

## Risk Assessment of Proposed ARFF Standards

### DETAILS

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## Acronyms

AC	Advisory Circular
ACRP	Airport Cooperative Research Program
ANPRM	Advance Notice of Proposed Rulemaking
ARFF	Aircraft Rescue and Fire Fighting
CAMI	Civil Aerospace Medical Institute
CFR	Code of Federal Regulations
CRFFAA	Critical Rescue and Fire Fighting Access Area
FAA	Federal Aviation Administration
FSF	Flight Safety Foundation
HIC	Head Injury Criteria
ICAO	International Civil Aviation Organization
NASA	National Aeronautics and Space Administration
NFPA	National Fire Protection Association
NPRM	Notice of Proposed Rulemaking
NTSB	National Transportation Safety Board
OSHA	Occupational Safety and Health Administration
PBE	Protective Breathing Equipment
PCA	Practical Critical Area
RRA	Rapid Response Area
RSA	Runway Safety Area
SARP's	Standards and Recommended Practices
SNPRM	Supplemental Notice of Proposed Rulemaking
TCA	Theoretical Critical Area
TSO	Technical Standard Order
U.S.C.	United States Code

## CHAPTER 1 INTRODUCTION

Airplane crashes have occurred since man first flew. The first airplane passenger death occurred in 1908 when an airplane piloted by Orville Wright crashed during a test flight at Fort Myers in the Washington, D.C., area. The passenger, Lt. Thomas Selfridge, died the day after the crash from a fractured skull and internal injuries sustained at impact. Calbraith Rodgers experienced several crashes and other mishaps when he became the first person to fly across the United States in 1911 but survived all of them during his transcontinental trip. However, a few months after completing that trip he became the first aviation fatality attributed to a bird strike when he collided with a flock of birds over Long Beach, CA, and crashed into the harbor.

Many improvements have taken place since those early days. The crash injury causal data discovered during accident investigations have been instrumental in directing safety recommendations, research efforts, and safety studies that have led to improvements in crash survivability. Safety research and safety studies continue to identify new materials, procedures, and standards that improve passenger and crew safety.

One important component of crash survivability in an aircraft accident that occurs on or adjacent to the airfield is the response and capability of the airport's Aircraft Rescue and Fire Fighting (ARFF) team. In the United States ARFF is only required at airports subject to 14 Code of Federal Regulations (CFR) Part 139 and may not exist at non-Part 139 airports including general aviation airports. Generally, airports serving scheduled air carrier passenger operations with more than nine passenger seats and unscheduled air carrier passenger service with more than 30 seats are required to have a Part 139 certificate.

The focus of this research effort is to review air carrier passenger aircraft accidents to determine if changes to ARFF standards would have reduced the number of fatalities or serious injuries that resulted from past accidents. The research team was tasked with comparing the standards set forth by the Federal Aviation Administration (FAA) in 14 CFR, Part 139, Certification of Airports with the standards of the International Civil Aviation Organization (ICAO) in Annex 14 and standards set forth by the National Fire Protection Association (NFPA) in making determinations of reducing the number of fatalities and serious injuries associated with each accident.

As stated previously ARFF is one component that contributes to survivability. In Chapter 2, some of the other measures that have been adopted primarily over the last 30 years and contribute to increased survivability are discussed.

Chapter 3 provides a brief overview and comparison of the ARFF standards that have been set forth by the FAA, ICAO, and NFPA. Where it could be documented the underlying basis for each organization's standards is provided.

In Chapter 4, the criteria for identifying "accidents of interest" to this research effort are discussed along with the databases that were searched for these accidents. Some observations on these accidents are also included in this chapter.

Chapter 5 explains the methodology that the research team used to determine whether different ARFF standards would have reduced the number of fatalities or serious injuries in each accident.

Chapter 6 contains the research team's conclusions based on the information in Chapter 5.

Appendix A contains basic information about each of the "accidents of interest" that is in this research effort. The accidents are placed in chronological order by the date of occurrence. The reductions in the number of fatalities and/or serious injuries and the research team's analysis used to reach that determination are contained in the Appendix A write-up for each accident.

Appendix B provides a graphical depiction of the location of accidents relative to a generic runway, its runway safety area, and the Rapid Response Area.

It should be noted that it is not the purpose of this research to recommend whether or not the proposed regulation should be enacted. Rather, it provides technical information and analysis that can be used by others, in conjunction with information from other sources, in formulating policies, regulations, and procedures related to this issue.

## **CHAPTER 2**

### **MEASURES THAT HAVE REDUCED ACCIDENT FATALITIES AND SERIOUS INJURIES**

This chapter presents measures that have been taken by the FAA or the aviation industry that have reduced or will reduce the number of fatalities or serious injuries associated with air carrier passenger aircraft accidents in the United States that occur on or directly adjacent to airport property. Many of these measures were adopted in response to recommendations made by the National Transportation Board (NTSB) as a result of its accident investigations. By no means should the measures presented in this chapter be considered a comprehensive, all-inclusive list of everything that has been done to increase crash survivability. We have tried to identify the more commonly known measures and when possible have identified accidents where these measures might have had or did have a positive impact.

For the purposes of this report we have grouped these measures under the following five headings in this chapter:

- Prevent the Accident
- Protect Airplane Occupants from Crash Impact
- Minimize Development and Severity of Crash Fires
- Enhance Evacuations
- Coordinate Response

#### **PREVENT THE ACCIDENT**

The best measure to reduce fatalities or serious injuries is to keep the accident from happening in the first place. This section examines measures implemented to reduce the risks resulting from the two types of accidents that can have the most serious consequences: runway collisions and runway excursions.

##### **Runway Collisions**

Although rare, a collision involving an air carrier aircraft on takeoff run or landing rollout can have catastrophic consequences. The worst accident in the history of civil aviation resulted in 583 fatalities when two Boeing 747's collided in 1977 on the runway at Tenerife in the Canary Islands. In the 81 accidents of interest for this study (see Appendix A) there are seven runway collisions—each one resulted in fatalities.

Runway collisions are a subset of runway incursions. Often the cause of a runway incursion is cited as a loss of situational awareness—by the pilot, controller, and/or vehicle operator. In a 2007 “Call to Action Meeting” the FAA and Industry developed an ambitious plan to address runway incursions. One of the recommendations from this meeting was that air carrier crews receive realistic training scenarios on ground operations in flight simulator training. Prior to that time, simulator training for most air carrier pilots began and ended on the runway. All 112 active air carriers in the United States have reported that this type of training has been incorporated into their training curriculums.

At the same “Call to Action” meeting, it was also agreed that all airports with a Part 139 certificate would install the enhanced taxiway centerline. This pavement marking



provides the pilot with visual cues that they are approaching a runway holding position. The enhanced centerline is expected to greatly reduce the number of runway incursions where a pilot acknowledges “Hold Short” instructions but then proceeds to cross the hold position markings.

In June 2010 the FAA amended its directive on air traffic control to require controllers to provide an explicit clearance to cross a runway to all pilots taxiing out for takeoff. Prior to this change, a clearance to taxi to a runway for takeoff implicitly allowed a pilot to cross any intervening runways. This change coupled with the enhanced taxiway centerline should result in a safer airfield environment by reducing the number of runway incursions.

### Runway Excursions

A runway excursion occurs when an aircraft that is taking off or landing runs off the side of the runway or runs off the departure end of the runway. These accidents are commonly referred to as veer-offs and overruns, respectively. In 2009, the Flight Safety Foundation (FSF) published a study, *Reducing the Risks of Runway Excursions*. The study examined 417 runway excursions that occurred worldwide from 1995 to 2008. This study sample included air carrier passenger, cargo, and business jet operations. Over this period 34 of these runway excursion accidents resulted in 712 fatalities. The FSF report offers several strategies for preventing runway excursions that address flight operations, airport operators, air traffic management, regulatory agencies, and aircraft manufacturers.

For the purpose of this report, two of the strategies from the FSF study that are directed at airport operators have been selected for discussion. The first strategy is to:

Ensure that runways are constructed and maintained to ICAO specifications, so that effective friction levels and drainage are achieved (e.g., runway grooving, porous friction overlay.)

In the United States, the importance of improving pavement drainage to reduce hydroplaning was recognized in the 1970’s. The Policies section (49 USC 47101) of the law establishing the Airport Improvement Program, which provides grants for development to airport operators, recognizes the importance of this treatment when it states:

**(f) Maximum Use of Safety Facilities.**— This subchapter should be carried out consistently with a comprehensive airspace system plan, giving highest priority to commercial service airports, to maximize the use of safety facilities, including installing, operating, and maintaining, to the extent possible with available money and considering other safety needs—

(1) ...

(2) grooving or friction treatment of each primary and secondary runway...

With this policy in place, virtually every runway used by air carriers operating under 14 CFR Part 121 was either grooved or had some other surface treatment to improve drainage by the mid-1980s.

The other strategy dovetails nicely with a major initiative that the FAA already had underway since the late 1990s. That strategy is to:

Ensure that all runway ends have a runway end safety area as required by ICAO, Annex 14 or appropriate mitigation measures such as an arrestor bed.

Runway safety areas are designed and graded to minimize structural damage to an aircraft that enters them and minimize injuries to the occupants. Runway safety areas also extend along the sides of runways to accommodate aircraft that veer-off the runway. They are graded and under dry conditions capable of supporting the weight of the aircraft, as well as responding ARFF equipment. The objective is to have an aircraft entering a runway safety area result in an incident rather than an accident since the aircraft should not experience significant damage nor should any of its occupants be killed or sustain serious injuries.

The concept of runway safety areas was first recognized in FAA standards in 1969. At that time the landing strip which extended 100 feet beyond each runway end was incorporated into the runway safety area. The runway safety area was extended an additional 100 feet providing a graded area of 200 feet beyond each runway end. For air carrier runways it was recommended that an extended safety area be constructed that extended an additional 800 feet beyond the 200 feet. To accommodate veer-offs the safety area for most air carrier runways extends a distance of 250 feet on either side of the runway centerline or extended runway centerline. Almost all airports could comply with the width standard and the 200 feet beyond the runway end standard but progress in achieving the additional 800 feet was primarily limited to new runways. In the late 1990's the FAA began an initiative to review the safety areas at each certificated airport and determine what upgrades were practicable. The FAA then allocated grant funds under the Airport Improvement Program to make those improvements. A cellular cement arrestor bed was also developed and approved in the 1990's as an acceptable alternative for complying with the runway safety area requirements if the available real estate or other constraints made it impracticable to obtain the full safety area.

In the 2006 appropriations act that provides funding for the FAA, Congress included the following language:

That not later than December 31, 2015, the owner or operator of an airport certificated under 49 U.S.C. 44706 shall improve the airport's runway safety areas to comply with the Federal Aviation Administration design standards required by 14 CFR Part 139...

In a speech at the 2010 Annual Meeting of the American Association of Airport Executives in Dallas, Texas, the FAA's Administrator, J. Randolph Babbitt stated:

Airports in particular have also been making considerable progress on improving Runway Safety Areas. Since 2000, 80 percent of runway safety areas requiring improvement have been updated. Improving the RSA will continue to be a high priority for us and the airport community as we move to our goal of completing the required RSA improvements at certificated airports by the end of 2015.

The completion of the runway safety area initiative will greatly enhance the safety of the U.S. airport system. The accompanying shadow box illustrates how the safety area improvements at one airport prevented a fatal accident.

## The Fatal Accident That Wasn't Fatal and Wasn't an Accident

As one may surmise from its nickname, “the Mountain State,” it is difficult to find a large tract of relatively flat land in West Virginia to build an airport with clear approaches to its runways. This is the task that the citizens of Kanawha County, which includes the state capitol of Charleston, faced in the 1940's when they were looking for a site to replace the existing airport that was encroached upon by a synthetic rubber plant needed for the war effort. They decided that the best solution was to “push” some mountains together and create their own plateau with approaches clear of any terrain obstructions.

The new airport that opened in 1947 is still used to provide commercial air service to the area and is known as Yeager Airport. Over the years the airport has faced its challenges. It was built at a time when the commercial fleet consisted of propeller-driven planes. Its runways had to be extended to accommodate jet-powered aircraft. This can be very expensive when your site is surrounded by severe drop-offs.

The latest challenge was how to accommodate the Federal Aviation Administration's requirement for a safety area on each runway end. Normally the safety area is a



cleared, graded area that extends 1000 feet beyond the runway end and 250 feet on either side of the extended centerline. To construct a safety area of these dimensions at Yeager Airport would have been exorbitant. Instead the airport operator chose to extend the existing safety area at the departure end of runway 23 from 120 feet to 460 feet in length. It then installed a passive arresting system consisting of cellular cement on 405 feet of this newly graded area. Although it was expensive, this was a relatively cheap solution compared to the

standard runway safety area. This project was completed in September 2007.

The benefit of the safety area improvements became readily apparent on January 19, 2010. The captain of USAirways Express Flight 2495 determined that the flaps were not properly set for takeoff as the aircraft was accelerating down the runway and decided to abort the takeoff. The Bombardier CL-600 had 3 crew members and 31 passengers onboard. It is estimated that the aircraft entered the cellular cement arresting bed, which starts 50 feet from the runway end, at a speed of 50 knots. The nosewheel stopped after traveling a distance of 128 feet into the bed. Since there were no fatalities, no serious injuries, or substantial damage to aircraft, the event, which if it occurred 3 years earlier would undoubtedly have been a tragic accident involving several fatalities and serious injuries, was classified as an incident.

## PROTECT AIRPLANE OCCUPANTS FROM CRASH IMPACT

### The 16g Seat

In 1988 the FAA concurrently published a final rule, “Improved Seat Safety Standards” and a notice of proposed rulemaking, “Retrofit of Improved Seats in Air Carrier Transport Category Airplanes” that upgraded the certification standards for occupant protection during emergency landing conditions in transport category airplanes from only a 9g static standard to a new 16g dynamic standard (1, 2). Notice 88-8 proposed to prohibit, after June 16, 1995, the operation of transport category airplanes under parts 121 and 135 that were type-certificated after January 1, 1958, unless all seats onboard met the certification requirements of 14 CFR 25.785 in effect on June 16, 1988. These certification requirements include the 16g standard created by Amendment 25-64.

Industry needed time to work out the technical problems of meeting the 16g seat standard. FAA also needed time to evaluate specific problems presented by Industry and develop proper guidance material for obtaining 16g seat certification. As Industry and FAA addressed these issues, standards and guidance material evolved. FAA published advisory circulars to provide Industry guidance on the dynamic test process (3).

FAA working with industry through the Society of Automotive Engineers Seat Committee developed a standard that detailed the requirements for dynamic testing of a 16g seat (4). That standard was incorporated in Technical Standard Order (TSO)-C127 (Rotorcraft, Transport Airplane, and Normal and Utility Airplane Seating Systems) in 1992 and revised in 1998 (TSO-C127a).

On October 4, 2002, the FAA published a supplemental notice of proposed rulemaking (SNPRM), “Improved Seats in Air Carrier Transport Category Airplanes” (5). In preparing the SNPRM, the FAA hired a consultant to conduct an analysis of the benefits of 16g seats over 9g seats in transport category airplanes. This consultant analyzed and produced a report entitled “A Benefit Analysis for Aircraft 16g Dynamic Seats” (The Cherry Report) (6).

The Cherry Report studied transport category airplane accidents that occurred from 1984 to 1998 and predicted the benefits to the occupants if 16g seats had been installed in those airplanes. It predicted a range in the reduction of serious injuries and fatalities to occupants in impact-survivable accidents if they were in 16g seats instead of 9g seats.

After publication of the SNPRM, an addendum report was published entitled, “A Benefit Analysis for Aircraft 16g Dynamic Seats Configured Without Enhancements to Head Injury Criteria” (The Cherry Report Addendum) (7). The report assessed the incremental benefits resulting from the enhanced Head Injury Criteria.

Head Injury Criteria (HIC) is the measure of head impact forces during a crash where contact with seats or other structures can occur. Protection must be provided so that the head impact forces do not exceed a specified level.

The 16g seat involves three regulations: 25.785, 25.562, and 121.311. The first two regulations pertain to the aircraft and the last one is the operating rule. The first two went into effect on June 16, 1988, and they required that the 16g seat be installed in aircraft

manufactured or refurbished after that date. The operating rule requires 16g seats be on aircraft operating under Part 121 after October 27, 2009 (8). This last rule effectively banned the 9g seat.

Although the operating rule did not have to be complied with until October 2009, manufacturers had been installing 16g compatible seats in new aircraft since 1988. In 2005, the Air Transport Association estimated that 90% of the seats in the US commercial fleet were 16g compatible. One reason for the high number of 16g seats in current aircraft is that many older 9g seat equipped aircraft were retired from the fleet after the airline industry suffered the adverse effects on travel resulting from the 9/11 disaster.

The Cherry Report discusses 25 impact-survivable accidents involving aircraft operating to 14 CFR Part 121 or equivalent that were identified during the period from 1984 to 1998 and may have had seat-related fatal or serious injuries (6). Each of these accidents was analyzed in detail and a mathematical technique was used to model each accident scenario. Monte Carlo simulations were used to assess a high, median, and low value for the total achievable benefits over the period 1984 to 1998 to U.S. registered aircraft operating under 14 CFR Part 121. The objective of this study was to assess the number of serious injuries and fatalities that might have been avoided from the use of 16g dynamic seats.

Two methodologies were used. The first was based on worldwide accident data for aircraft operating under 14 CFR Part 121 or equivalent. This analysis involved 25 accidents that resulted in 1423 fatalities and 527 serious injuries. The analysis predicted the following benefits:

**Reduction in Fatalities = 51** with a 95 percentile range from 33 to 68 fatalities  
**Reduction in Serious Injuries = 54** with a 95 percentile range from 28 to 79 serious injuries

The second analysis was carried out on the accident data pertaining to U.S. aircraft operating under 14 CFR Part 121 only. This analysis involved 13 accidents that resulted in 766 fatalities and 177 serious injuries. The analysis of this smaller data set has resulted in the following prediction of lives to be saved:

**Reduction in Fatalities = 23** with a 95 percentile range from 12 to 40 fatalities  
**Reduction in Serious Injuries = 18** with a 95 percentile range from -1 to 32 serious injuries

A negative value for the reduction in serious injuries is associated with situations where the number of fatal injuries reduced to serious injuries is higher than the number of serious injuries reduced to minor or no injuries. The net outcome is an increase in serious injuries.

Account has been taken of the reduction in fire threat afforded to the impact survivors by the improved fire-worthiness of cabin interiors compliant with the standards defined in 14 CFR Part 25 including Amendment 72.

## MINIMIZE DEVELOPMENT AND SEVERITY OF CRASH FIRES

### General

The FAA conducts research at the William J. Hughes Technical Center and Civil Aerospace Medical Institute (CAMI). The Technical Center located in New Jersey is the world's premier aviation research and development and test and evaluation facility. The Technical Center serves as the national scientific test base for the FAA. Technical Center programs include research and development, test and evaluation, and verification and validation in air traffic control, communications, navigation, airports, aircraft safety, and security.

CAMI is located at the Mike Monroney Aeronautical Center in Oklahoma. The Aerospace Medical Research conducted at CAMI is enhancing human safety, health, security, and survivability in civilian aerospace endeavors.

Research at these facilities is twofold. One is to test and/or develop new safety products or procedures; the other is to develop test methods to ensure regulatory compliance with the new products or procedures.

### Evacuation and ARFF Response Times

Since the early 1970s, the FAA Technical Center has conducted numerous studies and research projects related to passenger/crew safety in aircraft crashes. The work has helped decrease passenger/crew injuries and deaths through better post-crash fire protection standards that have led to new safety regulations on current air carrier aircraft. Much of the research work has been a cooperative effort involving the aviation industry, the military, NASA, academia, and more recently some foreign governments. A perusal of the Technical Center's web site under the heading Fire Research shows the several references related to some of their fire safety work.

In May 2009, Technical Center published a study entitled *Determination of Evacuation and Firefighting Times Based on an Analysis of Aircraft Accident Fire Survivability Data*. The study looked at a number of transport aircraft accidents that occurred from March 1967 through October 2000 (9). Of the 147 accidents selected, 101 of these accidents were considered to be survivable. Of the 101 "Survivable Accidents" 70 had a fire involvement. Of these 70 fire-related accidents, 36 were confirmed as ground pool fire accidents. Ground pool fires occur in situations where the aircraft fuel tanks or fuel lines are ruptured and the leak results in a pool of fuel on the ground that is ignited.

The study gathered data on the relative proportion of large transport aircraft accidents that involved ground pool fires and analyzed statistical data on the following:

- Time to initiate an evacuation measured from the time the aircraft came to rest to the time the evacuation started.
- Time to complete an evacuation measured from the commencement of the evacuation to the time the last occupant exited the aircraft.
- Time to arrival of firefighters measured from the time the aircraft stopped to the time firefighters were in a position to start fire-fighting activities.

- Time for firefighters to establish control in a ground pool fire accident measured from the time of arrival of the firefighters to the time they established control of the fire.

The data was extracted from accident reports and other information published by investigating and airworthiness authorities using the Cabin Safety Research Technical Group Aircraft Accident Database as the search facility.

For the four areas of interest listed above, the “Curve of Best Fit” was derived, assuming that the data may be represented by a Weibull Distribution. Results of the analysis suggest the following:

1. For Evacuation Initiation Times: 50% of evacuations are initiated within 20 seconds and 90% within 40 seconds.
2. For Evacuation Completion Times: 50% of evacuations are completed within 130 seconds and 90% within 325 seconds.
3. For Time to Arrival of Fire-Fighters: on 50% of occasions, the firefighters arrive within 4 minutes (240 seconds) and 90% of occasions within 12 minutes (720 seconds).
4. For Firefighters to Establish Control: on 50% of occasions, the firefighters establish control within 10 minutes (600 seconds) and 90% of occasions within 42 minutes (2520 seconds).

### **Burn-through Times**

In another research project the Technical Center conducted 28 full-scale fuselage burn-through tests. There are typically three barriers that a ground pool fuel fire must penetrate in order to burn-through to the cabin interior: the aluminum skin, the thermal-acoustical insulation, and the interior sidewall and floor panel combination. The aluminum skin will burn through in 30 to 60 seconds, depending on the thickness. Thermal-acoustical insulation, typically comprised of fiberglass batting encased in a polyvinyl fluoride (PVF) moisture barrier, can offer an additional 1 to 2 minutes protection. The honeycomb sandwich panels used in the sidewall and floor areas offer a substantial barrier to fire.

