.0004	0.0006	0.008
180,000	11,000	0.0001	0.0002	0.0003	0.004

* Assumes number of crew averages 5% of enplaned passengers

The number of fatalities prevented at an airport with 30 million E/D passengers per year is estimated to average 0.046 per year, with a *High* value of 0.60 per year. At the smaller CAR 303 airports the number of fatalities prevented drops to less than 0.001 per year, with a *High* value of 0.01.

VI. CONCLUSION

The primary role of airport ERS is the prevention of fatalities and serious injuries in aviation occurrences. ERS is a reactionary safety measure in that it can only fulfill its role once an occurrence has occurred. Current requirements for ERS at Canadian airports are based to a large extent on old data, some dating back to the period 1966 to 1985. ERS's role has diminished greatly over the past 24 years as the numbers of aviation accidents has declined and fewer of the accidents involve life threatening fires.

An examination of aviation occurrences at airports in Canada with ERS as required by CAR 303 found that there have been no occurrences in the 24-year period, 1986-2009, where ERS was **likely** to have prevented fatalities or serious injuries. Ten occurrences were identified where ERS **may possibly** have prevented fatalities or serious injuries. Based on a risk analysis of these ten occurrences, it is estimated that the number of fatalities prevented by ERS per million enplaned passengers declined by a factor of 76 from 0.23 for the period 1966 to 1985 to 0.003 for the period 1996 to 2009. At current levels of traffic, one would expect ERS to prevent an occurrence from being fatal once in every 27 to 60 years in Canada, and prevent on average 0.15 fatalities per year.

At these low levels of effective live saving actions by ERS, the role of ERS at airports needs to be re-evaluated in the context of the SMS. The safety benefits of ERS need to be considered in comparison with other proactive safety measures such as, for example, implementing measures to improve the safety culture and improving landing navigation systems, airfield lighting and aircraft/vehicles monitoring on the airport to reduce collisions. Standards and requirements for how ERS is provided need to be examined to determine ways of providing most of the perceived safety benefits of ERS while allowing ERS personnel to be actively engaged in other proactive safety measures at the airport. ERS should be incorporated into the overall safety management plan for the airport and resources available as part of the plan should be used as efficiently as possible to improve safety.

APPENDIX A

OCCURRENCES EXAMINED

Accidents at CAR 303 Examined for Potential ERS Role in Preventing Fatalities or Serious Injuries

Date	Location	Aircraft	Carrier	Minor Injur.	Serious Injuries	Fatal-ities	Location	ERS Role	ERS Evac Assistance	ERS Fire Assistance	Comment
27-Jun-95	CYVR Vancouver	DC-9-32	Air Canada	0	0	0	Airport	Responded	Not Required	Fire, appears to have been extinguished by crew	Engine fire pulling back from ramp
13-May-02	CYYZ Toronto	767-300	Air Canada	0	0	0	Airport	Responded	Assisted, minimal risk	Smoke, no fire	
16-Dec-97	CYFC Fredericton	CL-600 (RJ)	Air Canada	33	9	0	Airport	Responded	Late, assisted evac of seriously injured	No fire	Took >2hrs to evacuated seriously injured, equip supplied by community fire fighting
19-Oct-95	CYVR Vancouver	DC-10-30	International	6	0	0	Airport	Responded	Assisted, minimal risk	Extinguished small fires around hot brakes	Foam applied under aircraft as a precaution in case of possible fuel spill
2-Aug-05	CYYZ Toronto	A340-300	Air France	21	12	0	Airport	Responded	Not required	Unable to put out fire	Overran into gully, ERS arrived after pax evacuated
13-Sep-00	CYYZ Toronto	A320-200	Skyservice Airlines	0	0	0	Airport	Standby	Not Required	No fire	
4-Apr-01	CYYT ST. John`s Intl	737-200	Royal Airlines	0	0	0	Airport	Responded	Not Required	No fire	
22-May-01	CYZF Yellowknife	737-200	Bradley Air Services	0	0	0	Airport	Not called	Not Required	No fire	
16-Apr-02	CYWG Winnipeg	SA-227-AT	Perimeter Airlines	0	0	0	Airport	Responded	Assisted, minimal risk	No fire	
11-Jan-03	CYYT St. John's	1900D	Labrador Airways Ltd	0	0	0	Airport	Responded	Not Required	No fire	Hit windrow on taxiway
14-Oct-04	CYHZ Halifax	747-200	Mk Airlines	0	0	7	Airport	Responded	Unsurvivable	Unable to put out fire	Struck embankment, severe post crash fire, TSB: "the accident was not survivable"