The twenty-eight tests were conducted on modified fiberglass batting or replacement insulation materials. Several new materials and combinations tested showed vast improvements in burn-through resistance over existing materials. A heat-treated, oxidized polyacrylonitrile fiber (OPF) encased in a polyimide bagging material prevented burn-through for over 8 minutes. This contrasted with current insulation blankets, which fail in as little as 2 minutes (10).

Some of these new materials and their installation were mandated in new large aircraft manufactured after July 2003 and in all large aircraft operating under Part 121 after September 2007. Some manufacturers were ahead of the regulation and using the materials before they were mandated (11, 12).

Prior to the requirements for the insulation materials the Federal Aviation Administration (FAA) issued Amendments 25-59, 29-23, and 121-184 on October 23, 1984, which became effective November 26, 1984. These amendments were part of the FAA's continuing efforts to upgrade aircraft cabin safety and improve occupant survivability in aircraft accidents. They require that seat cushions installed on transport category airplanes and rotorcraft meet improved flammability standards. Affected operators were required to comply with these amendments after November 26, 1987.

Some of the benefits of these improvements have probably been realized in recent crashes but it is hard to verify without seeing the aircraft manufacturer's data. For example, in August 2005 an Air France Airbus A340 with 297 passengers and 12 crew members on board landing at Toronto-Lester B. Pearson International Airport overran the departure end of the runway. Although the aircraft experienced a high impact and a post-crash fire, all the passengers and crew members escaped the aircraft. In all likelihood, the occupants' evacuation of the aircraft benefited from the aircraft's fire resistant materials (13).

In the Delta B-727 crash at Dallas-Fort Worth International Airport in July 1988, the fire blocking seats were shown to slow the cabin fire enough to allow more time for the passengers to escape thus increasing the number of survivors (14). Evidence showed that the fire entered the aft cargo compartment before the airplane came to rest. After the airplane stopped, the fire burned through the cargo compartment liners and cabin floor. The fire also entered the cabin through the aft break in the fuselage, the opened right-side overwing exit, and later through a burn through in the center wing box area. The fire entering the fuselage through the aft break trapped passengers in the aft end of the cabin. The fire burning through the floor probably caused the fatalities in that area. The autopsy reports showed the cause of death to all fatalities as smoke inhalation.

The forward cabin remained survivable for about 4 minutes and 20 seconds, despite the large fuel fire at the ruptured area. Some of this survival time can be attributed to the use of fire blocking materials on the seat cushions. There was evidence of the fire blocking slowing the spread of fire into the cabin. Many seat cushions remained intact or showed signs that the blocker inhibited burning. With a large fuel fire entering the cabin, fire blocking will not stop the spread of fire, but will slow it down giving added time for escape. The NTSB's investigation found that the airport's aircraft rescue and fire fighting equipment was in place and applying extinguishing agents to the airplane about 4 minutes and 20 seconds after the accident and the last passengers to leave the airplane reported being hit by foam as they exited. The predicted survival time, based upon FAA tests without the fire blocking layers in place, would have been about 2 minutes and 50 seconds. While there is some margin for error in both times, the NTSB's analysis concluded that a number of lives were saved because the seat cushions were covered with fire blocking material (15).

## **ENHANCE EVACUATIONS**

### **Slide Improvements**

In the 1960s when the first wide-bodied aircraft entered service with their ability to carry more passengers, new evacuation problems arose. These aircraft were built with larger and wider doors that could accommodate dual lane evacuation slides. The larger slides offered an opportunity to adapt the larger slides into a combination slide/raft. The



problem was that FAA had a Technical Standard Order (TSO) for single lane slides and another TSO for rafts, but nothing that covered dual lane slide/rafts. FAA's CAMI and the manufacturer did some initial water and evacuation testing and from the collected data the manufacturers developed the first design standards for slide/rafts and those early slide/rafts were certified as part of the aircraft type certificate.

In March 1978 a Continental Airlines DC-10 aborted a takeoff and overran the end of the runway at Los Angeles resulting in the failure of the left main gear that ruptured two fuel tanks and caused a large ground pool fire. None of the left side slide/rafts were useable because of fire on that side. All four of the slide/rafts on the right failed before the evacuation was completed. The unit at exit R4 suffered a failure from asymmetrical loading when passengers could not get off the bottom end of the slide as fast as passengers were entering at the top. This forced the passengers caught in the middle of the slide to start moving into and across the pontoons attached to sides of the outboard slide lanes. When the girt fabric that attaches the slide unit to the airframe failed the slide/raft fell to the ground. The unit at R3 did not deploy properly because of the resting angle of the aircraft coupled with the in-rush of air that was feeding the fire. A few passengers used the unit at R2 before it was destroyed by fire. The unit at R1 was operational for a longer period of time but was destroyed by radiant heat before the evacuation was complete thereby forcing the remaining passengers and crewmembers to slide down escape ropes from the cockpit windows (16).

The NTSB issued Safety Recommendations addressing the problems uncovered in the accident investigation (17). FAA responded and developed a TSO for dual lane slides and slide/rafts. FAA issued TSO C-69a that has since been updated to TSO C-69c (18).

### **Lighting Improvements**

In an aircraft accident that involves smoke in the cabin, it can be difficult for passengers to find their way to the emergency exits. Thus, the regulations were changed in 1984 that required a floor proximity emergency escape path marking to provide emergency evacuation guidance for passengers when all sources of illumination more than 4 feet above the cabin aisle floor are totally obscured. The regulation requiring this is 14 CFR 25.812.

### **Passenger Safety Briefings**

Briefing guidance is provided in Advisory Circular AC 121-24C, 7/23/03, Briefing and Briefing Cards Passenger Safety Information. This is a 26 page document that covers standard oral briefings, video briefing and briefing cards.

In addition to the regular Passenger Safety Briefing required since 1965 by 14 CFR 121.571, is an Exit Row Occupancy requirement. This 1996 rule requires that persons seated in the exit rows be able-bodied, understand the language and agree to perform the evacuation duties at the exit as depicted on the briefing card in the event of an emergency. The responsibilities and passenger capabilities are defined in 14 CFR 121.585. Currently, personal briefings are not required for passengers seated in the exit rows.

On July 14, 2000, the NTSB issued a Safety Recommendation on exit seating (A-00-77). It asked the FAA to strongly encourage air carriers to require crewmembers to provide a preflight personal briefing to each passenger seated in an exit seat. Although many

airlines do conduct exit row briefings there is no requirement to do so. Safety Recommendation A-00-77 was closed, unacceptable action on October 21, 2004.

### **Exit Row Briefing**

The benefit of exit row passengers' receiving oral briefings from flight attendants was demonstrated in the runway collision accident in Los Angeles, California, on February 1, 1991 (19). The NTSB's report of that accident contained the following information:

Passengers seated around row 10 stated that, prior to departure, the flight attendant assigned to the R1 position interviewed a young passenger who was seated in 10D about whether he could fulfill the duties of an able-bodied person in the event of an emergency. The passenger advised the flight attendant that he was 17 years old. However, to be sure the youth understood his responsibilities, the flight attendant conducted a special oral briefing for the persons seated in and around row 10. Passengers stated that the instructions provided by the R1 flight attendant aided in their evacuation.

Past accident investigations have shown that in a preplanned emergency, such as a gear up landing, the passengers are much more attentive to the safety briefing. They relate to a need for the information. Many passengers, who ignore the regular safety briefing, will pay attention when they perceive a real danger.

### **Access to Exits**

In 1992, 14 CFR 25.813 Emergency Exit Access rule was modified to provide better access to Type III exits. The Type III exit is a rectangular opening of not less than 20 inches wide by 36 inches high. The exit is usually located over the wing area. Depending on the aircraft it can be equipped with one or two Type III exits over each wing.

The rule was changed as a result of a British Airtours Boeing 737 accident in Manchester, England on August 22, 1985. Fifty-three passengers and two crew members were unable to exit the aircraft and all but one of them died from asphyxiation after inhaling the toxic fumes. As a result of the accident, CAMI conducted two studies on emergency evacuations through Type III exits (20, 21). The FAA used the data collected from these studies to support a rule change that was issued on June 3, 1992. The new rule addressed several things including pathway widths from the aisle to the exit(s) and required placards showing how to open the exit, the exit's weight, and where to stow the exit after removing it.

### **Crewmember Emergency Training**

14 CFR 121.417 requires crew training on all aircraft emergency equipment. Emphasis is placed on the emergency evacuation drill with each person exiting the airplane or approved training device using at least one type of installed emergency evacuation slide. The crewmember may either observe the airplane exits being opened in the emergency mode and the associated exit slide/raft pack being deployed and inflated, or perform the tasks resulting in the accomplishment of these actions.

After September 1, 1993, no crewmember may serve in operations under this part unless that crewmember has at least one approved protective breathing equipment (PBE) drill. As part of the drill, the crewmember has to combat an actual or simulated

fire using at least one type of installed hand fire extinguisher or approved fire extinguisher that is appropriate for the type of actual fire or simulated fire to be fought while using the type of installed PBE required by §121.337 or approved PBE simulation device.

The benefits of protecting airplane occupants from crash impact, minimizing the development and severity of crash fires, and enhancing the evacuation are all illustrated in an accident that occurred in Columbia on August 16, 2010.

### Was that really a miracle?

In the early morning hours of August 16, 2010, a Boeing 737 operating as Aires Flight 8250 from Bogota to San Andres Island (Columbia) touched down short of the runway at its destination. The accident is still under investigation and it has been reported that the aircraft was struck by lightning on its final approach. Momentum carried it some 300 feet down the runway where the fuselage broke apart into three pieces. All the people on board (crew of six and 121 passengers) survived the crash, although an older passenger later died from a heart attack. Several passengers were hospitalized so there were probably some serious injuries also.

When the news of the accident spread, it was described as a “miracle” since no one died in the actual crash sequence and everyone was able to evacuate the destroyed aircraft. In an article written by Alan Levin in the August 18, 2010 edition of USA Today, he points out some people take exception to the “miracle” designation and feel the outcome of the accident was the result of decades of work by engineers and accident investigators to improve airline safety. He includes a quote from John Hickey, the FAA’s Deputy Associate Administrator for Aviation Safety who stated:

“I cringe when I see these headlines that this was a miracle. We as engineers and scientists don’t believe that this is a miracle. We are totally convinced that the work that we did in the 1980s has proven its value.”

In the 1980’s when an aircraft fuselage broke apart in the accident, it almost always resulted in fatalities. Since that time, federal regulations have been changed to require stronger seats, better emergency lighting, more accessible exits and numerous protections against fire.

Bill Voss, the Chief Executive Officer and President of the independent Flight Safety Foundation shares Hickey’s assessment. "This can’t be all luck. I think you have a series of unglamorous incremental improvements making a difference."

The improvements may have been “unglamorous” but they were certainly effective.

## COORDINATE RESPONSE

### Airport Emergency Plan

Improved crash survivability also includes rapid rescue and transportation of injured victims to medical facilities. This is accomplished through a current comprehensive Airport Emergency Plan.

In 1984 the NTSB conducted a Safety Study entitled, Airport Certification and Operations. One of the twenty-one Safety Recommendations resulting from the study was to require a full-scale demonstration of the airport emergency plan once every two years and an annual table-top exercise (22).

On August 2, 1985 a Delta Air Lines Lockheed L-1011 crashed on approach at the Dallas/Fort Worth International Airport. The investigation of the accident uncovered several problems with the airport's emergency plan including emergency response communications procedures. Six years had lapsed since Dallas/Fort Worth International Airport had had a full-scale exercise of their emergency plan. The NTSB reiterated their 1984 recommendation.

The FAA amended Part 139 in 1988 to require a full-scale exercise every three years. When the DC-10 crashed at the Sioux Gateway Airport in Sioux City, Iowa on July 19, 1989, the pilot had high praise for the emergency response. It turns out that the airport had gone through a full-scale exercise just days before the crash. The rapid response of the on-airport and off-airport emergency responders was credited with saving lives (23).

### Discrete Emergency Frequency

In some accident scenarios, it is beneficial for the flight crew and the ARFF Incident Commander to be in direct communication with each other. From an ARFF perspective, it is important to know such things as the number of souls on board, the amount of fuel remaining, if there is any hazmat on the aircraft and where it is located, and the pilot's intentions. From the flight crew's perspective, the ARFF incident commander is able to provide information on the external condition of the aircraft and whether or not evacuation is recommended. Prior to 1999 the common practice was to channel communications between the crew of an aircraft that declared an emergency and the ARFF incident commander through the air traffic controller. The procedure of routing these communications through the controller not only caused delays in getting needed information between the flight crews and the ARFF incident commander but also opened the possibility of the original message being inadvertently modified.

In 1999, the FAA published Advisory Circular 150/5210-7C, which provided for a frequency to be set aside at an airport that would be used for direct communication between the flight crew and the ARFF incident commander. Similar provisions were included in internal agency orders governing ATC procedures. Known as the Discrete Emergency Frequency, ATC specifies when the flight crew and the ARFF incident commander should switch over to this frequency.

### ARFF Improvements

Throughout the years, there have been many changes and improvements in fire fighting safety, as well as in airport operations. It is important to note that although a new equipment feature may be available, it is not necessarily available at all airports. Although sometimes it is possible to retrofit an old piece of equipment with these new

features, many airports acquire the new features as part of an overall equipment purchase, e.g., acquisition of a new ARFF vehicle. Some of these changes and improvements are listed below:

1. Many ARFF vehicles have been redesigned to lower their center of gravity and to have improved suspension systems, making them more stable and reducing roll-over potential.
2. New types of nozzles have been developed that are capable of encapsulating different types of extinguishing agents for greater knock-down power.
3. High-reach extendable waterway systems are available that allow the aircraft cabin to be penetrated by piercing nozzles. This allows for the cabin to be kept cooler as water is sprayed into the cabin, thereby reducing the extreme heat buildup inside the fuselage.
4. Forward-looking infrared devices are now mandatory on new ARFF vehicles purchased with Federal funds. This equipment can pinpoint the source of heat and indicates whether a fire is spreading or contained.
5. Design changes in personnel proximity suits allow for greater protection from aircraft fires and more comfort to the wearer.
6. Most ARFF vehicles are now designed to allow a one-person operation.

## CHAPTER 3 COMPARISON OF FAA, ICAO, AND NFPA STANDARDS

This Chapter discusses the authority of the Federal Aviation Administration (FAA), the International Civil Aviation Organization (ICAO), and the National Fire Protection Association (NFPA) to issue standards for aircraft rescue and fire fighting (ARFF). The differences between the ARFF standards issued by these organizations are identified and where information was available the basis for the standards is provided.

### AUTHORITY OF FAA, ICAO, AND NFPA TO ISSUE ARFF STANDARDS

#### Federal Aviation Administration (FAA)

Under Title 49 of the United States Code, § 44706, the FAA is authorized to certificate airports receiving scheduled air carrier service with aircraft having more than nine passenger seats and unscheduled air carrier service with aircraft having more than 30 passenger seats. Section 44706 is implemented by 14 CFR Part 139, the FAA regulation that sets forth the requirements for airport certification. Part 139 contains specific requirements for operators of airports with air carrier passenger service, including requirements for ARFF. Part 139 is not applicable to heliports or to airports that:

- a. are served by large all-cargo aircraft only,
- b. are in Alaska and are served by air carrier aircraft with less than 31 passenger seats, or
- c. do not have air carrier service that uses aircraft with more than nine passenger seats.

The FAA adopted Title 14 CFR Part 139, Airport Certification, in 1972. Since then, the regulation has been amended on several occasions and substantially revised in 1988 and 2004. Part 139 requirements concerning aircraft rescue and fire fighting are found in Sections 139.315, 139.317 and 139.319.

The requirements in 14 CFR Part 139 are established by the Federal rulemaking process and codified in Federal regulations. Prior to beginning the rulemaking process the FAA can seek input from interested parties. This can be done informally through public contact, participation on an industry committee or open forum, or formally through the Aviation Rulemaking Advisory Committee. Once the rulemaking process begins, e.g., by issuance of an Advance Notice of Proposed Rulemaking (ANPRM) or Notice of Proposed Rulemaking (NPRM), agency rules on ex parte communications apply. The regulatory process generally starts with the development of a regulation that is published as an NPRM. The NPRM is published in the Federal Register and public comment is sought for a set comment period, typically 45 or 60 days. Once the public comment period closes, the FAA will evaluate all the comments and decide whether to withdraw the proposed rule, adopt it as a final rule, or adopt a revised rule to reflect the comments received. A final rule may impose less burdensome requirements than the proposed rule, but cannot impose more stringent requirements than proposed in the NPRM without a supplemental notice and additional opportunity for public comment. All rules are required to undergo a benefit/cost analysis. The proposed rule will generally not be adopted unless the benefits of the rule outweigh its costs. If the final version of the rule has a benefit-cost ration greater than one, the agency may decide to issue the rule. The various requirements contained in the final rule then become required for entities and

persons within the applicability of the rule. For Part 139, this includes certificated airport operators and their employees.

The FAA also develops and publishes standards in both advisory circulars and engineering briefs. These standards show an acceptable means of complying with the requirements of the rule, but can have regulatory effect only if incorporated by reference in an agency regulation. The standards may also be required as a condition of FAA grant agreements. If an airport operator is using Federal funds for airport development, the operator is required as a condition of the grant to comply with the standards set forth in the Advisory Circulars and engineering briefs that apply to the project. Consequently, these standards are used by airport operators, consultants and contractors in designing airport projects, putting together specifications for the procurement of airport equipment, and in meeting the requirements of the airport certification program (Part 139). Individuals, airport operators, manufacturers, or trade associations may request that a new standard be developed or an existing one be changed. For airport Advisory Circulars, that request is made to the Airports line of business in the FAA. In some cases, the FAA may contract with an organization or consultant to investigate a particular problem and propose viable solutions. In other cases, the FAA may initiate a research and development project at the Technical Center.

The agency generally reviews existing Advisory Circulars on a 5-year schedule to consider the need for revision. The FAA may decide to change an existing advisory circular or issue a new one, as appropriate. It may do this in-house or it may call a meeting with industry to consider a change to the existing standards. Once there is agreement to add or change (or, in some cases, to delete) a standard, the FAA will produce a draft change to the appropriate advisory circular. If the standard is very specialized or intended only as an interim standard, the FAA may issue it in the form of an engineering brief. The draft change is posted on the FAA's website for comment. Anyone may comment on the draft. Typically comments are received from various aviation industry organizations, such as the Airline Pilot Association, the American Association of Airport Executives, the Airports Council International – North America, the Airports Consultants Council, and the Air Transport Association. The FAA will consider all comments received during the comment period and prepare a disposition of the comments. Based upon the comments received, the draft change may be withdrawn, modified to address the comments received, or issued as originally proposed. The final advisory circular change is approved by the appropriate Office Director (for engineering standards, the Director of Airport Safety and Standards) and reviewed for legal sufficiency by the Office of Chief Counsel. After approval by the Office of the Chief Counsel, the Director issues the revised Advisory Circular and posts it on the FAA Airports website.

### **International Civil Aviation Organization (ICAO)**

The ICAO is a special agency of the United Nations linked to the Economic and Social Council. The constitution of ICAO is the Convention on International Civil Aviation, drawn up by a conference in Chicago in November and December 1944, and to which each ICAO Contracting State is a party. ICAO works in close co-operation with other organizations of the United Nations, such as the World Meteorological Organization, the International Telecommunication Union, the Universal Postal Union, the World Health Organization and the International Maritime Organization. Non-governmental organizations that participate in ICAO's work include the International Air Transport

Association, the Airports Council International, the International Federation of Air Line Pilots' Association and the International Council of Aircraft Owner and Pilot Associations.

ICAO's mandate is to ensure the safe, efficient and orderly evolution of international civil aviation. This is done through the issue of Standards and Recommended Practices (SARPs), which are adopted and incorporated as Annexes to the Convention on International Civil Aviation. The principal body concerned with the development of technical standards and other provisions is the Air Navigation Commission. Its primary role is to advise the ICAO council on air navigation issues. It is composed of fifteen experts with appropriate qualifications and experience in various fields of aviation. Its members are nominated by Contracting States and are appointed by the Council. They are expected to function as independent experts and not as representatives of their States.

ICAO Annex 14, paragraph 1.2.2 states: "the specifications, unless otherwise indicated in a particular context, shall apply to all aerodromes open to public use in accordance with the requirements of Article 15 of the (Chicago) Convention." However, Annex 14 standards apply to states (countries) and are only applicable to airport operators if their country adopts the Annex 14 standard. In addition to standards, ICAO also provides "Recommendations." Countries may adopt or not adopt ICAO standards and recommendations. The ARFF standards and recommended practices adopted by ICAO are found in Annex 14, Chapter 9, Section 9.2 (24).

The development of Standards and Recommended Practices to ICAO Annex 14 is a lengthy process that starts with a member country or an observer (such as Airports Council International or International Federation of Airlines Pilot Association) requesting the Working Group Chair to allow the topic be added to a meeting agenda. Along with the request is the submittal of a discussion paper to the Working Group and a presentation of supportive evidence. Although it is not an ICAO requirement, the submitter may include a benefit/cost analysis as part of its proposal.

If the majority of the Working Group feels the Discussion Paper [proposal] has merit, then the Working Group will either accept the presented arguments or may ask for more supportive evidence to determine a new or revised Standard or Recommended Practice. Once the Working Group has considered the change and agreed to it, the chair will submit the proposal to the Aerodrome Panel, which directs the various Working Groups. If the Aerodrome Panel accepts it, then the item will go up the chain of command within ICAO for further discussion and approval or disapproval.

Once the ICAO approves the change, the item is sent to all the various member countries who will then be asked to vote on the measure. If a majority of countries vote to adopt the Standard or Recommended Practice or change to the SARP, then the change is made and given an effective date. This process can take up to 2 or 3 years.

In setting standards and recommendations that apply to airports throughout the world, ICAO recognizes that all countries or all airports within a country may not be able to comply with those standards and recommendations. The reasons for non-compliance vary but often are related to the economic feasibility of the standard including the cost to implement and the expected benefit to be received. For this reason, countries may adopt or not adopt ICAO standards and recommendations. If a country does not adopt a



standard, it is required to file a “difference” with ICAO explaining what part of the Annex 14 standards that it does not comply with.

The United States is a signatory country and an active member of the ICAO. Many of the SARPS published by the ICAO are reflected in the Advisory Circulars. Where the SARPS have not been adopted, the U. S. has filed the appropriate “difference.”

### **National Fire Protection Administration (NFPA)**

The mission of the international, nonprofit NFPA, established in 1896, is to reduce the worldwide burden of fire and other hazards on the quality of life by providing and advocating consensus codes and standards, research, training, and education. The NFPA develops, publishes and disseminates more than 300 consensus codes and standards intended to minimize the possibility and effects of fire and other risks. These codes are developed by technical committees and are adopted and enforced throughout the world.

NFPA standards are written for airports of all sizes and types of operations, e.g., air carrier passenger service, air cargo, and general aviation operations. NFPA standards apply to airport operators if the state where the airport is located or the airport operator has adopted those standards. NFPA 403, Standard for Aircraft Rescue and Fire-Fighting Services at Airports (2009 Edition), is the principal standard governing ARFF, although there are a number of other NFPA standards that affect airports and airport operations (25).

The following information with more detail can be found in the NFPA Brochure entitled “Codes and Standards, An introduction to the NFPA Codes and Standards Development Process.” The process for introducing or changing the NFPA codes and standards starts with a Call for Proposals. This Call for Proposals is a public notice asking for any interested party to submit specific written proposals on an existing document or a committee-approved new draft document. The responsible Technical Committee or Panel holds a meeting to consider and act on all the submitted Proposals. The committee or panel may also develop its own Proposals. A document known as the Report on Proposals (ROP), is prepared containing all the Public Proposals.

Once the ROP becomes available, there is a 60-day comment period during which anyone may submit a Public Comment on the proposed changes documented in the ROP. The committee or panel reconvenes at the end of the comment period and acts on all public Comments. Approval obtained via written ballot in accordance with NFPA’s Regulations is required on all committee and panel actions. All of this information is compiled into a second Report, called the Report on Comments (ROC), which, like the ROP, is published and made available for public review for a seven-week period.

Following the completion of the Proposal and Comment periods, there is yet a further opportunity for debate and discussion through the Association Technical Meeting that takes place at the NFPA Conference & Expo each June. The Association Technical Meeting provides an opportunity for the NFPA membership to amend the Technical Committee Reports (i.e., the ROP and ROC) on each proposed new or revised document.

The NFPA Standards Council, as the overseer of the NFPA codes and standards development process, acts as the official issuer of all NFPA codes and standards. The

Council, if appropriate, issues the Document as an official NFPA code or standard. Subject only to limited review by the NFPA Board of Directors, the Decision of the Standards Council is final, and the new NFPA code or standard becomes effective twenty days after Standards Council issuance.

NFPA does not have a requirement that a benefit/cost analysis be performed for any of its standards. The performance of such an analysis is left to the discretion of the jurisdiction or authority that decides to adopt the NFPA standard.

*For a more complete explanation of the roles of these organizations, please refer to the ACRP Web-Only Document 7: How Proposed ARFF Standards Would Impact Airports, submitted June 2009.*

## CLASSIFICATION OF AIRPORTS

### FAA

Currently, there are four classifications of air carrier airports under 14 CFR Part 139. Table 1 shows how these apply to passenger service in terms of aircraft seating capacity for scheduled and non-scheduled operations and the number of airports in each class. Effectively, a Class I airport can serve all sizes of aircraft (e.g., a Beech 1900 to a Boeing 747) while a Class III airport can have scheduled and unscheduled passenger services with aircraft of 30 seats or less.

**Table 1. Part 139 Airport Classification by Seating Capacity and Service Type**

Airport Class	Scheduled Passenger Operations	Non-Scheduled Passenger Operations	Number of Airports*
I	10 or more	31 or more	381
II	10 or more but less than 31	31 or more	50
III	10 or more but less than 31	30 or less	35
IV	N/A	31 or more	89

\*As of 9/02/2010

Due to the various sizes of aircraft serving Class I airports, they are further divided into five categories (each category is labeled as an index) for purposes of ARFF. The length of the longest scheduled aircraft serving the airport with more than five scheduled departures a day determines the Index:

1. Index A airports serve air carrier aircraft less than 90 feet in length
2. Index B airports serve air carrier aircraft at least 90 feet in length but less than 126 feet
3. Index C airports serve air carrier aircraft at least 126 feet in length but less than 159 feet
4. Index D airports serve air carrier aircraft at least 159 feet in length but less than 200 feet
5. Index E airports serve air carrier aircraft at least 200 feet in length

Class II, III, and IV airports must meet the Index A requirements, at a minimum. However, Class III airports may substitute an alternate procedure using a fire fighting

response from the local community. This procedure is outlined in 139.315(e). In contrast to ICAO and NFPA, the FAA requirements for determining the ARFF Index do not take into account the width of the aircraft serving the airport.

### ICAO and NFPA

The ICAO and the NFPA airport classifications are somewhat different than the FAA classifications. ICAO and NFPA use a classification based from Category 1 through Category 10. The first 3 categories describe smaller airports that do not have air carrier commercial service based on the FAA equivalent. The FAA Index A is equivalent to the ICAO and the NFPA Category 4 airport. The ICAO and NFPA standards consider both aircraft length and width to determine the airport's category (equivalent to an FAA Index). Table 2 compares the manner in which all three standards categorize airports using differences in aircraft size.

**Table 2. FAA ARFF Index Comparison to ICAO and NFPA**

FAA Airport Index	Aircraft Length (ft.)	ICAO Airport Cat.	Aircraft Length (ft.) up to but not including	Width up to but not including	NFPA Airport Cat.	Aircraft Length up to but not including	Width up to but not including	Sample Aircraft
A	<90'	4	78' 24m	13.1' 4m	4	78'	13.0'	EMB120
A	<90'	5	91' 28m	13.1' 4m	5	90'	13.0'	CRJ-200; Saab 340
B	90' <126'	6	127' 39m	16.4' 5m	6	126'	16.4'	DC-9, A320
C	126' <159'	7	160' 61m	16.4' 5m	7	160'	16.4'	B757-200; B767- 200ER
D	159' <200'	8	200' 61m	22.9' 7m	8	200'	23.0'	A300; B757-300
E	>200'	9	249' 76m	22.9' 7m	9	250'	23.0'	A340-600; B777
E	>200'	10	295' 90m	26.2' 8m	10	295'	25.0'	AN-225, A380

### NUMBER OF VEHICLES

#### FAA, ICAO, and NFPA

Section 139.317 addresses, among other things, the number of vehicles required by each airport index/category. FAA allows some flexibility in the number of vehicles for Index B and C airports as can be seen in Table 3. While FAA and ICAO call for three vehicles for Index E airports (NFPA/ICAO categories 9 and 10), NFPA's standard requires four vehicles. However, the actual number of vehicles may be affected by the response time standards, since meeting response times can require more than one ARFF station.

**Table 3. Minimum Number of ARFF Vehicles Required**

ICAO/NFPA Airport Category	FAA Airport Index	Vehicles			Example Aircraft
		ICAO	FAA	NFPA	
4	A	1	1	1	DHC-8-100
5	A	1	1	2	ATR-72
6	B	2	1 - 2	2	B-737-300; Emb-145
7	C	2	2 - 3	3	B-757
8	D	3	3	3	A300; B-767-300
9	E	3	3	4	B-747-200; A340-400
10	E	3		4	AN-225; A380

## QUANTITY OF AGENT

### FAA/ICAO/NFPA

ICAO first considered standards for the quantity of fire extinguishing agent in 1972. The standards include the concept of theoretical critical area (TCA) and practical critical area (PCA). (These are the physical areas in which fire fighting is expected to take place.)

The PCA is two-thirds the size of the TCA. A discussion of the TCA and the PCA as well as the mathematical formulas for the TCA and the PCA can be found in NFPA 403, Annex B. The FAA Advisory Circular 150/5210-6D, Aircraft Fire and Rescue Facilities and Extinguishing Agents, in Chapter 1, also discusses the concepts of control time and extinguishment time. The amounts of extinguishing agents to control and to extinguish a fire are determined separately. The quantities are named and defined as follows.

*Quantity Q1*—The quantity of water required to obtain a one-minute control time in the PCA. (Advisory Circular 150/5210-6, Aircraft Fire extinguishing Agents, defines the control time as the time required from the arrival of the first fire fighting vehicle and the beginning of agent discharge to reduce the initial intensity of the fire by 90 percent. The equipment and techniques to be used should be capable of controlling the fire in the PCA in 1 minute.) The formula for the water required for control (Q1) in the PCA can be found in NFPA 403, Annex B.

*Quantity Q2*—The quantity of water required for continued control of the fire after the first minute or for complete extinguishment of the fire or both. The amount of water required for Q2 cannot be calculated exactly, as it depends on a number of variables, consisting of the following:

- 1) **Aircraft Size**—Aircraft size reflects the potential level of risk. This risk factor is a composite of the occupant load, the potential internal fire load, flammable liquid fuel capacity and fuselage length and width. Careful consideration of all these factors allows the identification of a meaningful operational objective, that is, the area to be rendered fire free (controlled or extinguished).
- 2) **Relative Effectiveness of Agent Selected**—This is accounted for by the specific application rate identified for the common generic foam concentrate types.

- 3) Time Required to Achieve PCA Fire Control—Information from reliable large-scale fire tests, empirical data from a wide variety of sources, and field experience worldwide indicates that 1 minute is both a reasonable and a necessary operational objective.
- 4) Time Required to Maintain the Controlled Area Fire-Free or to Extinguish the Fire—An operational objective that provides a safety factor for the initial fire attack on the PCA while waiting for the arrival of backup support or to complete extinguishment of remaining fires outside the PCA.

*Quantity Q3*—The quantity of water required for fire-fighting operations in the aircraft interior. This quantity of water, called Q3, is based on the need for hand lines to be used for interior fire fighting. The actual amount of water comprising Q3 is found in Table B.5.3 of NFPA 403 for the various NFPA categories. The amount ranges from 600 gallons for Category 4 to 5,000 gallons for Category 10, and was adopted by NFPA but was not by the FAA or ICAO. NFPA adopted the Q3 water quantity in 1993 since it believed that there was an insufficient amount of water to launch interior attacks once the external fire had been contained.

Table 4 shows the amount of water required by the FAA, ICAO and NFPA for airport index/category. It is the total amount of water required (or the sum of Q1, Q2 and Q3) to properly mix with the foam concentrate carried on the trucks.

**Table 4. Water/Quantity Comparison**

ICAO/NFPA Airport Category	FAA Airport Category	Water (U.S. Gallons), Q1+Q2			Example Aircraft
		FAA	ICAO	NFPA*	
4	A	100	634	730	DHC-8-100
5	A	100	1,427	1,510	ATR-72
6	B	1,500	2,087	2,490	B737; Emb-145
7	C	3,000	3,197	3,630	B757
8	D	4,000	4,808	5,280	A300; B767-300
9	E	6,000	6,419	7,070	B747-200; A340-400
10	E	6,000	8,533	9,264	AN225, A380

\*In addition to Q1 and Q2, NFPA requires an additional quantity of water, Q3, which ranges from 600 gallons for Category 4 to 5000 gallons for Category 10.

## AIRCRAFT RESCUE AND FIRE FIGHTING STAFFING

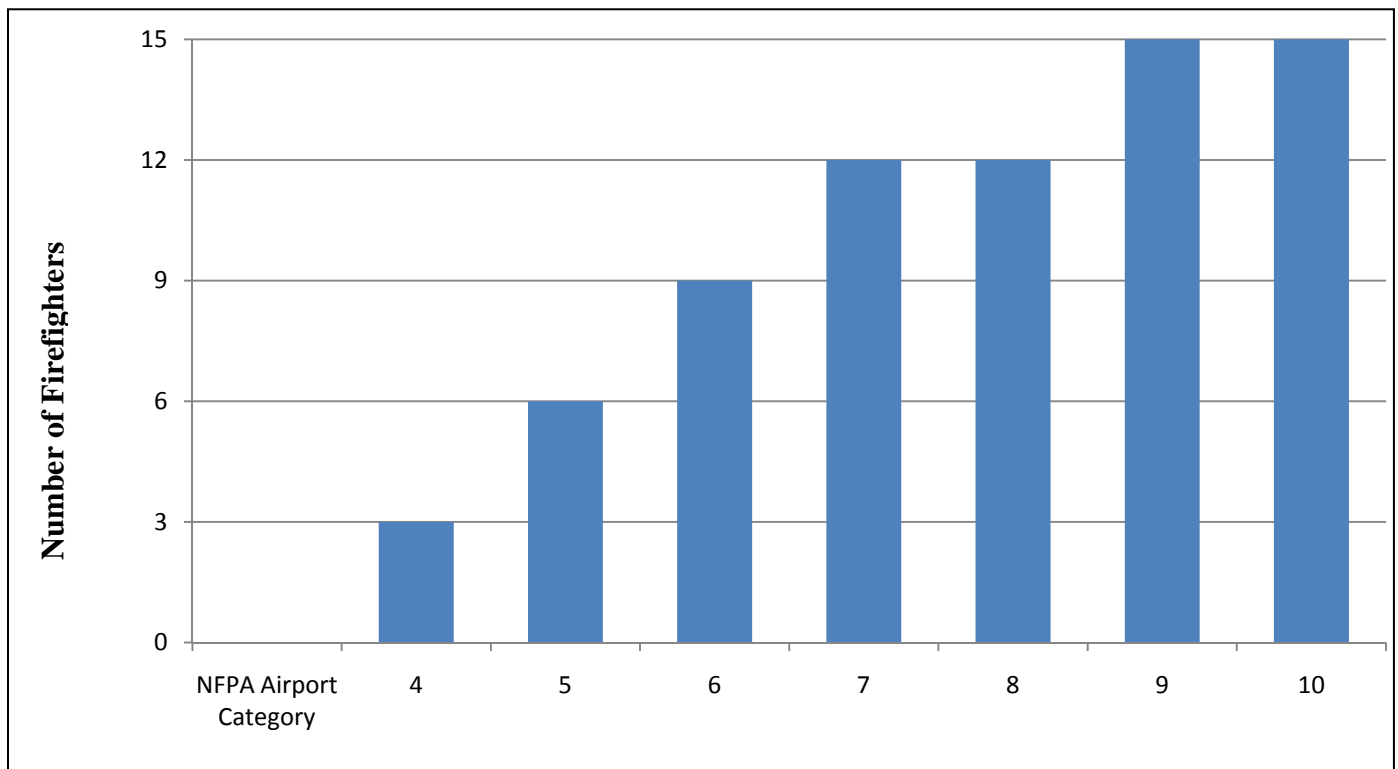
### FAA and ICAO

FAA and ICAO standards do not require a specific minimum number of firefighters. Instead those standards require that a “sufficient number” of trained personnel be present to operate vehicles, meet response time standards, and meet the agent discharge rates specified in the standards.

## NFPA

NFPA, on the other hand, does publish a minimum staffing requirement based on the category of airport. Annex D to NFPA 403 contains an explanation of how NFPA developed its staffing figures. Basically, it is based on a Task and Resource Analysis Model that was used to determine the minimum number of qualified personnel required to deal with an aircraft accident or incident. Figure 1 shows the staffing required by the NPFA.

**Figure 1. NFPA 403 Minimum Number of Firefighters per Shift**



## RESPONSE TIMES

Response time standards are important in determining the numbers and locations of fire stations required at an airport and therefore the required numbers of ARFF vehicles and staffing. Although there are variations in response times and areas among the three organizations, all three organizations provide that the demonstration of compliance be done in optimum conditions, i.e., daylight, dry pavement, etc.

## FAA

Section 139.319 (h) requires an airport operator to demonstrate that its aircraft rescue and fire fighting vehicles can respond to the midpoint of the farthest air carrier runway in three minutes for the first vehicle and four minutes for all other required vehicles. When Part 139 was originally adopted in 1972, the 3-minute response was considered a reasonable time due to the rollover potential. The ARFF vehicles of that era had a high center of gravity and slow acceleration speeds.

**ICAO**

ICAO has a response time standard, which requires airports to demonstrate that the first ARFF vehicle can reach any point on a runway within three minutes.

**NFPA**

NFPA requires the first vehicle to reach any point on the operational runway in two minutes or less (NFPA 403, Paragraph 9.1.3 [2009 Edition]). Other ARFF vehicles shall arrive at intervals not exceeding 30 seconds. NFPA 402, Guide for Aircraft Rescue and Fire Fighting Operations (26), and NFPA 403, Standards for Aircraft Rescue and Fire Fighting Services at Airports, can trace the inclusion of a response time back to 1968. At that time, the NFPA documents included a response time of 3 minutes. This is probably the basis for the FAA's adoption of the Part 139 response time. In 1975, the response time was changed in NFPA 403 to be a response time not exceeding 3 minutes but preferably 2 minutes. In 1988 NFPA changed the response time in its standards to 2 minutes or less to any point on the operational runway and 2 ½ minutes to any point remaining within the on-airport portion of the rapid response area (NFPA 403, Paragraph 9.1.3).

The Rapid Response Area is defined in NFPA 403 as a rectangle that includes the runway and the surrounding area extending to but not beyond the airport property line. Its width extends 500 feet outward from each side of the runway centerline and its maximum length is 1650 feet beyond each runway end. The NFPA also includes another area, called the Critical Rescue and Fire Fighting Access Area (CRFFAA) that is a rectangular area surrounding any runway within which most aircraft accidents can be expected to occur on airports. Its width extends 500 feet from each side of the runway centerline and its length is 3300 feet beyond each runway end. In NFPA 403, Annex A, Explanatory Material, states that approximately 85 percent of the (aircraft) accidents as historically recorded in the CRFFAA occurred within the boundary of the Rapid Response Area. No other information supporting this statement is included in Annex A.

**TRAINING****FAA**

Section 139.319 specifies the initial and recurrent training required for certificated airport fire fighting personnel. The requirements enumerated in paragraph 139.319(i) specify the training curriculum should include initial and recurrent training in the following areas:

- a. Airport familiarization
- b. Aircraft familiarization
- c. Rescue and fire fighting personnel safety
- d. Emergency communications systems
- e. Use of fire hoses, nozzles, turrets, and other appliances
- f. Application of the types of extinguishing agents
- g. Emergency aircraft evacuation assistance
- h. Fire fighting operations
- i. Adaption and use of structural rescue and fire fighting equipment for aircraft rescue and fire fighting
- j. Dangerous goods
- k. Familiarization with fire fighters' duties under the airport emergency plan

**ICAO**

ICAO Annex 14, Paragraph 9.2.34 specifies that all rescue and fire fighting personnel shall be properly trained to perform their duties in an efficient manner and shall participate in live fire drills commensurate with the types of aircraft and type of rescue and fire fighting equipment in use at the aerodrome. In the ICAO Airport Services Manual, Part I, Rescue and Fire Fighting, ICAO devotes a chapter (Chapter 14) to training (27). Chapter 14 specifies a training curriculum that is the same as for Part 139 above.

**NFPA**

The training required by NFPA can be found in NFPA 1003, Standards for Airport Fire Fighters Professional Qualifications, and in NFPA 405, Standard for the Recurring Proficiency of Airport Fire Fighters. Both of these documents parallel the FAA requirements except they are in greater detail.

**ARFF MISSION AND RESPONSE STRATEGIES****FAA**

The FAA's concept has been based on the need for controlling and extinguishing any fire that may be endangering the lives of the passengers and crew by securing an escape path(s) from the aircraft. Since the airport owner is usually the jurisdiction in which the airport is located, there is a responsibility for the downtown fire departments to respond to the airport as they would whenever there was a fire or accident anywhere within that jurisdiction. At those airports not within the same jurisdiction, then the airport operator normally enters into mutual aid agreements with the jurisdiction(s) in which the airport is physically located. In theory, by the time the fire is brought under control, the additional fire assistance will have arrived and would be implementing the airport's emergency plan.

At some airports, response from outside agencies is dependent upon a call from the airport operator. At other airports, the response is automatic and initiated when the Air Traffic Controller notifies the ARFF department. This is normally the case when the airport fire department is associated with the downtown fire department.

**ICAO**

ICAO states in its Airport Services Manual, Part I, Rescue and Fire Fighting, that the principal objective of a rescue and fire fighting service is to save lives in the event of an aircraft accident or incident (Paragraph 1.1.1). The Manual goes on to say that the provisions of adequate and special means of dealing promptly with an aircraft accident or incident occurring at, or in the immediate vicinity of, an airport assumes primary importance because it is within this area that there are the greatest opportunities of saving lives.

**NFPA**

NFPA 403 states in 1.2 Purpose, paragraph 1.2.2, "that the principal objective of a rescue and fire-fighting service is to save lives. For this reason, the preparation for dealing with an aircraft accident or incident occurring at, or in the immediate vicinity of, an airport is of primary importance because it is within this location that the greatest opportunity to save lives exists. The possibility of, and need for, extinguishing a fire that



can occur either immediately following an aircraft accident or incident, or at any time during rescue operations, must be assumed at all times.”

NFPA response strategy is designed to have a sufficient number of aircraft rescue and fire fighting personnel on duty that would respond to the fire and could commence not only fire suppression but also aid in rescue operations. Based on an OSHA regulation, there is a requirement known as the “2-in/2-out” rule. This rule says that for a fire in a confined space a team of 2 fire fighters may enter the confined space but must have a safety team on the outside in case of an emergency involving the 2-man entry team. Based on interpretation from OSHA, an aircraft is considered to be a confined space and therefore the rule would be applicable.

In the preamble to the 14 CFR Part 139 final rule that was published in the Federal Register on February 19, 2004 (FR Vol. 69, No.27, Feb. 10, 2004, page 6403), there was a discussion on OSHA’s “2-in/2-out” rule. In a legal memorandum developed jointly by the FAA and OSHA (dated July 7, 1999) it was determined that the respiratory standard is applicable only to personnel fighting a fire within a structure and not an outside aircraft fire. As the primary purpose of ARFF personnel is to suppress the external aircraft fire and to establish an escape route for the aircraft crew and passengers, the “2-in/2-out” rule does not apply to ARFF.

## CHAPTER 4

### IDENTIFICATION AND REVIEW OF “ACCIDENTS OF INTEREST”

Air carrier passenger aircraft accidents were reviewed to determine whether or not if different ARFF standards were in effect at the time of the accident there would have been a different outcome in terms of a reduced number of fatalities and/or serious injuries. Specifically the research scope was directed towards looking at what the differences in fatalities and serious injuries may have been if standards set forth by the International Civil Aviation Organization or the National Fire Protection Association would have been in effect, in lieu of the standards set forth by the Federal Aviation Administration (FAA).

In reading the remainder of this report, it is important that the reader keep this study scope in mind. If an aircraft accident did not involve fatalities or serious injuries, it was not of interest to this study. Consequently, there are accidents where an aircraft may have been substantially damaged during the crash sequence or, perhaps, even destroyed by fire. If all the “souls on board” these aircraft were able to evacuate the aircraft without sustaining any serious injuries, the accident was not included in this research effort. The “accident of interest” criteria that are discussed later in this chapter identify other filters that were used to screen accidents and the basis for each of these filters.