Date	Location	Aircraft	Carrier	Minor Injur.	Serious Injuries	Fatal-ities	Location	ERS Role	ERS Evac Assistance	ERS Fire Assistance	Comment
25-Feb-04	CYEG Edmonton Intl	737-200	First Air	0	0	0	Airport	Responded	Assisted, minimal risk	No fire	
15-Nov-05	CYHM Hamilton	ASTRA SPX	Jetport Inc.	0	0	0	Airport	Responded	Not Required	No fire	
26-Nov-06	CYUL Montréal Trudeau	LJ35A	Canadian Global Air Ambulance	0	0	0	Airport	Responded	Not Required	No fire	
20-May-07	CYYZ Toronto	CL-600-(RJ)	Air Canada Jazz	0	0	0	Airport	Responded	Assisted, minimal risk	No fire	
14-Oct-07	CYYC Diverted from Springbank	LJ55	Florida Jet Service Inc.	0	0	0	Airport	Standby	Not Required	No fire	Diverted to YYC
19-Feb-08	CYHM Hamilton	727-200	Cargojet Airways Ltd.	0	0	0	Airport	Standby	Not Required	No fire	
21-Apr-09	CYOW Ottawa	DHC-8-400	Porter Airlines Inc.	0	0	0	Airport	Not called	Not Required	No fire	
4-Jan-86	CYQM Moncton	MERLIN IVA	Air Niagara	0	0	0	Airport	Responded	Assisted, minimal risk	No fire	
17-Jul-86	CYWG WINNIPEG	C46F 5CU	Northland Airways	0	0	0	Airport	Responded	Assisted, minimal risk	No fire	
10-Mar-86	CYYZ Toronto	727-200	Eastern Air Lines	0	0	0	Airport	Not called	Not Required	No fire	
9-Dec-87	CYSJ Saint John	Commander 500		0	0	0	Airport	Standby	Not Required	No fire	
20-Nov-87	CYXU London	BE200		0	0	0	Airport	Responded	Assisted, minimal risk	No fire	
22-Nov-88	CYQX Gander	DC-8-63F	Arrow Air	0	0	0	Airport	Responded	Not Required	No fire	
30-Mar-88	CYQR Regina	C401	Prairie Flying Service	0	0	0	Airport	Responded	Not Required	No fire	

Date	Location	Aircraft	Carrier	Minor Injur.	Serious Injuries	Fatal-ities	Location	ERS Role	ERS Evac Assistance	ERS Fire Assistance	Comment
12-Jan-88	CYHM Hamilton	MERLIN IVA	Soundair	0	0	0	Airport	Responded	Assisted, minimal risk	Effective after evacuation	
7-Apr-88	CYXD Edmonton Municipal	A340		0	0	0	Airport	Responded	Not Required	Smoke, no fire	
29-Nov-89	CYEG Edmonton Int'l	METRO II	Brooker-Wheaton Aviation	0	0	0	Airport	Standby	Not Required	No fire	
2-Feb-90	CYEG Edmonton Int'l	CITATIO N II		0	0	0	Airport	Standby	Not Required	No fire	
17-Sep-90	CYEG Edmonton Intl	METRO II	Brooker-Wheaton Aviation	0	0	0	Airport	Standby	Not Required	No fire	
20-Aug-91	CYHZ Halifax Diverted from Sable Island	BN-2A-21	Provincial Airlines	0	0	0	Airport	Standby	Not Required	No fire	
28-Jan-91	CYOW Ottawa	BE65-A90	Transport Canada	0	0	0	Airport	Standby	Not Required	No fire	
20-May-91	CYXS Prince George	Firecat	Conair	0	0	0	Airport	Responded	Not Required	No fire	
13-Apr-92	CYFC Fredericton	BE60	New Brunswick Government	0	0	0	Airport	Standby	Not Required	No fire	
30-Jul-92	CYYC Calgary	F-28 MK 1000	Time Air	0	0	0	Airport	Standby	Not Required	No fire	
27-Jan-93	CYHZ Halifax	PA-31-350	Prince Edward Air	0	0	0	Airport	Responded	Not Required	No fire	
13-Jan-93	CYXU London	401	Brucelandair International	0	0	0	Airport	Responded	Not Required	No fire	
10-Feb-93	CYYZ Toronto	757-200	American Airlines	3	1	0	Airport	Not called	Not Required	No fire	
30-Apr-93	CYTZ Toronto Island	SA-26B Merlin IIB	Earlton Airways	0	0	0	Airport	Responded	Assisted, minimal risk	No fire	