This effort is being undertaken as legislation is being considered by the U. S. Congress that would require the FAA to adopt consensus ARFF standards for its airport certification program that is set forth in 14 CFR Part 139. If the proposed legislation is passed, it would affect ARFF standards but would not change the airports that are required to have ARFF coverage or the types of aircraft operations for which ARFF services are required to be provided. Consequently, this research study did not include air carrier passenger aircraft accidents if the aircraft had less than 10 passenger seats. It also did not look at accidents involving “all cargo” aircraft.

It should be noted that it is not the purpose of this research to recommend whether or not the proposed regulation should be enacted. Rather, it provides technical information and analysis that can be used by others, in conjunction with information from other sources, in formulating policies, regulations, and procedures related to this issue.

#### **Definition of Accident, Fatality, and Serious Injury**

The definition of accident that is contained in 49 CFR Part 830, which governs aircraft accident and incident reporting and investigation in the United States, was used in this research effort. This definition of aircraft accident is:

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, and in which any person suffers death or serious injury, or in which the aircraft receives substantial damage.

Since this research study is looking at the reduction of fatalities and serious injuries, it is important to understand the meanings of these two terms as used in the preceding definition.

*Fatal injury* means any injury which results in death within 30 days of the

accident.

*Serious injury* means any injury which: (1) Requires hospitalization for more than 48 hours, commencing within 7 days from the date the injury was received; (2) results in a fracture of any bone (except simple fractures of fingers, toes, or nose); (3) causes severe hemorrhages, nerve, muscle, or tendon damage; (4) involves any internal organ; or (5) involves second- or third-degree burns, or any burns affecting more than 5 percent of the body surface.

Although these are U.S. definitions, similar definitions are used in ICAO's Annex 13 and are used by agencies throughout the world that are involved in accident investigation. Consequently, the number of fatalities and serious injuries reported in an accident investigation should be consistent regardless of where the accident took place or what agency was in charge of the investigation.

#### **“Accident of Interest” Criteria**

Using the preceding background, the following criteria were used to identify the accidents that would be analyzed as part of this study. To be considered, the accident had to meet all of the following criteria. The reasoning underlying each of the criteria is set forth after each criterion. The accident must have:

1. Involved an air carrier airplane providing scheduled passenger service with more than nine seats or unscheduled air carrier passenger service with more than 30 seats.

Reasoning: The aircraft type, passenger service and seating requirements are based upon the legal authorization that the FAA uses to require airports to obtain airport operating certificates and provide the ARFF service associated with those certificates. At this time there is no indication that ARFF proposals that are under consideration by Congress would change the aircraft type, passenger service and/or seating requirements.

2. Involved a crew member/passenger fatality or serious injury.

Reasoning: Objective of this research effort is to see if there may have been reduced fatalities and/or serious injuries if different ARFF requirements had been in effect at the time of the accident. ARFF standards are set by FAA, ICAO, and NFPA based upon aircraft size which is the de facto measure of number of people on the aircraft. Fatalities or serious injuries to people located outside the aircraft such as ground handlers or people living in the vicinity of the airport were not considered since they are not considered in establishing the ARFF standards by FAA, ICAO, or NFPA. However, if the accident involved a collision of two aircraft, fatalities and serious injuries to the crew and passengers on both aircraft were considered as long as one of the aircraft met the first criterion.

3. Occurred on (or the crash sequence started on) airport property or, if adjacent to the airport within 2000 feet (600 meters) of the runway end and 500 feet (150 meters) on either side of the extended runway centerline.

Reasoning: This area not only encompasses all the response areas identified by FAA, ICAO, and NFPA standards but goes beyond them to include any accident

falling just beyond the response areas identified in those standards. Accidents that start on the airport but may end up outside the airport or the areas specified in this criteria were included in the review. For example, an aircraft overrun or veer-off that starts on the runway but where the aircraft ends up outside the area specified within the identified criterion's boundaries is still included in this effort since the accident sequence started on the airport.

4. Occurred from January 1, 1989, to present.

Reasoning: This will provide an approximately 20-year sample.

5. Have an accident report/record available in English.

Reasoning: The funds provided in the study were inadequate to retain translation services. Since English is the international language of aviation, many reports are translated into English. These reports usually have a disclaimer up front saying that if there are any discrepancies between the report in English and the one in the native language that the report in the native language governs.

### **Accident Records Search**

The NTSB's accident data base was reviewed to identify accidents that occurred in the United States that would be of interest to this study. One of the keys to this research effort was to obtain enough data points to use as input in the risk analysis. For this reason, the search for accidents of interest was expanded to include accidents that occurred in foreign countries. Thanks to the international treaties that govern aviation, the types of data that are recorded for accidents worldwide are basically the same and when reports are written they are normally in the format specified in ICAO's Annex 13.

An Internet search was conducted of government websites containing aircraft accident investigation records for accidents that met the preceding criteria. While some countries like the United States and United Kingdom have posted information on aircraft accidents going back several decades many other countries have posted 10 years or less of data. Some countries like France and Sweden provide English translations for only some of the accidents which occurred within their jurisdiction while others only provide accident reports in their national language.

Overall, foreign countries have very few accidents when compared to the United States. The difference in these numbers can be attributed to the difference in the number of aircraft operations. The number of aircraft operations in the United States far exceeds the volume of operations in any other country.

An Internet search was also conducted of the aviation accident data bases/reports from several countries to identify accidents that met the criteria for this study. The ability to establish filters to sort events listed in a country's data base varied from country to country and for most countries was extremely limited. Many of the data bases included both accidents and incidents. The entries for more than 3,000 events were reviewed to identify the ones that met the criteria established for this study. The review of the online accident data bases/reports for several countries revealed that they did not contain any accidents that met the established criteria.

The results from the preceding Internet search were crosschecked with accidents that were included in the Flight Safety Foundation (FSF) report entitled *Reducing the Risk of on Runway Excursions* and the Airport Cooperative Research Program project 04-08, *Improved Models for Risk Assessments of Runway Safety Areas*. Many of the accidents included in the FSF and ACRP studies did not meet the criteria for inclusion in the study. For example, the accident may not have resulted in any fatalities or serious injuries or there may have been fatalities to the flight crew but the flight was an all-cargo operation rather than an air carrier passenger flight. This crosscheck identified additional accidents of interest--however in many cases there was not enough information to include the accident in the current study effort. The information on many of the international accidents in the FSF report was just an initial notification with few details provided beyond type of aircraft and number of fatalities. Information on the ARFF response, in most cases, was very limited or non-existent. However, we were able to identify some additional accidents with sufficient information for review that were not included in the initial Internet search.

The results were also crosschecked with a listing of accidents and incidents involving commercial aircraft that was available on Wikipedia. In two cases, Wikipedia provided a link to the English translation of the accident report for an international accident that was not posted on the country's website or captured in the previous Internet searches.

## GENERAL DESCRIPTION AND CHARACTERISTICS OF "ACCIDENTS OF INTEREST"

The preceding search effort identified 81 accidents that occurred in 17 countries that met the established criteria. Table 5 provides information on the number of people aboard the aircraft involved in these accidents and the number of fatalities and serious injuries. A breakout is also provided between accidents that occurred at U.S. airports and non-U.S. airports. The 81 accidents included eight that involved a collision between two aircraft. For the collision accidents, Souls on Board (SOB's) is considered to be the sum of the total number of people on each aircraft.

**Table 5. Accidents of Interest (1989-2008)**

	Number of Accidents	Souls on Board	Number of Fatalities	Number of Serious Injuries
U.S. Airports	51	6881	316	214
Non-U.S. Airports	30	5383	831	352
Total	81	12264	1147	566

Appendix A provides details on each of these accidents. The accidents are listed in chronological order in the appendix. Throughout the remainder of this report references to a particular accident are made by providing the date of the accident and location identifier for the airport where it occurred.

### Types of Accidents

As one would expect the 81 accidents in this study included undershoots, overshoots, veer-offs, and accidents involving aircraft that stopped on the runway during landing or takeoff. In addition there were accidents resulting from runway collisions and accidents

that occurred during apron and taxiing operations. Finally there were 11 accidents that were categorized as “Other.” Each of these accident types is discussed further in this section.

Table 6 provides a breakout for 44 accidents that occurred during landing or take off. The last column of the table shows accidents where an aircraft in either the landing or takeoff phase of operation stopped on a runway or exit taxiway when the captain believed there was something amiss with the operation. This column also includes accidents where the captain decided to reject the takeoff and brought the aircraft to a stop on the runway or exit taxiway.

**Table 6. Number of Accidents by Accident Type (1989-2008)**

Phase of Operation	Undershoot	Veer-off	Overrun	Remained on R/w or T/w
Landing	2	8	8	13
Takeoff	-	3	6	4
Total	2	11	14	17

Some of the accidents involved the captain declaring an in-flight emergency. Of the 81 accidents, the ARFF units were pre-deployed prior to aircraft touching down in 11 of them. (They were not pre-deployed in 59 of the accidents. The pre-deployment status could not be determined for 11 of the accidents.)

In addition to the 44 accidents shown in the table there were seven runway collisions and 11 accidents that were labeled as “Other.” These “Other” accidents included situations where the aircraft stalled during landing or takeoff and proceeded to crash on the airport. “Other” events also occurred when the flight crew was unable to control the aircraft due to mechanical problems resulting in a crash occurring on airport property.

There were nine accidents that occurred on the apron and 10 that occurred on taxiways during taxiing. One of the accidents that occurred on the apron involved a collision between two aircraft.

To the extent information was available, the location of each accident for all the accidents except “taxiway” and “apron” accidents is graphically depicted relative to a generic runway in Appendix B.

### **Accidents Involving Fire**

Only 35 of the 81 accidents involved an actual fire. For the remaining 46 accidents, there were several accidents where the flight crew suspected there was a fire on board the aircraft. These included such things as faulty fire sensors in the engines or cargo compartments and reports of fire from parties outside the aircraft. During the accident investigation, it was found that there was never an actual fire in these instances.

### **Accidents Where All Fatalities and Serious Injuries Occurred during the Evacuation**

There were 38 accidents where all the fatalities and serious injuries occurred during the evacuation of the aircraft. This represents 47% of the 81 “accidents of interest” in this study.

There was only one accident that involved a fatality resulting from the evacuation of the aircraft (11/20/2000-KMIA). This accident is somewhat of an anomaly since the fatality involved a flight attendant who was ejected from the aircraft onto the apron when he opened a door to start the evacuation while the aircraft was still pressurized. However, there were three serious injuries that also occurred during the evacuation of that aircraft.

The serious injuries that were sustained in the 10 accidents that occurred on taxiways during the taxi phase of operation and all except one of the nine accidents that occurred on the apron resulted from evacuation of the aircraft. Table 7 provides a comparison of these “evacuation” injury accidents to all the accidents.

**Table 7. Comparison of Evacuation Injury Accidents to All Accidents (1989-2008)**

	Number of Accidents	Accidents with All Serious Injuries Due Only to Evacuations			Percent of Evacuation-related Accidents to Number of Accidents
		Number of Accidents	Souls On Board	Serious Injuries	
U.S. Accidents	51	29	3102	33	57
Non-U.S. Accidents	30	9	2435	32	30
Total Accidents	81	38	5537	65	47

These accidents included such things as people fracturing limbs from falling off the slides or breaking legs or ankles from jumping off wings. In the case of the accidents that had suspected but not actual fires, many of the aircraft did not meet the “substantial damage” criteria in the definition of aircraft accident. The event was classified as an accident due to the serious injury that occurred during the evacuation.

Events involving evacuations of the aircraft merit some additional discussion. Generally, the decision on whether or not to evacuate an air carrier aircraft is made by the captain. This normally involves the flight deck crew notifying the cabin crew and then proceeding with the actions listed on an emergency evacuation checklist such as shutting down the engines. However, most airlines allow the flight attendants to initiate the evacuation based on the immediate circumstances of the moment that they may be privy to. In the review of accidents there were some events where the passengers saw or heard something that they deem to be unsafe and self-initiated the evacuation. This usually catches the flight and cabin crews by surprise.

Any aircraft evacuation, regardless of who initiates it, can result in serious injuries. It is important to note that in many of the 38 accidents in this study only one or two people were seriously injured on an aircraft that may have had more than 100 souls on board. These injuries are normally not life-threatening—they often involve fractures such as a broken wrist, ankle, or leg. To keep things in the proper perspective, it should be noted

that there were also several other accidents (far more than 38) involving emergency evacuations that were initially reviewed but not included in this study effort since the accident did not involve any serious injuries.

### Extrication of Occupants

There were nine accidents where ARFF entered the aircraft and extricated people who were trapped in the aircraft or needed assistance to exit. Six of these accidents occurred at U.S. airports. (See Table 8 below.)

**Table 8. Accidents Where Occupants Needed to be Extricated from Aircraft by ARFF (1989-2008)**

Accident Date	Airport LOC ID	Fire	Description
7/19/89	KSUX	Yes*	Extricated flight crew that was trapped in deformed cockpit.
9/27/89	KGCN	Yes*	Extricated several passengers that were trapped in deformed fuselage.
2/1/91	KLAX	Yes	Rescued first officer from cockpit as flames approached.
7/2/94	KCLT	Yes*	Rescued several passengers from three rows of seats after extinguishing fire.
12/16/97	CYCF	No	Extricated seven passengers from deformed fuselage.
6/1/99	KLIT	Yes	Extricated first officer from the cockpit and assisted some passengers from first class in exiting aircraft.
8/22/99	HKG	Yes	Assisted passengers in evacuating the cabin.
7/9/06	IRK	Yes	Rescued 11 passengers from the cabin.
8/27/06	KLEX	Yes	Extricated first officer from the cockpit.

\* Fire was either not present in area of rescue or had been extinguished prior to rescue.

### Collision Accidents

The 81 accidents included 8 where two aircraft were involved in a collision. One of these occurred on an apron when the captain of a DC-9 that lost hydraulics taxied into the wing of an A-319 (5/10/05, KMSP). The captain of the DC-9 suffered serious injuries.

The remaining seven collisions all occurred on the runway with at least one of the aircraft being on takeoff roll or landing rollout. All seven accidents resulted in fatalities. Table 9 provides a summary of the numbers.



**Table 9. Accidents Involving Runway Collisions (1989-2008)**

Accident Date	Airport LOC ID	Aircraft Involved	Souls on Board*	Fatalities*	Serious Injuries*
1/18/90	KATL	Boeing 727 Beech King Air	159	1	1
12/3/90	KDTW	Boeing 727 DC-9	198	8	10
2/1/91	KLAX	Boeing 737 Fairchild Metroliner	101	34	13
11/22/94	KSTL	MD-82 Cessna 441	142	2	0
11/19/96	KUIN	Beech 1900 Beech A90	14	14	0
5/25/00	CDG	MD-83 Shorts 330	159	1	1
10/08/01	LIN	Boeing MD-87 Cessna 525A	114	114	0

\* Sum from both aircraft

### Response Times

As stated in Chapter 3, the FAA, ICAO, and NFPA all have standards that require a demonstration that an ARFF vehicle can reach a designated point on the airport in a designated time frame. Under the three organizations' standards these demonstrations are all done in ideal conditions, e.g., daylight, good visibility, and dry pavement. Unfortunately most accidents do not occur in ideal conditions.

As was pointed out in Chapter 2, an FAA Technical Center study looked at the time that elapsed from when the aircraft stops until the firefighters are in a position to fight the fire. For 50 per cent of the occasions firefighters were in place within 4 minutes and for 90 per cent of the occasions they were there within 12 minutes. Although the time period measured in the study differs from the "demonstrated" time period, one can still conclude that actual response times are greater than demonstrated times.

In the 81 accidents in this study, there were 12 accidents where the ARFF response was delayed. There were five accidents where the delay could be attributed to weather conditions, i.e., the ARFF units had trouble locating the aircraft because of the environmental conditions. In the runway collision at Detroit (12/3/90, KDTW) the ARFF knew the runway on which the collision had occurred but because of the low visibility had to drive slowly to the site as they navigated around aircraft that were holding on taxiways. In the Linate (10/08/01, LIN) runway collision, the responding ARFF units initially thought that they were responding to a building fire that was called in by a security guard. It was only when they arrived on site did they find that an aircraft had crashed into the building. Approximately 18 minutes elapsed before an aircraft returning to its parking position revealed that there was another aircraft located on the runway that was also ablaze.

### Communications Posed Similar Challenges

In one accident (9/27/89, KGCN), the accident aircraft cut the electric line that provides power to the airport including the radio communications system. In another accident

(3/9/97, KRN), the air traffic controllers could not contact ARFF because of the firefighters' failure to reset the alarm from an earlier notification.

It is not unusual for the response time to be affected by a combination of communication and weather issues. In the Little Rock accident (6/1/99, KLIT) the controller initially informed the ARFF units that he had an aircraft down on Runway 4R. In limited visibility conditions due to a driving rain storm, the ARFF units proceeded to the approach end of Runway 4R to search for the aircraft. The controller then informed the ARFF units that he had last seen the aircraft rolling out past the mid-point of Runway 4R. When ARFF arrived at the departure end of Runway 4R, they saw where the aircraft was located off the end of the runway but several feet below the runway elevation. The ARFF units had to backtrack to a maintenance roadway that provided access to the accident site.

A similar situation happened in Charlotte (7/2/94, KCLT). The controllers knew the aircraft had crashed but did not know its location. With that knowledge ARFF units began to drive on the airfield in search of the aircraft. When the weather improved, the controllers were able to provide the ARFF units with the location of a large plume of smoke. This occurred about the same time the ARFF units heard over the city radio frequency that there was an aircraft crash in the vicinity of a certain highway intersection.

One of the best examples of the differences between "demonstrated" and "actual" response times is illustrated by an accident that occurred at Denver International Airport (12/20/08, KDEN). During takeoff in the early evening hours, a Boeing 737 veered off the runway and came to rest approximately 100 to 200 yards behind an ARFF (see photo). The controller initially provided the wrong information on the accident location and failed to properly reset the notification system when he attempted to correct the location information. The vehicle from one of the ARFF stations exited the station towards the initially reported location without seeing the accident located right behind the station. By the time the ARFF units received the correct location information and reached the aircraft, it was ablaze. Fortunately, everyone on board had already evacuated. Incidentally, ARFF units from another station on the airport were the first to reach the accident site.



Photo courtesy of Denver International Airport

### **Rapid Response Area**

The Rapid Response Area (RRA) is a much larger area than either the FAA or ICAO have in their standards. For this reason the research team looked at how many accidents were located beyond the runway end that were outside the FAA's runway safety area which generally extends 1000 feet beyond the runway end and 250 feet either side of the extended runway centerline. The maximum RRA extends 1650 feet beyond the runway end and 500 feet either side of the extended runway centerline. The actual RRA for a runway extends from the runway end to the airport property line or 1650 feet, whichever comes first.

In the approach area there was one aircraft that touched down at 1080 feet from the runway threshold, i.e., 80 feet prior to the runway safety area (1/17/08, LHR). However, the aircraft came to rest 100 feet beyond the runway threshold off to the side of the runway.

In the departure area there were two aircraft that went beyond the runway safety area and ended up in the RRA. The one aircraft came to rest 1020 feet beyond the runway end and 100 feet to the right of centerline (7/9/06, IKT). The other aircraft which was involved in a runway collision became airborne and crashed into a building located 1520 feet beyond the runway end and 165 feet to the right of centerline (10/08/01, LIN).

While the runway safety area extends 250 feet each side of the runway centerline abeam the runway, the rapid response area extends to 500 feet on each side of the runway centerline abeam the runway. There were seven accidents that were in the RRA but not in the runway safety area. They are listed in Table 10.

**Table 10. Accidents Abeam the Runway Outside the Runway Safety Area but in the Rapid Response Area (1989-2008)**

Date	Airport ID	Type of Accident	Distance Off Centerline (ft)	Left or Right of Centerline
03/22/1992	KLGA	Other	370 ft	Left
07/30/1992	KJFK	Takeoff-VO	290 ft	Left
04/14/1993	KDFW	Landing-VO	325 ft	Right
04/26/1994	RNGO	Other	400 ft	Right
06/18/98	CYMX	Other	325 ft	Left
08/22/1999	HKG	Landing-VO	325 ft	Right
11/30/2001	ESNS	Landing-VO	400 ft	Left

## CHAPTER 5

### ESTIMATING THE REDUCTIONS IN FATALITIES AND SERIOUS INJURIES

#### ORIGINAL APPROACH

In reviewing the accident records, the ACRP oversight panel specifically directed the research team to look for any information in the reports concerning the following six elements: ARFF staffing, ARFF mission and response strategies, ARFF response times, ARFF response area, ARFF equipment requirements, and ARFF training requirements. The reasoning was that if any of these elements were positively or negatively mentioned in the report, the information would be helpful in comparing the FAA, ICAO, and NFPA standards.

After reviewing the reports (and in some cases the dockets) for the 81 “accidents of interest,” the research team concluded that the necessary data to perform the analysis that was envisioned by the panel are not available. In some accident reports, it was noted that there was an ARFF response to the accident but did not state what ARFF standards that the airport operator used. The following observations are offered on each of the six areas after reviewing the preceding reports:

1. ARFF staffing: The accident reports often stated the number of firefighters that responded to the accident. They sometimes also state the number of mutual aid responders. The reports sometimes even document the typical number of firefighters on a shift. However, only one report recommended that there should be more firefighters in the initial response. However, in the same report it was noted that additional firefighters would probably not have made a difference in the number of fatalities.
2. ARFF mission and response strategies: Often the accident reports stated that everyone or the vast majority of persons on board the aircraft had evacuated the aircraft by the time ARFF arrived on the scene. Chapter 4 provides some details on the nine accidents where ARFF entered the aircraft and extricated people from the aircraft—sometimes fire was involved and sometimes it was not.
3. ARFF response times: The response times set forth in the three standards (FAA, ICAO, and NFPA) are for demonstrations held under optimum conditions. Since accidents rarely occur in optimum conditions, these “standard” times are somewhat theoretical for actual accidents. In responding to an actual accident the practice is to get there as quickly and safely as possible. In many cases the actual response time of at least the initial vehicle is recorded or estimated in the accident report. However, it is not unusual for the various clocks used in deriving time stamps in an accident to be unsynchronized. Chapter 4 identifies some of the issues that have been mentioned in accident reports regarding response times. These include weather (fog, snow, etc.) and communications (vague information on location of accident or, in case of a runway collision, that two aircraft were involved.)
4. ARFF response area: In the standards, a specific area or location is linked to the ARFF response time. i.e., ARFF needs to demonstrate that it can reach a point in

a specified area in a specified time during a demonstration under optimum conditions. In reality, the response area of an airport ARFF unit for an aircraft accident is anywhere on the airport and, in some cases, depending upon mutual aid agreements, may also include areas off the airport. Many of the accidents that were reviewed involved ARFF units responding to accidents on aprons, taxiways, and in safety areas, as well as on runways.