Date	Location	Aircraft	Carrier	Minor Injur.	Serious Injuries	Fatal-ities	Location	ERS Role	ERS Evac Assistance	ERS Fire Assistance	Comment
25-Feb-93	CYUL Montreal Dorval	404	Air Alma	0	0	0	Airport	Responded	Not Required	No fire	
5-Mar-94	CYQR Regina	DC-9-32	Air Canada	0	0	0	Airport	Responded	Not Required	No fire	
21-Jan-95	CYMX Montreal (Mirabel)	747-400	Royal Air Maroc	2	0	3	Airport	Responded	Not Required	No fire	Exiting deicing area, knocked over 2 cherry-pickers killing 3 people in vehicles
5-Dec-95	CYQB Quebec	F28 Mk 1000	Inter-Canadian	0	0	0	Airport	Responded	Not Required	Fire, extinguished by ERS after evacuation	Fire in baggage compartment
1-Nov-95	CYYC Calgary	F-28	Canadian Regional Airlines	0	0	0	Airport	Responded	Not Required	No fire	
8-Mar-96	CYHZ Halifax	767-375	Canadian Airlines	0	0	0	Airport	Not called	Not Required	No fire	
9-Jun-96	CYQB Quebec	F28 Mk 1000	Inter-Canadian	0	0	0	Airport	Responded	Not Required	No fire	Loss of Wheels on Landing
13-Jun-97	CYOW Ottawa	METRO II	North American Airlines	0	0	0	Airport	Responded	Not Required	Effective after evacuation	
30-Dec-98	St. John`s	FALCON 20D	Knighthawk Air Express	0	0	0	Airport	Standby	Not Required	No fire	
18-Mar-98	CYHM Hamilton	727-260	Allcanada Express	0	0	0	Airport	Not called	Not Required	No fire	
18-Jun-98	CYMX Montreal (Mirabel)	SA-226-TC	Propair	0	0	11	Airport	Responded	Unsurvivable	Extinguished fire quickly	ERS on scene immediately and extinguished fire but all onboard were dead
1-Aug-99	CYYT St. John's	F28 Mk 1000	Inter-Canadian	7	0	0	Airport	Responded	Not Required	No fire	Overrun by 420 feet, nose gear broke off, ERS response time 1 min

Date	Location	Aircraft	Carrier	Minor Injur.	Serious Injuries	Fatal-ities	Location	ERS Role	ERS Evac Assistance	ERS Fire Assistance	Comment
14-Jun-99	CYQY Thunder Bay	BE A100	Thunder Airlines Limited	0	0	0	Airport	Responded	Not Required	Fire started as last occupants evacuated, ERS extinguished fire	Fire started after occupants had evacuated
10-Mar-99	CYYC Calgary	727-200	Delta Air Lines	0	0	0	Airport	Not called	Not Required	No fire	Wingstrike

Incidents at CAR 303 Examined for Potential ERS Role in Preventing Fatalities or Serious Injuries

Date	Location	Aircraft	Carrier	Minor Inj-uries	Serious Injuries	Fatal-ities	Location	ERS Role	ERS Evac Assistance	ERS Fire Assistance	Comment
10-Oct-94	CYYZ Toronto INTL	727	American Airlines	5	0	0	Airport	Responded	ERS assisted	Fire in landing gear, ERS role not stated	ERS on scene 3 min after a/c stopped, likely extinguished file, 5 minor injuries during evac.
13-Jul-86	CYQX Gander	L-1011	American Trans Air	3	0	0	Airport	Responded	Assisted	Engine fire extinguished by ERS	Flames shooting out of front & rear of engine, on ramp
22-May-08	CYXE Saskatoon	737-200	Canadian North	0	0	0	Airport	Responded	Evacuation by crew, ERS not required	Fire in engine, extinguished by ERS	ERS on standby & assisted, but very likely no fatalities or serious injuries if no ERS
10-Dec-04	CYVR Vancouver Intl	747-400	China Airlines	0	0	0	Airport	Responded	Not required	Extinguished small brake wheel fires	Extremely small risk that brake wheel fires could have spread
24-Dec-99	CYYC Calgary Intl	A320-200	Air Canada	0	0	0	Airport	Responded	ERS assisted	Fire in engine, extinguished by ERS	ERS standby, tail pipe engine fire, not serious, would likely have gone out on its own
19-Jul-00	CYEG Edmonton Intl	737-200	Canadian Airlines	0	0	0	Airport	Responded	Assisted, minimal risk	Smoke, took preventative action	Advised when safe to evacuate
12-Jan-86	CYSB Sudbury	737-200	Nordair (Sudair)	0	0	0	Airport	Not called	Not required	No fire	Risk of collision with vehicle
20-Apr-86	CYUL Montreal	DC9-32	Air Canada	0	0	0	Airport	Standby	Assisted, minimal risk	No fire	Smoke from Annunciation panel, short-circuit

Date	Location	Aircraft	Carrier	Minor Inj-uries	Serious Injuries	Fatal-ities	Location	ERS Role	ERS Evac Assistance	ERS Fire Assistance	Comment
14-Jul-86	CYLW Kelowna	737-200	Pacific Western	1	0	0	Airport	Responded	Assisted, minimal risk	No fire	Overrun
17-Sep-86	CYWG Winnipeg	DC-8-55	Soundair	0	0	0	Airport	Not called	Not required	No fire	Overrun by 17 feet
19-Mar-87	CYQX Gander	IL-86	Aeroflot	0	0	0	Airport	Not called	Not required	No fire	Hit runway edge lights and engine dragged in snowbank
19-Mar-87	CYQX GANDER	IL-86	Aeroflot	0	0	0	Airport	Not called	Not required	No fire	Hit runway edge lights and engine dragged in snowbank
17-May-87	CYYZ Toronto Pearson Int'l	767-200	Air Canada	0	0	0	Airport	Not called	Not required	No fire	Risk of collision with another a/c, aborted takeoff
12-Jul-87	CYYZ Toronto Pearson Int'l	DC-8-55	Air Charter Systems	0	0	0	Airport	Standby	Not required	Foamed very hot brakes	False engine fire warning, foam on hot brakes, possible minor fire on brakes
3-Aug-87	CYMX Montreal Mirabel	HS 125	Quebec Government - Gouvernment Du Quebec	0	0	0	Airport	Standby	Not required	Electrical fire	Solenoid had overheated
9-Sep-87	CYHZ Halifax	727-200	Air Canada	0	0	0	Airport	Not called	Not required	No fire	Hit runway edge lights
15-Nov-87	CYQX Gander	IL-62M		0	0	0	Airport	Not called	Not required	No fire	Hit runway edge lights
17-Jan-88	CYVR Vancouver	737-200	Delta Airlines	2	0	0	Airport	Responded	Assisted, minimal risk	Smoke, no fire	Engine failure, smoke in vicinity of engine

Date	Location	Aircraft	Carrier	Minor Inj-uries	Serious Injuries	Fatal-ities	Location	ERS Role	ERS Evac Assistance	ERS Fire Assistance	Comment
18-Jan-89	CYVR Vancouver	737-200	Canadian Airlines International	0	0	0	Airport	Responded	Assisted, minimal risk	APU fire warning	APU fire warning, discharged fire bottle, on ramp
5-Jun-89	CYYZ Toronto-Pearson	F-28-MK 1000	Air Ontario	0	0	0	Airport	Responded	Assisted, minimal risk	Smell of smoke, no fire	Smell of smoke in cabin
22-Jun-89	CYXE Saskatoon	737-200	Canadian Airlines International	0	0	0	Airport	Responded	Assisted, minimal risk	No fire	Overrun 10 ft
27-Jun-89	CYWG Winnipeg	DC-8-73F	Air Canada	0	0	0	Airport	Unknown	Not required	No fire	
10-Feb-90	CYQB Quebec	DC-8-61	Nationair (Nolisair)	0	0	0	Airport	Responded	Not required	No fire	Overrun
16-Sep-90	CYQX Gander	IL-62M	Aeroflot	0	0	0	Airport	Not called	Not required	No fire	Hit runway edge lights
18-Dec-90	CYYJ Victoria	DC-10-30	K.L.M. Royal Dutch Airlines	0	0	0	Airport	Standby	Not required	No fire	
23-Dec-90	CYYG Charlottetown	DC-9-32	Air Canada	0	0	0	Airport	Standby	Not required	No fire	Wing tip struck runway on a missed approach
19-Feb-91	CYUL Montreal Dorval	ATR 42-300	Intair (Formerly Inter-Canadien)	0	0	0	Airport	Not called	Not required	No fire	-
18-May-91	CYEG Edmonton Intl	767-200	Air Canada	0	0	0	Airport	Standby	Assisted, minimal risk	Smoke, no fire	Smoke in cockpit
6-Jun-91	CYYZ Toronto	767-233	Air Canada	0	0	0	Airport	Standby	Not required	No fire	Loss of separation
4-Oct-91	CYQM Moncton	DC-8-73F	Air Canada	0	0	0	Airport	Not called	Not required	No fire	Hit runway edge lights

Date	Location	Aircraft	Carrier	Minor Inj-uries	Serious Injuries	Fatal-ities	Location	ERS Role	ERS Evac Assistance	ERS Fire Assistance	Comment
18-Oct-91	CYHZ Halifax	DC-9-32	Air Canada	0	0	0	Airport	Not called	Not required	No fire	Departed then regained runway
8-Dec-91	CYOW Ottawa	A310	JES Air	0	0	0	Airport	Responded	Assisted, minimal risk	No fire	
9-Dec-91	CYEG Edmonton Municipal	737-200	Canadian Airlines International	0	0	0	Airport	Responded	Not required	No fire	False APU fire warning
15-Jan-92	CYYZ Toronto	DC-9-32	Air Canada	0	0	0	Airport	Standby	Not required	No fire	
3-Feb-92	CYYZ Toronto/	757-28A		0	0	0	Airport	Not called	Not required	No fire	Risk of collision with aircraft
13-Feb-92	CYSB Sudbury	DHC-8-300	Air Ontario	0	0	0	Airport	Not called	Not required	No fire	Risk of collision with vehicle
21-Feb-92	CYYZ TORONTO/	A320-200	Air Canada	0	0	0	Airport	Standby	Not required	No fire	
6-Apr-92	CYOW Ottawa	DC-8-62	Nationair (Nolisair)	0	0	0	Airport	Responded	Not required	Smoke, no fire	Extremely hot brakes, ERS monitored until safe
2-Apr-93	CYYC Calgary	A320-200	Canadian Airlines International	0	0	0	Airport	Not called	Not required	No fire	Hit runway edge lights
21-May-93	CYEG Edmonton Municipal	G-159	North American Airlines	0	0	0	Airport	Not called	Not required	No fire	Risk of collision with vehicle
3-Sep-93	CYMX Montreal/ Mirabel	DHC-8 (DASH 8)	Air Alliance	0	0	0	Airport	Standby	Not required	Smoke, no fire	
22-Oct-93	CYYZ Toronto	A320	Canada 3000 Airlines	0	0	0	Airport	Not called	Not required	No fire	Aborted takeoff