5. ARFF equipment requirements: There were not any accidents where the investigators cited inadequate equipment when an ARFF response was initiated. Sometimes problems that occurred with the equipment during the emergency are mentioned.
6. ARFF training requirements: There has been no mention in any of the reports that the responding firefighters were not adequately trained.

## **ALTERNATIVE APPROACH**

Since the data necessary for the original approach were not available, the research team proposed to review the aspects of each accident as a team and develop a range of reduction for fatalities and serious injuries where it believed that different ARFF standards could have resulted in such reductions. In making its determination, the research team considered carefully what the accident investigating agency said about the survivability of each accident. Although this approach was somewhat subjective, the members of the research team believed that they had the background to make objective reviews and determinations on these accidents. The team's decision to determine a range for the reductions, e.g. 0 to 2 serious injuries provided a means to capture uncertainty introduced by the subjective nature of the determination.

The research team prepared two case studies using accidents that occurred at Little Rock, AR (6/1/99, KLIT), and Quincy, IL (11/19/95, KUIN), to illustrate this alternative approach and the underlying logic. See the two shadow boxes.

While the Little Rock and Quincy accidents were rich with data, it turned out that most of the other accidents were not. This was particularly true for accidents that occurred outside the United States. Some accidents were relatively easy to analyze. For example, many of the fatalities were the result of trauma from impact or where the fire occurred so quickly the accident was considered non-survivable. In those cases, a change in ARFF standards would not have affected the number of fatalities. However, in other accidents, there would be a statement that "all the fatalities were due to impact or were fire related." In those accidents, the research team could not determine if a change in ARFF standards would have made any difference in the accident outcome.

There were two accidents in Indonesia (9/5/05, WIMM and 3/7/07 WARJ) where ARFF at the airports was not in accordance with the applicable ICAO standards. Among the problems noted in these two accidents was an uncoordinated response to the accident with the surrounding communities. The research team concluded that fatalities most likely would have been reduced if the airports were in compliance with the applicable standards.

Little Rock, AR, Accident  
June 1, 1999

A MD-82 aircraft with 6 crew members and 139 passengers crashed on landing after it overran the end of runway 4R during landing at Little Rock, AR. The airplane struck the left edge of the instrument landing system localizer array, passed through a chain link fence and over a rock embankment to a flood plain, located about 15 feet below the runway elevation; and collided with the structure supporting the runway 22L approach lighting system. The captain and 10 passengers were killed; the first officer, the flight attendants, and 105 passengers received serious or minor injuries; and 24 passengers were not injured. The airplane was destroyed by impact forces and a post-crash fire.

The controller called the ARFF units on the crash phone after several attempts to contact the flight crew after the airplane landed. The controller indicated the possibility of an accident at the end of runway 4R but did not specify which end of the runway. The ARFF units proceeded to the approach end of runway 4R, but the airplane was off the departure end. As a result, the ARFF units had to travel back to the taxiway at which they entered the runway and then proceed to the other end of the runway. The ARFF units located the airplane about 11 minutes after the initial call from the controller. However, they did not arrive on scene until 5 minutes later (16 minutes after the initial notification), because they had to travel in the opposite direction to an access road, turn onto a perimeter road back in the direction of the accident site, stop to manually unlock a perimeter security gate, and then continue on the perimeter road to the accident site.

According to the Pulaski County Coroner, the captain and 5 passengers died as a result of traumatic injuries, and 5 died from smoke and soot inhalation and/or thermal injuries.

Because the accident was potentially survivable for the passengers in seats 27E and 28D, the Safety Board considered whether a shorter ARFF response time could have prevented the fatalities but determined that the passengers' lives would not have been saved if emergency responders had arrived on scene earlier. Even with the shortest possible response time, the passenger in seat 28D would have already received the second- and third-degree burns to over half of her body and the severe inhalation injury from which she later died. The passenger in seat 27E remained on the airplane and therefore needed to be rescued from the wreckage. The Safety Board could not determine whether the passenger in seat 27E would have survived if sufficient ARFF personnel had been available to perform a rescue.

The research team believes that the ARFF response time, given the circumstances, was appropriate. Even if the ARFF facility had been closer to the runway to meet NFPA standard of 2 ½ minutes to any point in the Rapid Response Area, the delay would have been experienced as the visibility and heavy downpour would probably have prevented them from seeing the accident site upon leaving the station. Additional ARFF personnel may have allowed earlier entry into the aircraft, but the ARFF vehicular response would be delayed by the need to avoid the passengers who already exited the aircraft, which may have hampered immediate interior rescue attempts. The research team does not believe that a change in ARFF standards would have resulted in a reduction in fatalities in this accident.

Quincy, IL, Accident  
November 19, 1996

To meet its obligations under Part 139 the Quincy Municipal Airport had a 500 gallon ARFF vehicle that was staffed by fire fighters from the Quincy Fire Department when there were air carrier operations with more than 30 passenger seats. This vehicle was stored in a building by the terminal. Since this operation involved a Beech 1900 aircraft with 19 passenger seats, the ARFF vehicle was not staffed at the time of the accident. Since the accident, FAA's legal authority has been changed that allows the agency to certificate and require ARFF service for scheduled air carrier operations with aircraft having more than 9 passenger seats.

The coroner found that 10 aircraft occupants died from "carbon monoxide intoxication from inhalation of smoke and soot" and the remaining four occupants died from the "inhalation of products of combustion." The research team believes that any of the current FAA standards, ICAO standards, or NFPA standards would have saved some, if not all, of these lives. The Beechcraft 1900 is 57 feet 10 inches in length. Under the current standards the ARFF service required would be Index A for FAA and Category 4 for ICAO and NFPA.

-Response time would not have been a factor since the fire station was located approximately 1800 feet from the accident location. The NTSB determined that the ARFF truck should have been able to reach the accident site in no more than 1 minute. (The crew of the Beech 1900 was scheduled to be relieved at Quincy. The pilot from the relief crew made it on foot to the accident wreckage before the fire started.)

-Each of the three standards (FAA, ICAO, NFPA) requires one vehicle for this operation.

-The NFPA standard requires three firefighters for this type of aircraft operation. Neither FAA nor ICAO specifies a staffing number; however, it is very likely that under either of these standards only one person would have been assigned to the ARFF duties.

-The three standards vary in the amount of agent required with the NFPA requiring the most and FAA requiring the least. It took the Quincy Fire Department about 14 minutes to arrive on the airport. By that time, both aircraft were engulfed in flames. It took them approximately 10 minutes to control the fire. It is impossible to estimate how much agent would have been necessary to control the fire if the initial response had been made from an on-airport ARFF unit.

The research team believes that the additional two firefighters and agent that the NFPA standard would have required could have resulted in a reduction of 3 to 14 fatalities. This staffing level would have allowed one firefighter to apply agent to the Beech 1900, another one to take a handline and apply agent to the King Air, and the third firefighter to attempt to extricate the passengers from the Beech 1900. Since the FAA and the ICAO standards would have only one fire fighter responding, that firefighter would most likely have to choose between applying agent to the Beech 1900 with 12 people or the King Air with two people. Any efforts to extricate the passengers would have had to wait until mutual aid assistance arrived. Assuming that the firefighter would choose the Beech 1900, the research team believes that the FAA or ICAO standard would have resulted in a reduction of 1 to 12 fatalities.



In the case of Quincy (11/19/96, KUIN) where there was no requirement at the time of the accident for an on-airport ARFF response, the research team concluded any one of the three standards being compared in this study would have resulted in a reduced number of fatalities if it had been in effect.

For many of the accidents, the data included in the accident reports were not sufficient to allow the research team to conclude that a change in ARFF standards would have changed the accident outcome in terms of fatalities and/or serious injuries. Based on the data the research team was uncomfortable even with providing a range of estimates for fatalities and serious injuries. If additional data were available, it is possible that the research team may have reached a different conclusion for some of these accidents.

Problems with the data are discussed in the remainder of this chapter under the following headings:

- Fatality and Injury Information
- Standards in Effect at Time of the Accident
- Response Time

The results of the research team's analysis and determination for each accident are included in Appendix A.

### **Fatality and Injury Information**

The research team encountered several problems in trying to use the data from the accident reports to make meaningful determinations. For these determinations it was important to have information on the timing and cause of the fatality/serious injury. Some of these problems included:

- While some reports explicitly stated that X persons died on impact and Y persons died from thermal injuries or smoke inhalation, other reports stated that there was only a handful of autopsies and summarily stated that the remaining fatalities were all due to injuries that were either impact-related or fire-related.
- For accidents that involved several fatalities and serious injuries, the accident reports often focused on the fatalities and provided very little information on the serious injuries as to how they happened or when they occurred.
- As discussed in Chapter 4 there were 38 accidents where all the serious injuries from the accident occurred during the evacuation of the aircraft. Most of these accidents involved only one or two people being seriously injured. The accident report often provided specifics on how the injury occurred such as passenger broke ankle from jumping off the wing or passenger broke wrist falling off the slide. Most of these injuries fell under the second criterion of the definition for serious injury, i.e., results in a fracture of any bone (except simple fractures of fingers, toes, or nose), and did not appear to be life-threatening. Some of the serious injuries in the remaining 43 accidents also occurred during the evacuation of the aircraft but those accidents also had fatalities/serious injuries due to impact.

- The NFPA, in NFPA 402, *Guide for Aircraft Rescue and Fire Fighting Operations*, includes a provision that states “If time and conditions permit, ARFF personnel should assist in the off-loading of evacuees at the base of the evacuation slides to minimize injuries.” However, there is no specific guidance on how the firefighters should prevent these injuries. In view of the generality of the provision, it appears to be an action that should be considered by the on-site incident commander but with the current wording certainly could not be considered a requirement.

### **Standards in Effect at the Time of the Accident**

For some accidents at non-U.S. airports the accident report did not specifically state the ARFF standards applicable to the airport. In these accidents it was assumed that the airport operator complied with the ICAO Annex 14 standards. There were two accidents at non-U.S. airports where the investigating agency specifically stated that the airport operator was not in full compliance with all aspects of the Annex 14 standards. The research team did not find any accidents where it was stated in the accident records that the ARFF standards set forth by the NFPA were in effect at the airport.

### **Response Times**

It would seem logical that if a standard requires a quicker demonstrated response time, the result would be a quicker response to an actual accident. However, as was shown in the discussion in Chapter 4, real world conditions involving communications, weather, and access to the accident site often make demonstrated response times meaningless during an actual accident. None of the accident reports indicated that any of the airports involved complied with the NFPA demonstrated response times. Trying to locate additional stations on the airfield to comply with current demonstrated response times for a historical accident is difficult. Furthermore, attempting to determine actual response times to those historical accident sites from hypothetical fire stations is not a meaningful effort.

## **CHAPTER SUMMARY**

The inability to determine the cause of the fatalities and serious injuries, i.e., trauma vs. fire/smoke related, and the timing of these occurrences from the information in the accident reports hinders the ability to make a direct link to how many lives would be saved if changes were made to current ARFF standards.

For some accidents that did not involve a fire, the ARFF response to the accident may not even be mentioned or may be discussed in one or two sentences in the accident write-up. For accidents occurring outside the United States, some reports do not even mention what ARFF standards the airport uses.

There does not seem to be a correlation between demonstrated response times required by standards and the response time to an actual accident. This can be attributed to the fact that demonstrated response times are achieved in ideal conditions such as daytime, dry pavement, good visibility, and understandable communications. One or more of these ideal conditions are not normally present during a response to an actual accident. In view of the above, the research team found that there was no conclusive information in the accident reports that indicated a change in ARFF standards would have resulted in a reduction in fatalities or serious injuries.

## CHAPTER 6 CONCLUSIONS

After reviewing the 81 “accidents of interest” to this study, the research team concluded that the information contained in many of the accident records was not conducive for determining reductions in fatalities and serious injuries based upon changing the ARFF standards, i.e., the data was not to the level of detail required to make a conclusive determination that a change in standards would have reduced fatalities and/or serious injuries. The data for estimating reductions in serious injuries is particularly weak since the timing and cause of the serious injury is frequently not included in the accident report. At best, only subjective judgments could be made and even if the subjectivity was considered to be acceptable from a research perspective, there would be a question about consistency.

Notwithstanding the lack of detailed data, based upon the information contained in the accident reports, the research team’s collective judgment was that a change in ARFF standards would not have reduced fatalities or serious injuries in any of the accidents reviewed as part of this research effort with the possible exception of one accident .

For that accident, the regulations in effect at the time did not require an ARFF response for either aircraft since both aircraft had less than 31 passenger seats. Subsequent to the accident the regulation was changed for an ARFF response meeting the regulatory requirements for a Part 139 Index A airport. The research team’s estimated reduction of 1 to 12 fatalities is based upon the current FAA standard (see case study in Chapter 5). A similar reduction is estimated for the ICAO standard. In contrast it is estimated that if the current NFPA standard had been in effect, the reduction would have been 3 to 14 fatalities. This increased reduction over those estimated by the research team for the FAA and ICAO standards is based solely on having three firefighters at the scene to assist in suppression of the fire and extrication of the people on board the aircraft.

There are several accidents where the passengers were seriously injured during the evacuation of the aircraft. Neither the FAA nor ICAO address staffing evacuation slides to assist deplaning passengers from being injured during the evacuation. NFPA does address this situation in NFPA 402 with the following generalized statement “If time and conditions permit, ARFF personnel should assist in the off-loading of evacuees at the base of the evacuation slides to minimize injuries.” Furthermore the training programs set forth by each of the three organizations do not include any training to be conducted in evacuation assistance. There is a question as to how firefighters would be able to help people avoid these injuries. As stated previously, the serious injuries in these evacuation events are mainly bone fractures that are normally not life-threatening.

Overall, there is no conclusive evidence in the accident reports to indicate that accident fatalities or serious injuries would be reduced by replacing the current Part 139 ARFF standards with those found in ICAO Annex 14 or in NFPA 403 and its associated documents.

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# APPENDIX A. LISTING OF "ACCIDENTS OF INTEREST"

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
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7/19/1989	Sioux Gateway	KSUX	Other			R	Yes	Yes	296	111	47
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**Country:** United States

**ARFF Standards:** 14 CFR Part 139, Index B

**Aircraft Involved:** McDonnell Douglas 10

**Operator:** United Airlines

**Summary:** United Airlines Flt 232 was cruising at Flight Level 370, when there was a catastrophic failure of the # 2 (tail mounted) engine. This was due to separation, fragmentation & forceful discharge of the stage 1 fan rotor assembly parts from the #2 engine (uncontained failure), which led to loss of the 3 hydraulic systems that powered the flight controls. The flight crew experienced severe difficulties controlling the aircraft, which subsequently crashed during an emergency landing at Sioux City.

**Team Conclusion:** This operation into Sioux City airport was the result of a traumatic engine explosion and an emergency landing at an airport that was not certified for this size air carrier aircraft. In addition there was some confusion in Pre-deployment of ARFF equipment and personnel as a result of a very late change to the landing runway. However, there was a significant amount of mutual aid that was available from the National Guard and the Sioux City fire department. The NTSB believed that the mass application of foam to the cabin section facilitated the evacuation of ambulatory survivors. They were unable to determine whether attempts by firefighters could have rescued potential survivors because of the rapidly deteriorating survival conditions.

Changes in ARFF standards would have resulted in the following reductions: None

9/20/1989	LaGuardia	KLGA	Takeoff-Overrun	7150		R	No	No	63	2	3
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**Country:** United States

**ARFF Standards:** 14 CFR Part 139, Index D

**Aircraft Involved:** Boeing 737

**Operator:** USAIR

**Summary:** As the first officer began the takeoff he felt the airplane drift right. The captain noticed the drift also and used nosewheel tiller to help steer. The crew then heard a 'bang' and a continual rumbling noise. The captain then took over and rejected the takeoff but did not stop the airplane before running off the end of the runway and colliding with a wooden approach lighting pier. The airplane came to rest partially submerged in water.

**Team Conclusion:** The two fatalities occurred during or immediately following the impact. There were three serious injuries; one was caused by a rescue boat inadvertently backing over a passenger. There was not enough information available on the other two injuries to determine whether ARFF response might have prevented them, but it is likely that they occurred during the impact.

Changes in ARFF standards would have resulted in the following reductions: None

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
9/27/1989	Grand Canyon National Park	KGCN	Other	5400	1200	L	No	Yes	21	10	9

**Country:** United States

**ARFF Standards:** 14 CFR Part 139, Index A

**Aircraft Involved:** DeHavilland Twin Otter

**Operator:** Grand Canyon Airlines

**Summary:**

On September 27, 1989, Grand Canyon Airlines Flight "Canyon 5," a de Havilland DHC-6-300, Twin Otter, N75GC, was operating as a sightseeing flight under 14 CFR 135 from Grand Canyon National Park Airport, Tusayan, Arizona. The airplane crashed during its initial landing attempt and was destroyed. Witnesses described the airplane's approach as normal; however, the airplane traveled about 1,000 feet down the runway, which was 8,999 feet long at an altitude of about 5 feet prior to touchdown. The airplane reportedly dropped to the runway, bounced back into the air, continued another 1,000 feet and dropped back onto the runway near the intersection of taxiway "C." Witnesses then saw the airplane veer off to the right of the runway. When it neared the runway edge, observers saw it begin to climb in a nose-high attitude. The airplane continued to climb as it passed the control tower and reached an altitude of 150 to 200 feet above the runway. At this point, the aircraft rolled toward the left and crashed into trees on a hill about 1,200 feet to the left of the runway.

**Team Conclusion:**

ARFF response by 4 maintenance personnel who were also the airport's firefighters was delayed due to the electrical and phone lines having been cut by the accident aircraft. The cut wires, in turn caused a grass fire. Based on the accident report, the 2 pilots and 8 passengers died on impact. Nine passengers received serious injuries due to the crash and not due to evacuation.

Two survivors stated that they had to crawl out the window on the main cabin entrance door, which was against the ground. They then had to crawl between the fuselage and the ground to egress the airplane. Other passengers stated that they were unable to egress the wreckage, due to injuries, or that they were pinned in by the bodies of other passengers. These survivors were removed from the wreckage by ARFF personnel. Survivors stated that there was a strong smell of fuel around the wreckage but that there was no fire in the vicinity of the aircraft. All of the fatalities were due to blunt impact trauma.

Changes in ARFF standards would have resulted in the following reductions: None

12/26/1989	Tri-Cities Airport	KPSC	Other	400	0	CL	No	Yes	6	6	0
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**Country:** United States

**ARFF Standards:** 14 CFR Part 139, Index B

**Aircraft Involved:** BAe 3101 Jetstream

**Operator:** United Express

**Summary:**

During arrival for an ILS Runway 21R approach, the aircraft entered icing conditions for about 9-1/2 min. As the aircraft was vectored for the approach, the Seattle ARTCC controller used an expanded radar range and did not provide precise passing of the aircraft to the final approach course. The flight crew attempted to continue on a steep, unstabilized approach for a landing. Recorded radar data showed that the aircraft was well to the right of the ILS course line and well above the glide slope as it passed the outer marker/final approach fix. It did not intercept the localizer course until it was about 1.5 mi inside the final approach fix. Also, it was still well above the ILS glide slope. The recorded altitude data was lost when the aircraft was about 2.5 mi from the airport. Before reaching the runway, the aircraft nosed over and crashed in a steep descent. There was evidence that ice had accumulated on the airframe, including the horizontal stabilizers, which may have resulted in a tail plane stall.

**Team Conclusion:**

The aircraft was on an ILS approach to Pasco in icing conditions. An unstabilized approach led to the aircraft nosing over and crashing in a steep descent. The NTSB report states that the cause of death of the four passengers and two crew was "blunt impact trauma."

Changes in ARFF standards would have resulted in the following reductions: None

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
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1/18/1990	Atlanta-Hartsfield	KATL	Runway Collision	3800	75	R	No	No	159	1	1
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**Country:** United States

**ARFF Standards:** 14 CFR Part 139, Index E

**Aircraft Involved:** Boeing 727 & Beechcraft 100

**Operator:** Eastern Airlines / EPPS Air Service

**Summary:**

During arrival at night, a Beech 100 (King Air, N44UE) was cleared for an ILS Runway 26R approach behind Continental Flight 9687, then Eastern Airline (EA) Flight 111 (Boeing 727, N8867E) was cleared for the same approach behind the King Air. After landing, Flt 9687 had a radio problem and the tower controller had difficulty communicating with Flt 9687. Meanwhile, the King Air landed and its crew had moved the aircraft to the right side of the runway near Taxiway D (the primary taxiway for general aviation aircraft). The turnoff for Taxiway D was about 3800 ft from the approach end of Runway 26R. Before the King Air was clear of the runway, EA 111 landed and converged on the King Air. The crew of EA 111 did not see the King Air until moments before the accident. The captain tried to avoid a collision, but the Boeing's right wing struck the King Air, shearing the top of its fuselage and cockpit.

**Team Conclusion:**

The fatality and serious injury both occurred upon impact and could not have been prevented by ARFF.

Changes in ARFF standards would have resulted in the following reductions: None

3/24/1990	New Tokyo International	RNRT	Taxiway				No	No	301	0	2
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**Country:** Japan

**ARFF Standards:** Annex 14 Category Unknown

**Aircraft Involved:** Lockheed 1011

**Operator:** Cathay Pacific Airways

**Summary:**

Cathay Pacific L1011 made a hard landing on Runway 16 at New Tokyo International Airport. The landing damaged the rear spar of the wing root and its vicinity of left wing were damaged and fuel flowed out from the No. 1 fuel tank. There was no fire.

**Team Conclusion:**

The captain stopped the aircraft on the taxiway and shut down the engines. The first officer requested ARFF but transmission to ATCT was stepped on. This resulted in a longer response time to the aircraft. Meanwhile, the captain called for an emergency evacuation of the aircraft from the right side doors. By the time ARFF arrived, most people were off the aircraft. The two seriously injured passengers had bone fractures.

Changes in ARFF standards would have resulted in the following reductions: None



Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
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6/21/1990	Charleston International	KCHS	Landing-Remained on Runway	5300	0	CL	Yes	No	120	0	2
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**Country:** United States

**ARFF Standards:** 14 CFR Part 139, Index C

**Aircraft Involved:** Boeing 727

**Operator:** USAIR

**Summary:** While passing 10,000 feet msl on the descent for a night landing, the No. 2 engine fire warning light and bell activated. Captain requested ARFF deployment. Following accomplishment of all checklist procedures, the fire warning indications remained on. The captain ordered an emergency evacuation on the runway after the airplane landed. During the evacuation, one passenger was knocked off of the wing by another passenger and was seriously injured. Another passenger with two small children put one child on the slide, and the child resisted. The child fell from the slide and was seriously injured. Post-flight examination of the airplane revealed a faulty fire detection element on the No. 2 engine, and no evidence of in-flight fire was observed.