Date	Location	Aircraft	Carrier	Minor Inj-uries	Serious Injuries	Fatal-ities	Location	ERS Role	ERS Evac Assistance	ERS Fire Assistance	Comment
28-Nov-93	CYUL Montreal Dorval	Boeing	727-200	0	0	0	Airport	Responded	Not required	Fire extinguisher by crew	Fire in overhead storage container in cabin
8-Mar-94	CYYC Calgary	DC-8-62	Advance Air Charters	0	0	0	Airport	Standby	Not required	No fire	
21-Jul-94	CYYZ Toronto	767-375	Air Canada	0	0	0	Airport	Responded	Not required	No fire	
19-Aug-94	CYWG Winnipeg	737-242C	Canadian Airlines International	0	0	0	Airport	Standby	Not required	No fire	
11-May-95	CYYT St John's	727-200	Royal Aviation	0	0	0	Airport	Responded	Not required	No fire	
9-Aug-95	CYWG Winnipeg	737-200	Canadian Airlines International	0	0	0	Airport	Responded	Not required	No fire	
18-Aug-95	CYOW Ottawa International	F-28	American Airlines	0	0	0	Airport	Responded	Not required	Fire in engine, dissipated without ERS action	
8-Dec-95	CYWG Winnipeg	A320-200	Air Canada	4	0	0	Airport	Responded	Evac, minimal risk	Smoke, no fire	mechanical failure in heat/air cond. System
20-Dec-95	CYYC Calgary Intl	737-200	Canadian Airlines International	0	0	0	Airport	Not called	Not required	No fire	Risk of collision with other aircraft
13-Feb-96	CYQX Gander	DHC-8-100	Air Nova	0	0	0	Airport	Responded	Evac, minimal risk	No fire	
19-Feb-96	CYYZ Toronto	747-433	Air Canada	0	0	0	Airport	Not called	Not required	No fire	
3-Apr-96	CYQM Moncton	727-172C	Kelowna Flightcraft	0	0	0	Airport	Responded	Not required	No fire	

Date	Location	Aircraft	Carrier	Minor Inj-uries	Serious Injuries	Fatal-ities	Location	ERS Role	ERS Evac Assistance	ERS Fire Assistance	Comment
8-Apr-96	CYFC Fredericton	Canadair	Cl 600-2b19	0	0	0	Airport	Responded	Not required	No fire	Runway excersion
18-Jul-96	CYYZ Toronto-Pearson	Boeing	727-217	0	0	0	Airport	Standby	Not required	Fire extinguisher by crew	Inflight engine fire, extinguished by crew
29-Jul-96	CYHZ Halifax	L-1011-385	Air Transat A.T.	0	0	0	Airport	Responded	Evac, minimal risk	Smoke, no fire	
24-Sep-96	CYYZ Toronto	DC-10-30		0	0	0	Airport	Not called	Not required	No fire	Loss of separation
24-Dec-96	CYVR Vancouver	737-200	Canadian Airlines International	2	0	0	Airport	Responded	Not required	No fire	Appears to be false warning
17-Feb-97	CYYZ Toronto	DHC-8-100		0	0	0	Airport	Responded	Not required	Fire in engine, extinguished after evac	Evac in 30 sec before ERS arrived
8-Mar-97	CYYZ Toronto	737-200	Canadian Airlines International	0	0	0	Airport	Responded	Not required	No fire	
7-Oct-97	CYVR Vancouver	737	Continental Airlines	0	0	0	Airport	Standby	Not required	No fire	False APU fire warning
1-Feb-98	CYYZ Calgary	DC-9-32	Air Canada	0	0	0	Airport	Not called	Not required	No fire	Hit runway edge lights, regained runway
15-Mar-98	CYUL Montreal (Dorval)	DC-9-32	Air Canada	0	0	0	Airport	Responded	Not required	Fire in engine, dissipated without ERS action	
20-Apr-98	CYYZ Toronto	DHC-8-301	Air Ontario	0	0	0	Airport	Responded	Not required	Smoke, no fire	
14-Sep-98	CYYC Calgary Intl	767-300	Martinair Holland N.V.	0	0	0	Airport	Responded	Not required	No fire	Brakes very hot, ERS assisted in cooling them down