**Team Conclusion:** Changes in ARFF standards would have resulted in the following reductions: None

9/28/1990	Detroit Metro Airport	KDTW	Taxiway				No	Yes	132	0	2
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**Country:** United States

**ARFF Standards:** 14 CFR Part 139, Index E

**Aircraft Involved:** Boeing 727

**Operator:** Northwest Airlines

**Summary:** Four passengers were injured during the emergency evacuation following an auxiliary power unit (APU) fire. The crew reported the APU fire bell while taxiing. The captain elected to evacuate, but did not indicate the nature of the problem to either the cabin attendants or passengers. Several passengers used the overwing exits on the same side as the fire and were injured jumping off the wing. One said that the wing flaps were not lowered during the evacuation. The APU had been placarded inoperative prior to the flight. Post accident examination of the APU revealed that the fire started because of an attempted start of the defective unit.

**Team Conclusion:** A NW Airlines 727 taxiing in from landing had an APU fire after which the captain ordered an emergency evacuation, but did not inform either cabin attendants or passengers of the reason. This resulted in a confused evacuation with two serious and two minor injuries. There was no mention of ARFF in the accident report.

Changes in ARFF standards would have resulted in the following reductions: None

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
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12/3/1990	Detroit Metro	KDTW	Runway Collision				No	Yes	198	8	10
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**Country:** United States

**ARFF Standards:** 14 CFR Part 139, Index E

**Aircraft Involved:** McDonnell Douglas 9 & Boeing 727

**Operator:** Northwest Airlines

**Summary:**

On December 3, 1990, at 1345 EST, Northwest Flight 1482, a DC-9 (N3313L), and Northwest Flight 299, a Boeing 727 (N278US), collided near the intersection of runway 09/27 and 03C/21C in dense fog at Detroit Metropolitan/Wayne County Airport, Romulus, MI. At the time of the collision, the B-727 was on its takeoff roll, and the DC-9 had just taxied onto the active runway. The B-727 was substantially damaged, and the DC-9 was destroyed. All 154 crew and passengers onboard the B-727 either received minor injuries or were uninjured. DC-9 had 8 fatalities and 10 passengers with serious injuries --a Flight Attendant and a male passenger died of asphyxia secondary to smoke and soot inhalation. Both were found by the rear tailcone exit that malfunctioned and would not open. Two other passengers in the cabin died of the same cause. Another passenger in the cabin died of thermal injuries. Three other passengers in the cabin died of massive blunt force trauma from being struck by the wingtip of the B-727. No details are provided in the report on how the ten other passengers sustained their serious injuries.

ARFF response was 13 firefighters, 5 vehicles, 2 engine companies and two ambulances. Response was impacted by the low visibility in the fog (estimated to be 50-100 feet) and the fact they had to maneuver around aircraft on the taxiways. All ARFF vehicles initially found the B-727. They applied agent to fuel spill. One vehicle elected to look for the other aircraft which was about 2100 feet toward the approach end of the runway. When the ARFF vehicle found the DC-9 it was in flames. The other ARFF vehicles were called from the B-727 to bring the DC-9 fire under control.

ARFF started an interior attack but abandoned it because of the intensity of the fire and the danger to firefighters.

**Team Conclusion:**

The research team concluded that different ARFF standards would not have had any impact on the outcome of this accident. Passengers on the DC-9 stated that the fire started immediately after impact. By the time the ARFF reached the DC-9, it already was ablaze. At that time anyone who was going to survive had evacuated the aircraft. Although there was no information on how the 10 passengers sustained their serious injuries, the research team believes that they were all incurred prior to ARFF's arrival at the DC-9. The ARFF response to the DC-9 was affected by two factors--1) the dense fog that slowed the vehicular speed coupled with the need to maneuver around aircraft located on the taxiways, and 2) the focus of the ARFF response on the B-727 when it was found. The research team concluded that the fog and aircraft on taxiways would have hindered any ARFF response regardless of the standard. As for the focus on the B-727 rather than looking for the DC-9, the research team concluded that it had nothing to do with the ARFF standards that were in effect.

Changes in ARFF standards would have resulted in the following reductions: None

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
2/1/1991	Los Angeles	KLAX	Runway Collision	3554	600	L	No	Yes	101	34	13
<b>Country:</b> United States		<b>ARFF Standards:</b> 14 CFR Part 139, Index E									
<b>Aircraft Involved:</b> Boeing 737 & Fairchild Metroliner		<b>Operator:</b> USAir / Skywest									
<b>Summary:</b>		SKW5569, N683AV, had been cleared to Runway 24L, at intersection 45, to position and hold. The local controller, because of her preoccupation with another airplane, forgot she had placed SKW5569 on the runway and subsequently cleared USA1493, N388US, for landing. After the collision, the two airplanes slid off the runway into an unoccupied fire station.									
<b>Team Conclusion:</b>		There were 34 fatalities and 13 serious injuries, all of which occurred at the moment of impact or immediately thereafter. ARFF was at the scene of the accident within one minute with equipment that met and exceeded NFPA standards.									
		Changes in ARFF standards would have resulted in the following reductions: None									
5/5/1991	Atlanta-Hartsfield	KATL	Taxiway					Yes	102	0	1

**Country:** United States**ARFF Standards:** 14 CFR Part 139, Index E**Aircraft Involved:** McDonnell Douglas 88**Operator:** Delta Airlines**Summary:**

A Ford van used for baggage transport was transiting, at night, between the main terminal and a concourse. It was being driven along the designated roadway. While crossing the first ramp area after exiting from under the terminal, the van collided with a MD-88. The ramp and aircraft were well lit & the aircraft was in the center of its assigned taxi lane. The left main landing gear rolled into the rear of the van & the van caught fire. The aircraft was evacuated via emergency slides which resulted in injuries.

**Team Conclusion:**

One passenger was seriously injured during the evacuation and four other passengers received minor injuries. The evacuation occurred prior to ARFF arrival. It is doubtful that a change in ARFF standards would have made a difference in this case.

Changes in ARFF standards would have resulted in the following reductions: None

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
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9/19/1991	New Tokyo International Airport	RNRT	Landing-Taxied onto Taxiway				Yes	Yes	315	0	8
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Category Unknown

**Country:** Japan **ARFF Standards:** Annex 14

**Aircraft Involved:** Boeing 747 **Operator:** Northwest Airlines

**Summary:** Northwest 747 departed New Tokyo International Airport. During the climb over the Pacific ocean, the flight crew received signals that several of their systems were malfunctioning. Declared an emergency and returned to the airport. Landed normally and exited onto a taxiway and evacuated the aircraft.

**Team Conclusion:** ARFF followed 747 during its landing roll and subsequent taxi. Four ARFF vehicles were at aircraft: others were in a standby mode. There were 21 ARFF personnel on-duty during the evacuation.

Aircraft was evacuated from right side using slides. All eight of the serious injured suffered fractures. All injuries occurred during the emergency evacuation.

Changes in ARFF standards would have resulted in the following reductions: None

9/28/1991	Boston-Logan	KBOS	Taxiway				No	No	126	0	2
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**Country:** United States **ARFF Standards:** 14 CFR Part 139, Index E

**Aircraft Involved:** McDonnell Douglas 9 **Operator:** Continental Airlines

**Summary:** The airplane was taxiing for takeoff, when the cockpit filled with smoke. The captain stopped the airplane on a taxiway and ordered an emergency evacuation. An examination revealed a fuse holder for a cockpit instrument had malfunctioned and caused the fire/smoke.

**Team Conclusion:** The only mention of ARFF in the accident report is that the captain requested ARFF when smoke from the instrument panel was noticed. He then ordered an evacuation during which two passengers were seriously injured, one with a broken ankle and the other with a broken leg. There was no fire. The smoke resulted from an overloaded printed circuit board in the instrument panel.

Changes in ARFF standards would have resulted in the following reductions: None

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
3/22/1992	LaGuardia	KLGA	Other	6820	370	L	No	Yes	51	27	9
<b>Country:</b> United States				<b>ARFF Standards:</b> 14 CFR Part 139, Index D							
<b>Aircraft Involved:</b> Fokker F-28				<b>Operator:</b> USAIR							
<b>Summary:</b>		The airplane had been deiced 2 times before leaving the gate. However, 35 minutes had elapsed between the 2nd deicing & takeoff during which time ice accumulated on the wing. The first officer called VR 11 knots early, and the captain rotated about 5 knots early. The Fokker F-28 had been de-iced but exceeded the Type I deicing safe holdover time. After liftoff the aircraft stalled, struck a pump house and came to rest partially inverted and submerged in the bay. There were 27 fatalities-- 8 involved people with minor injuries that drowned; 7 involved people with serious injuries that drowned; 9 people died from blunt trauma of the impact; 1 person died from burns; 1 person died from smoke inhalation; and 1 person survived the accident but later died from cervical spine injury.									
<b>Team Conclusion:</b>		Several small fires broke out and were extinguished by the ARFF crews using the ARFF truck turrets, as well as handlines. The response consisted of 4 trucks with 7 ARFF personnel. Additionally, police/ARFF personnel responded from other locations, though no number is given. ARFF personnel reported that snow and fog hampered their visibility during the response.									
		The vehicles arrived approximately 4 minutes after the initial alarm but did not see the aircraft. The first truck put out the fire in the pump house. The firefighters then saw people gathered on the dike and realized that an aircraft was in the water. The weather hampered the initial response.									
		Changes in ARFF standards would have resulted in the following reductions: None									

7/30/1992	John F. Kennedy International	KJFK	Takeoff-Veeroff	14572	290	L	No	Yes	292	0	1
<b>Country:</b> United States				<b>ARFF Standards:</b> 14 CFR Part 139, Index E							
<b>Aircraft Involved:</b> Lockheed 1011				<b>Operator:</b> Trans World Airlines							
<b>Summary:</b>		Immediately after liftoff the stick shaker activated, and the first officer, who was making the takeoff, said 'you got it.' The captain took control, closed the thrust levers, and landed. He applied full reverse thrust and maximum braking, and turned the airplane off the runway to avoid a barrier at the end. A system design deficiency permitted a malfunctioning AOA sensor to cause a false stall warning.									
<b>Team Conclusion:</b>		There is not enough information in the reports to determine the circumstances of the single serious injury, which occurred during the evacuation.									
		Changes in ARFF standards would have resulted in the following reductions: None									

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
11/27/1992	Chicago-O'Hare	KORD	Apron				No	No	124	0	1
<b>Country:</b> United States		<b>ARFF Standards:</b> 14 CFR Part 139, Index E									
<b>Aircraft Involved:</b> Boeing 727		<b>Operator:</b> Delta Airlines									
<b>Summary:</b>		The flight had arrived at the jetway and the passengers were beginning to deplane. Before external ground power was supplied to the airplane, the captain prematurely shut down the No. 1 engine which was supplying electrical power to the cabin. When the engine was shut down, the main cabin lights went out, followed immediately by the illumination of the battery-powered emergency floor lights. The flight engineer announced to the captain that he was starting the auxiliary power unit (APU). As he started the APU, an exhaust flame momentarily came out from the APU exhaust pipe located near the top of the right wing root. Some passengers yelled 'fire' and began an uncommanded evacuation through the overwing exits. Crew members were able to stop the evacuation, but not before several passengers had jumped off the wings and incurred injuries. There is no mention of ARFF in the report.									
<b>Team Conclusion:</b>		When passengers were deplaning, the captain shut off an engine and the cabin light went out and emergency lights came on. In starting the APU an exhaust flame was seen by passengers who initiated an uncommanded evacuation during which several passengers jumped off the wings and were injured. There is no mention of ARFF in the report.									
		Changes in ARFF standards would have resulted in the following reductions: None									

4/14/1993	Dallas-Ft Worth	KDFW	Landing-Veeroff	8781	325	R	No	Yes	202	0	2
<b>Country:</b> United States		<b>ARFF Standards:</b> 14 CFR Part 139, Index E									
<b>Aircraft Involved:</b> McDonnell Douglas 10		<b>Operator:</b> American Airlines									
<b>Summary:</b>		At the time Flight 102 landed at Dallas-Ft Worth Airport, it was raining and there were numerous thunderstorms in the area. Shortly after touchdown on Runway 17L, the pilot lost directional control when the airplane began to weathervane and the captain failed to use sufficient rudder control to regain the proper ground track. The airplane eventually departed the right side of the runway.									
<b>Team Conclusion:</b>		There were a total of 202 occupants on the DC-10, and there were two serious injuries sustained during the evacuation. ARFF response was adequate; the equipment arrived about one minute after the airplane departed the runway.									
		Changes in ARFF standards would have resulted in the following reductions: None									

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
5/2/1993	Tokyo Haneda International	RHND	Apron				No	No	490	0	9
	<b>Country:</b> Japan						<b>ARFF Standards:</b> Annex 14, Category Unknown				
	<b>Aircraft Involved:</b> Boeing 747						<b>Operator:</b> All Nippon Airways				
	<b>Summary:</b>	All Nippon Airways 747 was taxiing in after landing at Tokyo International Airport on May 2, 1993 , came to a stop and made an emergency evacuation about 2055 hours near Parking Spot 56 because inside of the cabin was filled with white smoke. Nine passengers were seriously injured during the evacuation. No fire occurred on the airplane.									
	<b>Team Conclusion:</b>	While taxiing to the gate after landing, smoke was observed in the cabin and the crew initiated an evacuation. Among the 490 occupants, nine passengers suffered serious injuries during the evacuation, which was completed in about two minutes. ARFF units arrived after the evacuation had been completed.									
		Changes to ARFF standards would have resulted in the following reductions: None									

9/14/1993	Okecie International	WAW	Landing-Overrun	295	85	R	No	Yes	70	2	51
	<b>Country:</b> Poland						<b>ARFF Standards:</b> Annex 14 Category Unknown				
	<b>Aircraft Involved:</b> Airbus 320						<b>Operator:</b> Lufthansa Airlines				
	<b>Summary:</b>	The aircraft was cleared for a Warsaw runway 11 approach and were told of the existence of windshear on the approach. The Airbus' right gear touched down 770m from the runway 11 threshold. The left gear touched down 9 seconds later, 1525m from the threshold. Only when the left gear touched the runway, automatic systems depending on oleo strut (shock absorber) compression unlocked the use of ground spoilers and engine thrust reversers. The wheel brakes, depending on wheel rotation being equivalent of circumferential speed of 72 knots began to operate after about 4 seconds. Seeing the approaching end of the runway and the obstacle behind it, the pilot steered the aircraft off the runway to the right. The aircraft left the runway at a speed of 72 knots and rolled 90m before it hit the embankment and an LLZ aerial with the left wing. A fire started in the left wing area and penetrated into the passenger cabin.									
	<b>Team Conclusion:</b>	There were 2 fatal injuries—the pilot who died on impact and one passenger who died of smoke inhalation since he was unable to get out of the aircraft due to injuries. There were 51 serious injuries, 50 due to trauma and 1 due to fire or smoke. Most of the survivors evacuated the aircraft prior to the arrival of the ARFF personnel. Five Aerodrome Fire Service cars arrived in three minutes from the emergency call and managed to extinguish the external fire.									
		There is insufficient information in the accident report to determine the number of fire fighters that initially responded to the accident site. The ARFF service did arrive within 3 minutes of the emergency call with 5 ARFF units. The evacuation was started prior to the arrival of ARFF. However, due to the fires, the ARFF personnel were initially concerned with extinguishing the fires caused by leaking fuel.									
		Most of the serious injuries were caused by the impact of the aircraft.									
		Changes in ARFF standards would have resulted in the following reductions: None									

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
4/26/1994	Nagoya Airport	RNGO	Other	100	400			Yes	271	264	7

**Country:** Japan

**ARFF Standards:** Annex 14, Category 9

**Aircraft Involved:** Airbus 300

**Operator:** China Airlines

**Summary:**

A China Airlines A-300 while approaching Nagoya Airport for landing crashed near Taxiway E-1. 264 of the 271 people on board were killed and the other 7 were seriously injured. The aircraft ignited and was destroyed by fire. Aircraft stalled during attempted go around.

**Team Conclusion:**

According to autopsy reports a great number of the remains were bruised all over and had multiple fractures caused by the impact. Nearly half of the remains had been burned to various degrees. Of the 271 persons onboard, 16 were taken to the hospital of which six were dead on arrival. Three more of them died over the next few days. ARFF entered aircraft and rescued some people----uncertain as to how many of them were among the seven survivors.

Airport ARFF and Mutual aid responded to the accident. Airport ARFF was on accident site within two minutes of being notified. ARFF provided by Komaki Air Base--five chemical fire vehicles and one water wagon. Airport complies with Annex 14, Category 9 requirements in terms of water for foam production, fire extinguishing agents, and complementary agents and response times. However, airport did not meet the discharge rate for foam solution. ARFF vehicles had a discharge distance of 30 m. Not certain from the accident report as to how big of an impact this had on the ARFF response.

The research team believes a large number of people on the aircraft died immediately on impact from traumatic injuries; however, apparently individual autopsies were not performed on each fatality. For this reason, the research team does not believe that an accurate assessment can be made on reduction in fatalities or serious injuries.

Changes in ARFF standards may have resulted in the following reductions: Undetermined



Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
7/2/1994	Charlotte-Douglas International	KCLT	Other				No	Yes	57	37	16
	<b>Country:</b> United States		<b>ARFF Standards:</b> 14 CFR Part 139, Index D								
	<b>Aircraft Involved:</b> McDonnell Douglas 9		<b>Operator:</b> USAIR								
	<b>Summary:</b>	<p>On July 2, 1994, about 1843 eastern daylight time, a Douglas DC-9-3 l, , operated by USAir, Inc., as flight 1016, collided with trees and a private residence near the Charlotte/Douglas International Airport, Charlotte, North Carolina, shortly after the flight crew executed a missed approach from the instrument landing system approach to runway 18R. The captain, first officer, one flight attendant, and one passenger received minor injuries. Two flight attendants and 14 passengers sustained serious injuries. The remaining 37 passengers received fatal injuries. The airplane was destroyed by impact forces and a post-crash fire. Instrument meteorological conditions prevailed at the time of the accident. Flight 9096 was being conducted under 14 Code of Federal Regulations Part 121 as a regularly scheduled passenger flight from Columbia, South Carolina, to Charlotte.</p>									
	<b>Team Conclusion:</b>	<p>The airplane was executing a missed approach when it encountered windshear that caused the aircraft to initially touchdown in a grassy field located within the airport boundary fence, about 2,180 feet southwest of the threshold for runway 18 R. Its momentum carried the aircraft through the boundary fence across a road where it struck some houses. The accident location was outside the FAA’s runway safety area and the NFPA’s maximum Rapid Response Area.</p> <p>Of the 37 passengers who received fatal injuries, 32 were the result of blunt force trauma, 4 were due to thermal injuries, and 1 was the result of carbon monoxide inhalation. Passengers seated in rows 3 through 10 sustained nonsurvivable blunt force trauma: and 10 passengers seated aft of row 14 sustained fatal blunt force injuries. The passengers who received fatal thermal or carbon monoxide-related injuries were seated in the area directly over the wing or in very close proximity to it. Some of the passengers in seat rows 17 through 19 were trapped in the wreckage until they were extricated by rescue personnel, while other passengers in those rows were able to escape unassisted.</p> <p>At approximately 1845, the-Charlotte ATC tower activated the “crash phone” linked to the airport fire station and indicated that “we lost a plane on radar - 50 SOB [Souls on Board].” Eight fire fighters responded with three aircraft rescue and fire fighting (ARFF) trucks (Blaze 1, 2, and 7), and one quick response and command truck (Blaze 5) from the fire station located near the base of the ATC tower. Several fire fighters stated that at the time the equipment was dispatched, “it was raining very hard.” The initial notification to the fire station by the control tower did not identify any particular location of the downed aircraft because of the restricted visibility: thus. the fire equipment traversed the airport via taxiway “A” searching for evidence of an accident. At 1846:09, the ATC ground controller notified the crew in Blaze 5 “we have a large area of smoke visible from the tower, now it appears to be approximately a quarter mile north of the old hangar that CCAir is using....” Simultaneous to the ground controller’s transmission, the crew of Blaze 5 heard over their public communications radio a transmission from the City Alarm Room indicating that there was a “possible plane crash in the vicinity of Wallace Neel and Old Dowd.”</p> <p>The response from all fire departments totaled five alarms, and the Charlotte ARFF used a total of 187 gallons of AFFF. Despite a brief period of heavy rain and high winds, the fires were extinguished quickly, and the rescue of trapped and injured people commenced immediately.</p> <p>The research team concluded that different ARFF standards would not have had any impact on the outcome of this accident. This is based upon the weather conditions at the time of the accident, the unknown location of the accident site when ARFF was initially dispatched, and the location of the accident off airport property coupled with the prompt response to the off-airport location by municipal firefighters.</p> <p>Changes in ARFF standards would have resulted in the following reductions: None</p>									

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
11/22/1994	Lambert-St Louis	KSTL	Runway Collision	2850	75	L	No	No	142	2	0
<b>Country:</b> United States		<b>ARFF Standards:</b> 14 CFR Part 139, Index D									
<b>Aircraft Involved:</b> McDonnell Douglas 9 & Cessna 402		<b>Operator:</b> Trans World Airlines / Superior Aviation									
<b>Summary:</b>		During the takeoff roll on runway 30R, the MD-82, N954U, collided with the Cessna 441, N441KM, which was positioned on the runway waiting for takeoff clearance. After receiving taxi clearance to back-taxi into position and hold on runway 31, the pilot taxied into a position at an intersection on runway 30R, which was the assigned departure runway for the MD-82. The ATIS current at the time the Cessna pilot was operating in the Lambert-St. Louis area listed runways 30R and 30L as the active runways for arrivals and departures; there was no mention of the occasional use of runway 31.									
<b>Team Conclusion:</b>		Accident occurred at night making it difficult for both the ATCT and the MD-88 crew to see the Cessna on the runway. The Cessna was destroyed and both of its occupants were killed in the crash. Both fatalities were due to severe craniocerebral injuries. In their report the NTSB stated that "This accident was not survivable for the occupants of the Cessna."									
		The MD-88 had substantial damage. Of the 140 persons on the MD-88 eight sustained minor injuries and the remainder were uninjured.									
		Changes in ARFF standards would have resulted in the following reduction: None									