Date	Location	Aircraft	Carrier	Minor Inj-uries	Serious Injuries	Fatal-ities	Location	ERS Role	ERS Evac Assistance	ERS Fire Assistance	Comment
20-Apr-99	CYOW Ottawa	737-200	Royal Aviation	0	0	0	Airport	Standby	Not required	Fire in APU extinguished by crew	
21-Jun-99	CYYZ Toronto	767-200	Air Canada	0	0	0	Airport	Standby	Not required	No fire	Off-wing slide came off in flight
24-Sep-99	CYYT St. John`s Intl	A320-200	Air Canada	0	0	0	Airport	Not called	Not required	No fire	
8-Dec-99	CYFB Iqaluit	727-200	First Air	0	0	0	Airport	Responded	Not required	Smoke, no fire	
6-Mar-00	CYYC Calgary	DHC-8-300 & Jetstream 31	Air Bc	0	0	0	Airport	Not called	Not required	No fire	Risk of collision with aircraft
11-May-00	CYEG Edmonton	Douglas	Dc-9	0	0	0	Airport	Responded	Not required	No fire	Aborted take-off, ERS fanned hot brakes
23-Jul-00	CYUL Montréal Intl (Dorval)	747-200	Royal Air Maroc	0	0	0	Airport	Responded	No evacuation	Fire in engine, dissipated without ERS action	the flames had dissipated, and the firefighters did not have to take action.
26-Aug-00	CYUL Montréal (Dorval)	CL-600-2B19 (RJ) & A319	Air Canada	0	0	0	Airport	Not called	Not required	No fire	Risk of collision with aircraft
15-Sep-00	CYOW Ottawa	Boeing	727-200a	0	0	0	Airport	Responded	Not required	No fire	Overrun by 234 feet
22-Sep-00	CYFB Iqaluit	727-200	First Air	0	0	0	Airport	Unknown	No evacuation	No fire	
13-Nov-00	CYFC Fredericton	737-200	Canadian Airlines International	0	0	0	Airport	Responded	No evacuation	Fire in engine, dissipated without ERS action	

Date	Location	Aircraft	Carrier	Minor Inj-uries	Serious Injuries	Fatal-ities	Location	ERS Role	ERS Evac Assistance	ERS Fire Assistance	Comment
28-Nov-00	CYFC Fredericton	F-28 MK 1000	Canadian Regional Airlines	0	0	0	Airport	Responded	Not required	No fire	
18-Dec-00	CYQG Windsor	AN-124	Antonov Design Bureau	0	0	0	Airport	Responded	Not required	No fire	
1-Feb-01	CYYC Calgary Intl	737-200	Westjet Airlines	0	0	0	Airport	Not required	Not required	No fire	
18-Feb-01	SLAVE LAKE, 20 NM N, diverted to CYEG	737-200	Canadian Airlines International	0	0	0	Airport	Standby	Not required	No fire	
8-Mar-01	CYYC Calgary Intl	560	Syncrude Canada	0	0	0	Airport	Standby	Not required	No fire	
15-Mar-01	CYVR Vancouver Intl	DHC-8-200 & A319	Horizon Air	0	0	0	Airport	Not called	Not required	No fire	Loss of separation
25-May-01	CYYZ Toronto	DHC-8-300	Air Canada Regional	0	0	0	Airport	Responded	Assisted, minimal risk	Smoke, no fire	
9-Sep-01	CYYC Calgary, 13 NM NNE	757-200	Canada 3000 Airlines	0	0	0	Airport	Standby	Not required	No fire	Engine failure
14-Sep-01	CYYZ Toronto	767-200	Air Canada	7	0	0	Airport	Responded	Assisted, minimal risk	Smoke, no fire	
17-Jan-02	CYVR-Vancouver	A330-300	Air Canada	0	0	0	Airport	Responded	Not required	Fire extinguisher by crew	fire in the video system management unit while crew prepared a/c for boarding
27-Mar-02	CYSJ Saint John	F-28 MK 1000	Air Canada Regional	0	0	0	Airport	Not called	Not required	No fire	Left side of runway, regained runway
26-Apr-02	CYHZ Halifax Intl	DHC-8-300	Air Canada Jazz	0	0	0	Airport	Standby	Not required	No fire	

Date	Location	Aircraft	Carrier	Minor Inj-uries	Serious Injuries	Fatal-ities	Location	ERS Role	ERS Evac Assistance	ERS Fire Assistance	Comment
25-Aug-02	CYYZ Toronto	DC-9	Northwest Airlines	0	0	0	Airport	Standby	Not required	No fire	
10-Sep-02	CYQX Gander Intl	DC-8-63	Arrow Air	0	0	0	Airport	Not required	Not required	No fire	
24-Oct-02	CYYZ Toronto	DHC-8-300	Air Canada Jazz	0	0	0	Airport	Standby	Not required	No fire	Risk of collision with other aircraft
6-Nov-02	CYYC Calgary Intl	727-200	Winnport Logistics	0	0	0	Airport	Not called	Not required	No fire	
2-Feb-03	CYHZ Halifax Intl	737-200	Canjet Airlines	0	0	0	Airport	Not called	Not required	No fire	
11-Feb-03	CYQG Windsor	A320-212	Skyservice Airlines Inc	0	0	0	Airport	Not called	Not required	No fire	
25-Jul-03	CYUL Montréal (Dorval)	DO-328	Atlantic Coast Airlines	0	0	0	Airport	Responded	Assisted, minimal risk	Smoke, no fire	
26-Sep-03	CYYZ Toronto-Pearson	LP Astra SPX	Partner Jet Inc	0	0	0	Airport	Responded	Not required	No fire	Runway excersion
6-Nov-03	CYVR Vancouver	A330-300	Air Canada	0	0	0	Airport	Standby	Not required	No fire	Fuel leak after take-off
19-Jan-04	CYYZ Toronto-Pearson	A321-211	Air Canada	0	0	0	Airport	Not called	Not required	No fire	Half of nose gear assembly fell off on landing
3-Mar-04	CYVR Vancouver	182D	581977 British Columbia Ltd	0	0	0	Airport	Not called	Not required	No fire	Risk of collision with other aircraft
11-Apr-04	CYYZ Toronto	BAE 146	Air Canada Jazz	0	0	0	Airport	Responded	Assisted, minimal risk	Smoke, no fire	
28-May-04	CYQM Moncton	727-200	Cargojet Airways Ltd.	0	0	0	Airport	Not called	Not required	No fire	

Date	Location	Aircraft	Carrier	Minor Inj-uries	Serious Injuries	Fatal-ities	Location	ERS Role	ERS Evac Assistance	ERS Fire Assistance	Comment
4-Jun-04	CYYC Calgary Intl	737-200	Westjet Airlines	0	0	0	Airport	Responded	Not required	No fire	Almost a collision with C172 which veered to miss B737
14-Jul-04	CYOW Ottawa	EMB-145	Us Airways Express	0	0	0	Airport	Responded	Not required	No fire	Overrun
31-Aug-04	CYQM Moncton	727-200	Morningstar Air Express Inc	0	0	0	Airport	Responded	Not required	No fire	
2-Sep-04	CYPQ Peterborough Diverted to CYYZ	DHC-8-100	Air Canada Jazz	0	0	0	Airport	Standby	Not required	No fire	
29-Oct-04	CYVR Vancouver	DHC-8 (DASH 8)	Air Canada Jazz	0	0	0	Airport	Not called	Not required	No fire	Risk of collision with other aircraft
20-Jan-05	CYYC Calgary	DC-9-83	Jetsgo	0	0	0	Airport	Not called	Not required	No fire	
2-Jun-05	CYYZ Toronto	800 XP	Flight Options	0	0	0	Airport	Standby	Not required	No fire	
30-Oct-05	CYYC Calgary	737-900	Alaska Airlines	0	0	0	Airport	Responded	Evac underway when ERS arrived	Fire in engine, dissipated without ERS action	
25-Dec-05	CYHZ Halifax Intl	737-700	Westjet	0	0	0	Airport	Not called	Not required	No fire	
26-Dec-05	CYWG Winnipeg	A319-100	Air Canada	0	0	0	Airport	Not called	Not required	No fire	
22-Apr-06	CYUL Montréal	737-200	First Air	0	0	0	Airport	Responded	Not required	No fire	False fire indication

Date	Location	Aircraft	Carrier	Minor Inj-uries	Serious Injuries	Fatal-ities	Location	ERS Role	ERS Evac Assistance	ERS Fire Assistance	Comment
13-Dec-06	CYXE Saskatoon (diverted from Regina)	727-227	Kelowna Flightcraft Air Charter Ltd	0	0	0	Airport	Standby	Not required	No fire	
26-Mar-07	CYOW Ottawa	205A-1	National Research Council Canada	0	0	0	Airport	Not called	Not required	No fire	False fire indication
31-Mar-07	CYQX GANDER Intl	AN-124	Volga-Dnepr Group	0	0	0	Airport	Responded	Not required	No fire	
25-Apr-07	CYQB Québec	CL-600-2B19 (RJ)	Air Canada Jazz	0	0	0	Airport	Responded	Not required	No fire	
27-Dec-07	CYVR Vancouver	SA227-DC	Sunwest Aviation Ltd.	0	0	0	Airport	Standby	Not required	No fire	False fire indication
17-Feb-08	CYOW Ottawa	737-700	Westjet	0	0	0	Airport	Responded	Not required	No fire	
20-Mar-08	CYQB Quebec	CL-600-2A12	Service Aérien Gouv. Du Québec	0	0	0	Airport	Standby	Not required	No fire	Nose gear wheels up landing
22-Jul-08	CYHM Hamilton	727-200	Kelowna Flightcraft	0	0	0	Airport	Responded	Not required	No fire	
29-Jul-08	CYYZ Toronto	737-700	Westjet	0	0	0	Airport	Not called	Not required	No fire	Risk of collision with vehicles
9-Aug-08	CYYZ Toronto	757-200	Thomas Cook Airlines UK	0	0	0	Airport	Not called	Not required	No fire	Risk of collision on runway with B747, 1 a/c aborted T/O
26-Aug-08	CYUL Montréal/ Trudeau	747-400	Air France	0	0	0	Airport	Responded	Not required	No fire	
13-Nov-08	CYMM Fort McMurray	CL-600-2B19 (RJ)	Air Canada Jazz	0	0	0	Airport	Standby	Not required	No fire	