4/2/1995	John F. Kennedy International	KJFK	Taxiway				Unknown	No	109	0	2
<b>Country:</b> United States		<b>ARFF Standards:</b> 14 CFR Part 139, Index E									
<b>Aircraft Involved:</b> McDonnell Douglas 11		<b>Operator:</b> American Airlines									
<b>Summary:</b>		The flight crew was informed by the flight crew of another airplane that there was a tailpipe fire in the No. 2 engine. The crew shut down the engine using the engine fire checklist; however, crash fire rescue personnel reported that smoke and fire continued. The captain ordered an emergency evacuation, during which two passengers were seriously injured. Examination of the engine and subsequent test cell running revealed no anomalies.									
<b>Team Conclusion:</b>		The crew of the MD-11 was informed by the flight crew of another aircraft that there was a fire in the No. 2 engine. The engine was shut down, but when smoke continued the captain ordered the emergency evacuation. 32 of the 99 passengers were taken to a hospital, two with serious injuries. ARFF was on the scene before the evacuation.									
		Changes in ARFF standards would have resulted in the following reductions: None									

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
6/8/1995	Atlanta-Hartsfield	KATL	Takeoff-Remained on Runway	1500		CL		Yes	62	0	1
	<b>Country:</b> United States			<b>ARFF Standards:</b> 14 CFR Part 139, Index E							
	<b>Aircraft Involved:</b> McDonnell Douglas 9			<b>Operator:</b> Valujet							
	<b>Summary:</b>			As ValuJet Flight 597 began its takeoff roll, a 'loud Bang' was heard by the occupants, the right engine fire warning light illuminated, the crew of a following airplane reported to the Valujet crew that the right engine was on fire, and the takeoff was rejected. Shrapnel from the right engine penetrated the fuselage and the right engine main fuel line, and a cabin fire erupted. The airplane was stopped on the runway, and the captain ordered evacuation of the airplane. A flight attendant (F/A) received serious puncture wounds from shrapnel and thermal injuries; another F/A and 5 passengers received minor injuries.							
	<b>Team Conclusion:</b>			The single serious injury was sustained by a flight attendant who was struck by fragments of the exploding engine which penetrated the fuselage. Following the abort, ARFF response was adequate.							
	Changes in ARFF standards would have resulted in the following reductions: None										

12/20/1995	John F. Kennedy International	KJFK	Takeoff-Veeroff	4800	600	L	No	No	468	0	1
	<b>Country:</b> United States			<b>ARFF Standards:</b> 14 CFR Part 139, Index E							
	<b>Aircraft Involved:</b> Boeing 747			<b>Operator:</b> Tower Air							
	<b>Summary:</b>			The captain initiated a takeoff on runway 4L, which was covered with patches of ice and snow. The wind was from 330 degrees at 11 knots. Before receiving an 80-knot call from the 1st officer, the airplane began to veer to the left. Subsequently, it went off the left side of the runway and collided with signs and an electric transformer.							
	<b>Team Conclusion:</b>			Shortly after initiating the takeoff, the pilot reported that the airplane veered to the left of centerline and exited the left side of the runway about 2100 feet from the start of the takeoff roll. After the airplane departed the runway, the number 4 engine impacted a concrete structure, containing electrical wires, and the entire pylon separated from the wing. As the airplane continued in soft terrain, the right wing landing gear and nose gear collapsed. The airplane came to rest between two taxiways, approximately 4800 feet from the start of the takeoff roll.							
	The captain determined that there was no sign of fire and the injuries to passengers were not serious; therefore, he elected to not order an emergency evacuation. The removal of passengers was conducted in an orderly manner by airport personnel. One flight attendant was seriously injured. An ice cart broke loose during the veeroff and hit her in the right shoulder. She suffered a broken right shoulder. Since serious injury occurred during the crash sequence, different ARFF standards would not have had any impact on the outcome of this accident.										

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
2/20/1996	Portland International	KPDX	Taxiway				No	No	143	0	1
<b>Country:</b> United States				<b>ARFF Standards:</b> 14 CFR Part 139, Index E							
<b>Aircraft Involved:</b> Boeing 767				<b>Operator:</b> Delta Airlines							
<b>Summary:</b>		While the Boeing 767 was taxiing for departure, the crew of another aircraft reported that there was smoke and flames coming from the Boeing 767 APU exhaust. The crew of the Boeing 767 shut down the APU and began coordinating with dispatch for a return to the gate. The crew was then directed by the tower to hold their position and to shut down their engines. Soon thereafter, the tower advised the crew that the Fire Marshall had called for the aircraft to be evacuated because there was still smoke coming from the APU exhaust. The aircraft was evacuated using the evacuation slides at the door exits. One passenger received serious injuries during the evacuation.									
<b>Team Conclusion:</b>		Portland International Airport is an Index E airport. In this incident, the report does not state whether the ARFF crews arrived prior to evacuation. But, based on the statement that the Fire Marshall "ordered" the pilot to evacuate, it would seem logical that the ARFF crews arrived prior to evacuation.									
		The aircraft was evacuated using the evacuation slides at the door exits. One passenger received serious injuries during the evacuation.									
		Changes in ARFF standards would have resulted in the following reductions: None									
6/13/1996	Fukuoka	RJFF	Takeoff-Overrun	2034	75	R	No	Yes	275	3	18

**Country:** Japan **ARFF Standards:** Annex 14, Category 9

**Aircraft Involved:** McDonnell Douglas 10 **Operator:** Garuda Indonesia

**Summary:** A DC-10 Of Garuda Indonesia (GIA) on takeoff from Runway 16 at Fukuoka Airport aborted the takeoff and overran the departure end of Runway 16.

**Team Conclusion:** The aircraft, a DC-10, aborted its takeoff and crossed a public road and hit a concrete abutment that wiped out the landing gear. It proceeded to slide another 1000' on its belly. Rear portion of Aircraft broke apart and was consumed by post crash fire especially in aft section of aircraft. Fuselage broke into parts. Aircraft came to rest outside the maximum Rapid Response Area defined in the NFPA standards.

Two deaths were attributed to impact and one to fire.

Based on the accident report, the evacuation was started at approximately 12:08 pm immediately after the aircraft came to rest. It was completed at 12:10 pm. The first ARFF units arrived at approximately 12:14. While the original fire station had 2 ARFF trucks, a rapid intervention vehicle, a water vehicle and an ambulance with a compliment of 12 personnel on duty. An additional station had one ARFF unit and a water supply vehicle with a complement of 6 personnel.

Changes in ARFF standards would have resulted in the following reductions: None

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
7/6/1996	Pensacola Regional	KPNS	Takeoff-Remained on Runway	1400	0	CL	No	No	142	2	2
<b>Country:</b> United States				<b>ARFF Standards:</b> 14 CFR Part 139, Index C							
<b>Aircraft Involved:</b> McDonnell Douglas 88				<b>Operator:</b> Delta Airlines							
<b>Summary:</b>		On July 6, 1996, Delta Airlines flight 1288, an MD-88, N927DA, experienced an uncontained failure of the left engine during the beginning of the takeoff roll. The flight crew stopped the airplane about 1400 feet down the takeoff runway. On board the airplane were 142 passengers, 2 flight crew members, 3 cabin crew, and 2 non-revenue Delta employees occupying the cockpit and aft jump seats. Engine parts entered the left side of the aft cabin resulting in 2 passengers sustaining fatal injuries and 2 sustained major injuries. Three other passengers received minor injuries during the evacuation. The captain stopped the evacuation from the emergency exits, and an air-stairs was brought to the airplane to evacuate the remaining passengers and the crew.									
<b>Team Conclusion:</b>		The MD-88 of Delta Airlines had an uncontained engine failure shortly after beginning it's takeoff roll . The flight crew rejected the takeoff, but the captain did not want an emergency evacuation. However, a flight attendant in the rear of the plane, next to where the aircraft was penetrated by engine parts, did initiate an evacuation through the rear door. As a result about 30 passengers evacuated resulting in one major injury during the evacuation. Two passengers sustained fatal injuries and one passenger sustained major injuries from the engine explosion.									
Changes in ARFF standards would have resulted in the following reductions: None											

7/8/1996	Nashville International	KBNA	Takeoff-Overrun	750	100	L	No	No	127	0	1
<b>Country:</b> United States				<b>ARFF Standards:</b> 14 CFR Part 139, Index C							
<b>Aircraft Involved:</b> Boeing 737				<b>Operator:</b> Southwest Airlines							
<b>Summary:</b>		During the takeoff roll, after V1 was called by the first officer, a bird was ingested in the left engine, resulting in a compressor stall. The captain initiated a rejected takeoff as VR was called. The airplane continued accelerating momentarily, & V1 was exceeded by 10 knots, resulting in an overrun of the runway. After stopping on the overrun, the captain made a PA announcement for the passengers to remain seated. Fire/rescue personnel arrived, confirmed there was no fire. They also noted the tires were deflating and smoking (due to excessive brake temperature from the rejected takeoff which melted the fuse plugs & deflated the tires). Evacuation slides were de-armed and the cabin doors were opened for ventilation. Fire erupted from the right brake and was immediately extinguished by fire personnel. Hearing a fireman shout 'fire,' the flight attendants at the forward and aft entry doors commanded an evacuation without informing the captain that a fire had been reported, without communicating first with each other, and without determining the location of the fire. To evacuate, they closed the cabin doors, rearmed the slides, and began the evacuation. During evacuation, 1 passenger was seriously injured; 4 received minor injuries.									
<b>Team Conclusion:</b>		The evacuation was initiated by flight attendants after the airplane had come to a stop on the runway. ARFF personnel had responded following the abort. When the flight attendants heard a fireman shout "fire" (a small brake fire had started) they rearmed the slides and started the evacuation, during which one passenger sustained a broken leg while descending the escape slide. Additional ARFF response would not have affected the outcome.									
Changes in ARFF standards would have resulted in the following reductions: None											

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
11/19/1996	Kent County International	KGRR	Landing-Taxied onto Taxiway				No	No	87	0	1
	<b>Country:</b> United States			<b>ARFF Standards:</b> 14 CFR Part 139, Index C							
	<b>Aircraft Involved:</b> Boeing 737			<b>Operator:</b> United Airlines							
	<b>Summary:</b>	The flight crew received an engine fire warning during an approach to land. The crew performed engine fire emergency procedures and a single engine landing was accomplished. After landing, it was reported that the smoke was coming out of the No. 2 engine and the captain ordered an evacuation of the airplane. The exit door 1R slide deployed automatically when the door was opened. The slides for exit doors 1L and 2R did not automatically inflate. Both slides were inflated manually. A passenger exited out of the 1L door and fractured her ankle. According to one of the flight attendants, the passenger did not jump out the exit as directed, but rather sat down, and slid out.									
	<b>Team Conclusion:</b>	Shortly after landing, the captain was advised that fire/rescue personnel reported smoke coming from the No. 2 engine cowling. The captain then used the PA system to issue the command to evacuate the airplane. While there is little to no discussion of the ARFF response during this incident/accident, the ARFF apparently was present at the aircraft prior to the evacuation.									
		A 79 year old passenger received a fractured ankle. According to one of the flight attendants, the passenger did not jump out the exit as directed, but rather sat down, and slid out resulting in a fractured ankle.									
		Changes in ARFF standards would have resulted in the following reductions: None									

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
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11/19/1996	Quincy Municipal	KUIN	Runway Collision	2520	90	L	No	Yes	14	14	0
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**Country:** United States

**ARFF Standards:** No ARFF required

**Aircraft Involved:** Beechcraft 1900 & Beechcraft King Air A90

**Operator:** United Express / Private Operator

**Summary:**

The Beech 1900C, N87GL, was in its landing roll on runway 13, and the Beech A90, N1127D, was in its takeoff roll on runway 4. The collision occurred at the intersection of the two runways. The flight crew of the Beech 1900C mistook a Cherokee pilot's transmission (that he was holding for departure on runway 4) as a response from the Beech A90 to their request for the Beech A90's intentions, and therefore mistakenly believed that the Beech A90 was not planning to take off until after the Beech 1900C had cleared the runway.

**Team Conclusion:**

To meet its obligations under Part 139 the Quincy Municipal Airport had a 500 gallon ARFF vehicle that was staffed by fire fighters from the Quincy Fire Department when there were air carrier operations with more than 30 passenger seats. Since this operation involved a Beech 1900 aircraft with 19 passenger seats, the ARFF vehicle was not staffed at the time of the accident. Since the accident, FAA's legal authority has been changed that allows the agency to certificate and require ARFF service at airports with scheduled air carrier operations using aircraft having more than 9 passenger seats. The coroner found that 10 aircraft occupants died from "carbon monoxide intoxication from inhalation of smoke and soot" and the remaining four occupants died from the "inhalation of products of combustion." The research team believes that any of the current FAA, ICAO or NFPA standards could have potentially saved some, if not all, of these lives. Under the current standards the ARFF service required would be Index A for FAA and Category 4 for ICAO and NFPA.

-Response time would not have been a factor since the fire station was located approximately 1800 feet from the accident location. The NTSB determined that the ARFF truck should have been able to reach the accident site in no more than 1 minute. (The crew of the Beech 1900, who was scheduled to be relieved at Quincy made it on foot to the accident wreckage before the fire started.)

-The NFPA standard requires three firefighters for this type of aircraft operation. Neither FAA nor ICAO specify a staffing number; however, it is very likely that under either of these standards only one person would have been assigned to the ARFF duties.

-The three standards vary in the amount of agent required with the NFPA requiring the most and FAA requiring the least. It took the Quincy Fire Department about 14 minutes to arrive on the airport. By that time, both aircraft were engulfed in flames. It took them approximately 10 minutes to control the fire. It is impossible to estimate how much agent would have been necessary to control the fire if the initial response had been made from an on-airport ARFF unit.

The research team examined and believes that in view of the additional two firefighters and agent that had the NFPA standards been in place at UIN, it could have potentially resulted in a reduction of 3 to 14 fatalities. This staffing level could have allowed one firefighter to apply agent to the Beech 1900, another one to take a handline and apply agent to the King Air, and the third firefighter to extricate the passengers from Beech 1900. Since the FAA and the ICAO standards would have only one firefighter responding that firefighter would have to choose between applying agent to the Beech 1900 with 12 people or the King Air with two people. Any efforts to extricate the passengers would have had to wait until mutual aid assistance arrived. Assuming that the firefighter would choose the Beech 1900, the research team believes that the FAA or ICAO standard could have potentially resulted in a reduction of 1 to 12 fatalities.

Changes in ARFF standards may have resulted in the following reductions: NFPA - 3 to 14 fatalities; FAA and ICAO - 1 to 12 fatalities.

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
3/9/1997	Kiruna Airport	KRN	Landing-Veeroff	6170	135	L	No	No	156	0	1

**Country:** Sweden

**ARFF Standards:** Unknown

**Aircraft Involved:** McDonnell Douglas 9

**Operator:** SAS

**Summary:**

After a flight from Stockholm/Arlanda, SAS 1042, was about to land at Kiruna airport. The captain was the pilot flying and the first officer was the non-flying-pilot. When the aircraft was approaching Kiruna the pilots were informed that runway 21 was in use and had braking coefficients 0.36, 0.32, 0.32 with 100% ice on the runway, which had been sanded. The co-pilot acquired visual contact with the runway at approximately 500 – 600 feet above the ground. There was turbulence and heavy snowfall during the approach. The captain crabbed the aircraft into the wind and shortly before touchdown on the runway he removed the crab towards the runway heading. The landing was performed with the automatic brake system set on medium brake effect and the Anti-Skid System activated in connection with the reverse thrust after touchdown the captain believed that the aircraft swerved to the right. He then unreversed and steered the aircraft in the direction of runway heading. At the same time he requested maximum brake effect. The aircraft then began to drift towards the left edge of the runway, without him being able to prevent it from doing so. Approximately 1,500 meters down the runway the aircraft departed the left edge of the runway and continued parallel to the runway for approximately 400 meters until it came to a stop in half- meter deep snow. An emergency evacuation of the aircraft was performed and the crew estimated that the evacuation had taken 60-70 seconds. An elderly passenger received a shoulder injury and had to be carried from the aircraft on a stretcher.

**Team Conclusion:**

On a flight from Stockholm, SAS flight 1042, a DC-9 attempted to land in high winds on a ice-contaminated runway. The aircraft landed on the runway, but eventually drifted off and ended up in a foot and a half of snow. An emergency evacuation took place which the crew estimated took from 60-70 seconds. One elderly passenger had a shoulder injury and had to be carried on a stretcher. There was no fire.

Changes in ARFF standards would have resulted in the following reductions: None

5/11/1997	Luis Munoz Marin International	KSJU	Taxiway				No	Yes	263	0	1
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**Country:** United States

**ARFF Standards:** 14 CFR Part 139, Index D

**Aircraft Involved:** McDonnell Douglas DC-10

**Operator:** Flying Colours

**Summary:**

The airplane was taxiing for departure on taxiway 'N', when a fuel smell was detected in the cabin. About the same time, the crew of a commuter flight taxiing behind the DC-10 reported that the right engine was on fire. The crew saw the smoke from the cockpit window; the captain stopped the airplane, shut the engines down, and ordered an evacuation. Crash fire rescue equipment was used to put out the fire. According to a passenger's description of the evacuation there was general panic in the cabin, passengers screamed and pushed to get out. Some passengers had not cleared the bottom of the escape chute, because no one was at the bottom of the chute to help people stand up and move out of the way promptly. After evacuating the airplane passengers were standing around on the tarmac and did not know where to go, because nobody was directing passengers away from the plane. Some passengers were standing near the bottom of the chute, and others were moving away in all possible directions. Event started about 1934EDT. At 1939, crash fire rescue equipment was used to put out the fire.

**Team Conclusion:**

Shortly after the DC-10 began to taxi out a fire broke out in the core engine with a strong smell of fuel in the cabin. The captain brought the aircraft to a stop on taxiway close to the airport fire station. ARFF arrived very quickly while engine was still running and with fire flames still coming from the engine. When the engine was shut down the fire decayed and was quickly extinguished. The captain had ordered an evacuation. A passenger described a scene of panic in the cabin. Passenger evacuation was hindered by the fact that no one was moving passengers out of the way after they reached ground.

Changes in ARFF standards would have resulted in the following reductions: None



Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
8/7/1997	Honolulu International	KHNL	Takeoff-Remained on Runway				No	Yes	305	0	1
	<b>Country:</b> United States		<b>ARFF Standards:</b> 14 CFR Part 139, Index E								
	<b>Aircraft Involved:</b> Lockheed 1011		<b>Operator:</b> Delta Airlines								
	<b>Summary:</b>		<p>During the takeoff roll, the 3F tire exploded, resulting in vibration, shudder, and yaw. The sudden instability, combined with a phantom C1 cargo door light, caused the captain to abort. The abort was initiated about Vr (165 knots) with approximately 6,000 feet of runway remaining. As the aircraft came to a stop, the nose wheels were 164 feet short of the overrun area for runway 8R. A brake fire began while the aircraft was stopping and the captain directed an emergency evacuation. The 2R and 4R doors failed to open, and the 4L and 3L doors were not used due to their proximity to the fire and smoke. The 4R door was jammed by a broken piece of backboard, and the 2R door malfunctioned due to a partially broken counterbalance spring. The flight attendant who attempted to open the 2R door did not attempt to manually lift the door. All evacuations were made through the 1L, 1R, 2L, and 3R doors. Firefighters had difficulty communicating with the flight crew and in verifying the total number onboard because the airline's passenger count does not include lap children. A total of 56 passengers and 2 flight attendants were treated for minor injuries, while 1 passenger received a broken ankle. All injuries were attributed to the use of the slides. Passengers failed to follow flight attendants instructions and attempted to evacuate with their carryons. The airline did not effectively supervise the passengers after the evacuation and several began walking toward an active runway.</p>								
	<b>Team Conclusion:</b>		<p>There were a total of 305 persons on board the L-1011. Although only half of the slides were used and the evacuation was not effectively supervised by the cabin crew, there was only one serious injury; a broken ankle sustained by a passenger. ARFF response was initiated before the alarm had been received from the tower, and the first units arrived at the aircraft between 45 seconds and one minute after the abort.</p> <p>Changes in ARFF standards may have resulted in the following reductions: None</p>								

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
12/16/1997	Fredericton Airport, New Brunswick	CYFC	Landing-Veeroff	4800	1130	R	No	No	42	0	9
	<b>Country:</b> Canada			<b>ARFF Standards:</b> CAR Part III, Section 303							
	<b>Aircraft Involved:</b> Canadair 600			<b>Operator:</b> Canadair CL-6002B19							
	<b>Summary:</b>	Air Canada Flight 646, C-FSKI, departed Toronto-Lester B. Pearson International Airport, Ontario, at 2124 EST on a scheduled flight to Fredericton, New Brunswick. On arrival, the reported ceiling was 100 feet obscured, the visibility one-eighth of a mile in fog, and the runway visual range 1200 feet. The crew conducted a Category I instrument landing system 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. An evacuation was conducted; however, seven passengers were trapped in the aircraft until rescued. Of the 39 passengers and 3 crew members, 9 were seriously injured and the rest received minor or no injuries.									
	<b>Team Conclusion:</b>	On approach to the airport the Canadair CL-600 stalled when initiating a go around. It struck the runway and went off some 2100 feet before hitting a tree. The captain and 8 passengers were injured during the crash sequence. Seven passengers needed to be extricated from the aircraft by response personnel. There was no fire. A FSS specialist dispatched a firefighter to the runway to search for the aircraft. The airport maintenance foreman, who was listening to the radios, also joined in the search. The drivers searched unsuccessfully for the aircraft and for tracks the length of runway 15/33, off each side and each end, having to travel at slow speed because of the reduced visibility in dense fog. About 14 minutes after the crash, a driver spotted someone walking toward the runway and determined that he was a passenger, and that the aircraft had crashed and was west of the runway. A second airport firefighter arrived at the airport and took the Rapid Intervention Vehicle out to the runway to assist the firefighter from Red 3. The two firefighters discussed the requirement to extend a handline [fire hose] from a fire truck to the aircraft because of the leaking fuel. They tried to drive the Rapid Intervention Vehicle through the snow, but, as it was not designed to travel off roads in deep snow, it became stuck after driving only a few feet.									
		Changes in ARFF standards would have resulted in the following reductions: None									

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
3/22/1998	Bacolod Airport	BCD	Landing-Overrun	660			No	No	130	0	44
<b>Country:</b> Philippines			<b>ARFF Standards:</b> Annex 14 Category 9								
<b>Aircraft Involved:</b> Airbus 320			<b>Operator:</b> Phillipine Airlines								
<b>Summary:</b>			<p>Upon touchdown the first officer called out "no spoilers, no reverse, no decel". Engine No. 2 was set to full reverse thrust after touchdown, but the Engine No. 1 thrust lever was not retarded to idle and remained in the climb power position. Consequently, the spoilers did not deploy. Because one engine was set to reverse, the autothrust system automatically disengaged. With the autothrust disengaged, nr.1 engine thrust increased to climb thrust. Due to the asymmetrical thrust condition, the A320 ran off the right side of the runway. At this speed, rudder and nosewheel steering are ineffective. Engine No. 2 was moved out of reverse up to more than 70 percent N1 and the airplane swerved back onto the runway. The A320 continued past the runway end. The aircraft hit the airport perimeter fence and then jumped over a small river. It continued to slice through a hallow block fence where it went through several clusters of shanties and trees. No fire ensued after the crash.</p>								
<b>Team Conclusion:</b>			<p>During landing rollout, the A320 ran off the right side of the runway and continued past the runway end. The aircraft hit the airport perimeter fence and then jumped over a small river. It continued to slice through a hallow block fence where it went through several clusters of shanties and trees. No fire ensued after the crash on account of the timely arrival of the ATO Crash Fire Rescue Team with the assistance support of the Bacolod City Fire Brigade.</p> <p>Of the 130 people on board the aircraft, 44 sustained serious injuries from trauma during the crash sequence. There were no fatalities. The research team concluded that different ARFF standards would not have had any impact on the outcome of this accident since all serious injuries were attributed to trauma during the crash sequence.</p> <p>Changes in ARFF standards would have resulted in the following reductions: None</p>								

3/30/1998	Ft Lauderdale	KFLL	Takeoff-Taxied onto Taxiway				No	No	194	0	3
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**Country:** United States **ARFF Standards:** 14 CFR Part 139, Index E

**Aircraft Involved:** Boeing 727 **Operator:** Royal Airlines

**Summary:** On March 30, 1998, about 2114 eastern standard time, a Boeing 727-212, Canadian registration C-FRYS, registered to and operated by Royal Aviation, Inc., as flight 311, a Title 14 CFR Part 129, nonscheduled international passenger flight, from Fort Lauderdale, Florida to Toronto, Canada, experienced a failure of No. 2 engine during takeoff roll at Fort Lauderdale-Hollywood International Airport. At about 110 knots, the pilot aborted the takeoff, brought the airplane to a stop on a high-speed taxiway, and requested that the "engine fire on ground" and "aborted takeoff" checklists be read and accomplished. When the tower advised that smoke was still emanating from the engine tailpipe, the pilot commanded that a passenger emergency evacuation be accomplished, and that the "emergency evacuation" checklist be read and accomplished. The four fuselage doors and slides were used, as well as the four overwing exits. Fire rescue personnel stated that upon arrival at the aircraft they observed that some passengers had assembled on-wing at the wing-tips. They were directed back toward the wing root area by the first officer and fire rescue personnel on the ground, and that no one actually jumped from the wing tip area.