Date	Location	Aircraft	Carrier	Minor Inj-uries	Serious Injuries	Fatal-ities	Location	ERS Role	ERS Evac Assistance	ERS Fire Assistance	Comment
28-Feb-10	CYYC Calgary Intl	CL-600-2B19 (RJ)	Nav Canada	0	0	0	Airport	Responded	Not required	No fire	Very high temp reading on brakes taxiing to deicing ramp
2-Mar-10	CYYC Calgary	BAE 125-800 & DHC-8-100	Sunwest Aviation Ltd.	0	0	0	Airport	Not called	Not required	No fire	Risk of collision with other aircraft
23-Mar-10	CYYZ Toronto Pearson	A320-200	Air Canada	4	0	0	Airport	Responded	Evacuation by crew, ERS not required	Smoke, no fire	

APPENDIX B

CONFIDENCE INTERVALS FOR PROBABILITIES OF ERS SAVING LIVES

CONFIDENCE INTERVALS FOR PROBABILITIES OF ERS SAVING LIVES

The number of occurrence in which ERS prevents fatalities is a typical example of a variable which has a Poisson probability distribution – a high number of trials (flights) with a very low probability of an event (fatal accident) on any one trial. Using the Poisson distribution it is possible to estimate a confidence interval for the true rate of fatal accidents prevented by ERS given an estimate of the average rate based on past data.

Under the Poisson distribution, the probability of observing n fatal accidents prevented by ERS is given by:

$Pr[X = n) = e^{-u} u^{n} / n!$

where u is the true (not estimated) number of fatal accidents prevented by ERS

If the true value of u was 4.6, the probability of obtaining the observed value of 0.35 or less would be 0.025. Similarly, if the true value of u was 0.038, the probability of obtaining the observed value of 0.35 or more would be 0.975. The 95% confidence interval for the expected number of fatal accidents prevented by ERS over the 24-year period is thus:

[0.038 , 4.6]

Since there were 21 million flights in that period, the 95% confidence interval for the number of fatal accidents prevented by ERS per million departures is:

[0.0018 , 0.215]

The analysis of 1986-2009 occurrences indicated that the expected number of fatalities prevented per occurrence where ERS prevented fatalities was 8.3. The 95% confidence interval for the number of fatalities prevented by ERS over the 24 years is:

[0.3 , 38]

Since there were 990 million enplaned passengers and crew in that period, the 95% confidence interval for the number of fatalities prevented by ERS per million enplaned passengers and crew is:

[0.0003 , 0.038]

These confidence intervals allow for the chance nature of the observed numbers of fatal accidents, but do not account for the uncertainty due to the interpretation of ERS's role in the particular occurrences examined. The (very) High Case estimates of 0.89 fatal accidents and 17.3 fatalities prevented by ERS over the 24-year period provide a possible high estimate of these reduction in risk. Using these numbers, the 95% confidence interval for the (very) High Case rate estimates are:

- Number of fatal accidents prevented by ERS per million departures: [0.009 , 0.22]
- Number of fatalities prevented by ERS per million enplaned passengers and crew: [0.004 , 0.095]

The upper limit of the 95% confidence interval for the (very) High Case rate of fatalities prevented is 0.095 per million passengers and crew. This represents the **extremely** unlikely case where there is less than a 2.5% chance of observing a such a low number of occurrences where ERS prevented fatalities, and a high number of fatalities are prevented in **all** those occurrences given the circumstances of the occurrence.

The estimated number of fatal accidents per million departures and number of fatalities per million enplaned passengers and crew prevented by ERS are summarized in Exhibit B-1.

Exhibit B-1.
Summary of Estimates of the Rates of Fatal Accident and Fatality Prevented by ERS

Case		Fatal accidents prevented per million flights	Fatalities prevented per Million passengers & crew	Likelihood	Note
Most Likely	Mid-point	0.016	0.003	Most likely	Expected/average value of ERS benefit
	Upper end of 95% Confidence Interval	0.214	0.038	High case, possible but not likely	Allows for chance nature of accidents occurring
High Case	Mid-point	0.037	0.016	High case, very unlikely	Allows for uncertainty in interpreting ERS role
	Upper end of 95% Confidence Interval	0.22	0.095	Very High Case, extremely unlikely	Allow for both chance nature of accidents and uncertainty in ERS role

Reasonably likely *High* values (approximately 95% confidence interval) for the two rates were set based on the maximum value of the upper end of 95% confidence interval for the Most Likely case and the High Case mid-point value. Based on these values, the *High* values of the rates are as follows:

- Number of fatal accidents prevented by ERS per million departures: 0.21; and
- Number of fatalities prevented by ERS per million enplaned passengers and crew: 0.038.

Note that the upper end of 95% confidence interval for the High Case rates (bottom row in exhibit) are considered extremely unlikely and corresponds more closely to a 99.7% or higher confidence interval.