**Team Conclusion:** The aircraft aborted on takeoff after an engine failed. Pilot taxied off the runway onto a taxiway and decided to evacuate the aircraft when the Tower advised him that there was still smoke coming from the tailpipe of the engine. Of the 169 passengers on board, 3 people received serious injury, all by sliding off the wing, which does not have evacuation chutes in the emergency over-the-wing exits. Additionally, the ARFF arrival occurred during the evacuation process. It is doubtful that a change in ARFF standards would have made a difference in this case.

Changes in ARFF standards would have resulted in the following reductions: None

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
4/19/1998	Chicago-O'Hare	KORD	Apron				No	No	156	0	1
<b>Country:</b> United States		<b>ARFF Standards:</b> 14 CFR Part 139, Index E									
<b>Aircraft Involved:</b> Boeing 727		<b>Operator:</b> American Airlines									
<b>Summary:</b>		The cockpit crew was in the process of starting the Auxiliary Power Unit (APU) when passengers saw flames coming from the right engine. A passenger was heard to scream 'Fire' at which time the uncommanded evacuation was initiated by the passengers. The captain attempted to calm the passengers with a PA announcement. Passengers exited the airplane via the over wing exit, the rear airstair door, and the main entry door onto the jet bridge. A ten year old boy received a broken arm and two other passengers received minor leg and ankle injuries as they jumped off the wing.									
<b>Team Conclusion:</b>		In the report on the accident, there was no mention of ARFF activities. The crew was starting the APU when passengers saw flames coming from an engine. A passenger screamed "fire" and passengers initiated an evacuation. One passenger suffered a broken arm.									
		Changes in ARFF standards would have resulted in the following reductions: None									
5/12/1998	New Tokyo International	RNRT	Apron				No	No	365	0	4

**Country:** Japan**ARFF Standards:** Annex 14 Category Unknown**Aircraft Involved:** Boeing 747**Operator:** United Airlines**Summary:**

On May 2, 1998 a Boeing 747-400 of United Airlines experienced a torching from tailpipe of No. 1 engine on an apron shortly after pushback from the parking spot was commenced. Thereafter, an emergency evacuation using evacuation slides was conducted. Flight attendant initiated the evacuation. There was a breakdown in communication between flight crew and cabin crew. ARFF was not notified until after evacuation had begun. 4 female passengers ranging in age from 38 to 73 years old sustained various fractures during the evacuation. One person was injured by baggage coming down the slide that hit her.

**Team Conclusion:**

ARFF arrived when evacuation was underway. Stood by to apply agent to No. 1 engine but there was no sign of fire.

Since ARFF was not pre-deployed and they were not notified of the evacuation until after it began, the research team concluded that different ARFF standards would not have prevented any of the serious injuries.

Changes in ARFF standards would have resulted in the following reductions: None

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
6/18/1998	Mirabel/Montreal International	CYMX	Other	2500		L	Yes	Yes	11	11	0
	<b>Country:</b> Canada		<b>ARFF Standards:</b> CAR Part III, Section 303								
	<b>Aircraft Involved:</b> Swearingen 226-TC		<b>Operator:</b> Propair Inc								
	<b>Summary:</b>	The aircraft, a Fairchild-Swearingen Metro II (SA226-TC), registration C-GQAL, serial number TC 233, took off as Propair 420 from Dorval / Montreal International Airport, Quebec, around 0701 eastern daylight time bound for Peterborough Airport, Ontario. On board were nine passengers and two pilots. About 12 minutes after take-off, at an altitude of 12 500 feet above sea level (asl), the crew advised air traffic control (ATC) that they had a hydraulic problem and requested clearance to return to Dorval. ATC granted this request. Around 0719, at 8600 feet asl, the crew advised ATC that the left engine had been shut down because it was on fire. Around 0720, the crew decided to proceed to Mirabel / Montreal International Airport, Quebec. At 0723, the crew advised ATC that the engine fire was out. On final for Runway 24, the crew advised ATC that the left engine was again on fire. The landing gear was extended on short final, and when the aircraft was over the runway, the left wing broke upwards. The fuselage pivoted more than 90° to the left around the longitudinal axis of the aircraft and struck the ground. All 11 occupants were fatally injured.									
	<b>Team Conclusion:</b>	The accident report stated that all 11 occupants suffered fatal injuries when the Metro II impacted the ground. ARFF response was not a factor.									
	Changes in ARFF standards would have resulted in the following reductions: None										
12/26/1998	Dallas-Ft.Worth	KDFW	Other				No	No	50	0	1

**Country:** United States**ARFF Standards:** 14 CFR Part 139, Index E**Aircraft Involved:** McDonnell Douglas 88**Operator:** Delta Airlines

**Summary:** The flight crew neglected to turn the ignition switch on during a delayed right engine start prior to taking the active runway for departure. During the second attempt to start the engine, an overtemp occurred and a tailpipe fire ensued. Tower personnel observed flames coming out of the exhaust stack and alerted the flight crew. The flight crew reported that they had experienced a 'hot start,' but according to their indications in the cockpit, the fire was out. The flight crew of an airplane in sequence behind the jet reported that the fire lingered in the exhaust. Personnel in the control tower confirmed that the engine was still on fire. The captain commanded an evacuation from the two doors on the left side of the airplane. All passengers were off the aircraft within 20 seconds of slide deployment. A passenger slid down the aft door slide past the awaiting crew members, twisting her right ankle. Subsequent medical reports and X-rays revealed she sustained a hairline fracture of a bone in her right ankle.

**Team Conclusion:** The evacuation of the 50 occupants was completed within 20 seconds of slide deployment, before ARFF arrived at the aircraft. The single serious injury, a hairline ankle fracture, occurred during the evacuation.

Changes in ARFF standards would have resulted in the following reductions: None

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
3/31/1999	St. John's Airport, Newfoundland	CYYT	Apron				No	No	Unknown	0	1
	<b>Country:</b> Canada		<b>ARFF Standards:</b> CAR Part III, Section 303								
	<b>Aircraft Involved:</b> Boeing 767		<b>Operator:</b> Air Canada								
	<b>Summary:</b>		Air Canada Flight 861 arrived in St. John's, Newfoundland, from London, England. As there is no direct access to the customs area from the company passenger bridge at the St. John's Airport, the aircraft was marshalled to a gate on the open ramp. A passenger stand was positioned at door L1 of the aircraft and two employees ascended the stairs to open the aircraft door and position the side gates. After approximately 10 to 12 passengers had exited the aircraft, a flight attendant carrying an infant in a car seat deplaned. When the flight attendant stepped on the passenger stand, he noticed that it was descending slowly away from the aircraft. He turned to tell the in-charge flight attendant, but at the same time as he turned, the infant's five-year old brother, who was following with his mother, stepped out and fell between the aircraft and stairs to the apron below. The child suffered a broken arm and lacerations to the head in the fall and was taken to the hospital for treatment and observation.								
	<b>Team Conclusion:</b>		There is no mention of ARFF involvement.								
			Changes in ARFF standards would have resulted in the following reductions: None								
5/8/1999	John F Kennedy International	KJFK	Landing-Overrun	350		CL	No	No	30	0	1

**Country:** United States

**ARFF Standards:** 14 CFR Part 139, Index E

**Aircraft Involved:** Saab 340

**Operator:** American Eagle

**Summary:**

On May 8, 1999, at 0701:39 Eastern Daylight Time, a Saab 340B, N232AE, sustained substantial damage during landing at John F. Kennedy International Airport (JFK), Jamaica, New York. The airplane was owned by AMR Leasing Corporation, and operated by American Eagle Airlines Inc. as flight 4925. There were no injuries to 3 crewmembers and 26 passengers, while 1 passenger sustained a serious injury.

**Team Conclusion:**

The airplane overran the runway during landing and came to rest in the passive arresting system of cellular cement. The aircraft was substantially damaged but there was no fire. One passenger fractured fibula while exiting aircraft resulting in a serious injury. Although it is fair to assume that ARFF responded to the accident, there is no mention of ARFF in the accident report.

The aircraft evacuation would have been completed before any ARFF units arrived on the accident site; therefore different ARFF standards would not have had any impact on the outcome of this accident.

Changes in ARFF standards would have resulted in the following reductions: None

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
6/1/1999	Little Rock National	KLIT	Landing-Overrun	800			No	Yes	145	11	45

**Country:** United States

**ARFF Standards:** 14 CFR Part 139, Index C

**Aircraft Involved:** McDonnell Douglas 9

**Operator:** American Airlines

**Summary:**

On June 1, 1999, at 2350:44 central daylight time, American Airlines flight 1420, a McDonnell Douglas DC-9-82 (MD-82), N215AA, crashed after it overran the end of runway 4R during landing at Little Rock National Airport in Little Rock, Arkansas. After departing the end of the runway, the airplane struck several tubes extending outward from the left edge of the instrument landing system (ILS) localizer array, located 411 feet beyond the end of the runway; passed through a chain link security fence and over a rock embankment to a flood plain, located approximately 15 feet below the runway elevation; and collided with the structure supporting the runway 22L approach lighting system. The captain and 10 passengers were killed; the first officer, the flight attendants, and 105 passengers received serious or minor injuries; and 24 passengers were not injured. The airplane was destroyed by impact forces and a postcrash fire.

**Team Conclusion:**

The aircraft overran the runway and hit non-frangible structures for the approach light system. The fuselage broke apart and several passengers exited the aircraft through these openings. Of the 145 people on board, there were 11 fatalities and 45 people who sustained serious injuries. Six of the fatalities were due to impact trauma and five were due to thermal injuries or smoke inhalation. The accident report does not contain any information on how the 45 people were seriously injured. ARFF had difficulty locating the accident site since visibility was limited and the controller's description could not be precise.

In its analysis, the NTSB determined that the accident was potentially survivable for two of the passengers that died; but that even with a shorter ARFF response time, the lives of these two passengers would not have been saved if emergency responders had arrived on the scene earlier. In one case, the passenger would have had to evacuate the aircraft immediately and, in the second case, the ARFF response team would have had to enter the aircraft instead of first suppressing the fire.

Given the limited visibility and the imprecise accident location, any ARFF response to this accident would have to overcome the limited visibility and the imprecise information on the accident location in order to rescue the two potential survivors identified by the NTSB. Based on the NTSB's analysis, the research team concluded that different ARFF standards would not have saved anyone's life in this accident. Since the accident report did not include any information on the serious injuries or how they were sustained the research team could not make any determinations on them.

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
8/22/1999	Hong Kong International	HKG	Landing-Veeroff	3775	325	R		Yes	315	3	50
<b>Country:</b> China				<b>ARFF Standards:</b> Annex 14 Category 9							
<b>Aircraft Involved:</b> McDonnell Douglas 11				<b>Operator:</b> China Airlines							
<b>Summary:</b>		China Airlines Flight 642, enroute from Bangkok to Taipei with Hong Kong as its intermediate stop, crashed while landing at Hong Kong International Airport. At the time the weather was under the influence of Severe Tropical Storm 'Sam' with the associated strong gusting wind from the northwest and heavy rain. As it touched down on the wet runway the hard impact caused the MD-11 aircraft's right main landing gear to collapse, followed immediately by the separation of the right wing and an outbreak of fire. It finally came to rest inverted on a grassy area to the right of the runway. As the result of the accident 3 passengers died and 219 persons (includes passengers and crew members) were admitted to the hospital with 50 suffering serious injuries and the rest sustaining minor injuries.									
<b>Team Conclusion:</b>		The aerodrome has 2 fire stations each equipped with 7 ARFF vehicles and 1 ambulance. The equipment consisted of 2 rapid intervention vehicles, 2 major foam tenders, 2 hose foam carriers and 1 snorkel. The number of personnel is not specified anywhere in the report but would number at about 14 at a minimum, assuming 1 person per vehicle.									
		The 14 vehicles arrived within 1 minute of the alarm which was sounded before the aircraft came to a rest. 50 people (6 crew and 44 passengers) suffered serious injuries from fire, impact and trying to evacuate the aircraft which was upside down.									
		Changes in ARFF standards would have resulted in the following reductions: None									

8/24/1999	Hualien Airport	HUN	Landing-Remained on Runway	6300	0	CL		Yes	96	1	13
<b>Country:</b> Republic of China				<b>ARFF Standards:</b> Annex 14 Category 7							
<b>Aircraft Involved:</b> McDonnell Douglas 90				<b>Operator:</b> UNI Airways							
<b>Summary:</b>		At 12:36 on August 24, 1999, local time (04:36 UTC), UNI AIR Flight No. 873 (serving Taipei - Hualien) had just landed and was rolling on Runway 21 at the Hualien Airport, when a explosion was heard in the front section of the passenger cabin, followed by smoke and then fire. The pilot immediately braked and brought the aircraft to a stop on the runway. Then, after lowering the passenger evacuation slides and initiating an emergency passenger evacuation, the pilot proceeded to call the tower for help. Upon receiving this call, fire squads at both the Hualien Airport and the Air Force Wing rushed to the scene to extinguish the fire. The fire was eventually put out at 13:45. While the upper part of the fuselage was completely destroyed, 90 passengers plus the crew of 6 was safely evacuated. Casualties included 14 seriously wounded passengers and another 14 that suffered minor injuries. Most of the wounded passengers suffered burns. Fragments produced by the explosion struck 1 passenger.									
<b>Team Conclusion:</b>		The explosion in the passenger cabin occurred just after landing when flammable vapors from gasoline in an overhead compartment were ignited by a motorbike battery in a nearby compartment. The fire progressed rapidly and 13 passengers sustained serious burn and explosion injuries. One other passenger with extensive burns died 47 days after the accident. ARFF responded promptly but all of the injuries had already occurred.									
		Changes in ARFF standards would have resulted in the following reductions: None									



Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
9/14/1999	Girona Airport	GRO	Landing-Veeroff	7454	508	R	No	No	245	1	2

**Country:** Spain

**ARFF Standards:** Unknown

**Aircraft Involved:** Boeing 757

**Operator:** Britannia Airways

**Summary:**

The aircraft made an approach and landing at Girona Airport, Spain, at night through heavy thunderstorms with rain. At a late stage of the approach the airfield lighting failed for a few seconds. The aircraft touched down hard simultaneously on the nose and mainwheels and bounced. A second harder touchdown on the nosewheel displaced the nose landing gear and its support structure. Resultant aircraft systems damage caused the loss of virtually all electrical power, interference with controls and uncommanded forward thrust increase. The aircraft ran off the side of the runway at high speed around 1,000 metres after the second touchdown. After crossing a number of obstacles it landed heavily in a field outside the airfield boundary and came to rest after having traveled almost 1,900 metres from the second touchdown. The fuselage had been fractured in two places and there was considerable disruption to the cabin. There was no fire. Evacuation of all the occupants, initiated by the cabin crew, was completed rapidly. Emergency services had difficulty in locating the aircraft in the adverse conditions and arrived on the scene after evacuation had been completed.

**Team Conclusion:**

Emergency services had difficulty in locating the aircraft in the adverse conditions and arrived on the scene after evacuation had been completed. Some 18 minutes after the accident, the passengers and the main part of the aircraft were located, on the right side of Runway 20, outside the airport perimeter fence. After a further delay in gaining access, rescue of the passengers and assistance for those who had been injured started. Two passengers were seriously injured during the crash impact. A third passenger who was initially admitted to hospital with apparently minor injuries was discharged the following day. He died five days later as a result of unsuspected internal injuries.

The research team concluded that different ARFF standards would not have had any impact on the outcome of this accident.

Changes in ARFF standards would have resulted in the following reductions: None

3/5/2000	Burbank-Glendale-Pasadena Airport	KBUR	Landing-Overrun	350	150	R	No	No	142	0	2
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**Country:** United States

**ARFF Standards:** 14 CFR Part 139, Index C

**Aircraft Involved:** Boeing 737

**Operator:** Southwest Airlines

**Summary:**

On March 5, 2000, about 1811 Pacific standard time (PST), Southwest Airlines, Inc., flight 1455, a Boeing 737-300 (737), N668SW, overran the departure end of runway 8 after landing at Burbank-Glendale-Pasadena Airport (BUR), Burbank, California. The airplane touched down at approximately 182 knots, and about 20 seconds later, at approximately 32 knots, collided with a metal blast fence and an airport perimeter wall. The airplane came to rest on a city street near a gas station off of the airport property. Of the 142 persons on board, 2 passengers sustained serious injuries; 41 passengers and the captain sustained minor injuries; and 94 passengers, 3 flight attendants, and the first officer sustained no injuries. The airplane sustained extensive exterior damage and some internal damage to the passenger cabin. Visual meteorological conditions (VMC) prevailed at the time of the accident, which occurred in twilight lighting conditions.

**Team Conclusion:**

Considering that the aircraft came to rest off the airport property, ARFF response was prompt and adequate. Although there were 142 persons on board there were only two serious injuries. There was no information in the investigation reports that indicated whether the serious injuries were due to impact or occurred during the evacuation.

Changes in ARFF standards would have resulted in the following reductions: None

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
5/25/2000	Charles De Gaulle	CDG	Runway Collision	5675	40	L	No	Yes	159	1	1

**Country:** France

**ARFF Standards:** Regulatory Part Book II, Chapter III

**Aircraft Involved:** McDonnell Douglas 83 & Shorts 330

**Operator:** SA Air Liberte / Streamline Aviation

**Summary:**

The MD 83 registered F-GHED was cleared to take off from runway 27 at Paris Charles de Gaulle. The Shorts 330 registered G-SSWN was then cleared to line up and to wait as “number two”. The controller believed that the two aircraft were at the threshold of the runway, whereas the Shorts had been cleared to use an intermediate taxiway. The Shorts entered the runway at the moment the MD 83 was reaching its rotation speed. The tip of the MD 83’s left wing went through the Shorts 330’s cockpit and hit both pilots. The MD 83 aborted its takeoff.

**Team Conclusion:**

An Air Liberte MD 83 and a Shorts 330 collided on the ground due to a misunderstanding of controller instructions. The Shorts entered runway 27 as the MD 83 was approaching rotation speed. The left wingtip of the MD 83 struck the Shorts cockpit on killing the copilot and injuring the pilot. The MD aborted its takeoff. There was no fire or fuel leakage.

Changes in ARFF standards would have resulted in the following reductions: None

10/31/2000	Chiang- Kai-Shek International	TPE	Other	6900	75	L	No	Yes	179	83	39
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**Country:** Republic of China

**ARFF Standards:** Annex 14, Category 9

**Aircraft Involved:** Boeing 747

**Operator:** Singapore Airlines

**Summary:**

On October 31, 2000, approximately 2317 Taiwan time (1517 UTC), a Singapore Airlines Flight SQ006, with Singapore registration 9V-SPK, Boeing 747-400 airplane entered the incorrect runway at Chiang- Kai-Shek(CKS) Airport, Taiwan. Heavy rain and strong wind from typhoon “Xiang Sane” prevailed at the time of the accident. The airplane was destroyed by its collision with the runway construction equipment and by post impact fire.

**Team Conclusion:**

Chiang Kai Shek International Airport on Taiwan is an ICAO Category 9 aerodrome. The accident involved Singapore Airlines Flight 006 departing to Los Angeles, CA in rain storm. The flights had on board 3 flight crew members, 17 cabin crew, and 159 passengers. There were 83 fatalities, at least 1 from trauma, at least 6 due to smoke or fire and 76 due to unknown causes. [There were only 7 autopsies completed.], and 39 serious injuries.

There are 2 fire stations located on the airport. However, the north station was closed for maintenance and its 2 fire trucks were stationed at the domestic terminal which was located southwest of runways 05L and 05R. The south station had 2 rapid intervention vehicles, 4 foam tenders, 1 nurse truck, 4 ambulances and 2 lighting units. There were 32 ARFF personnel on duty at the time. Response was immediate but hampered somewhat by weather.

There was intense fire but firefighters were able to rescue several people. Most injuries were sustained during the impact and the ensuing fires that erupted immediately after impact.

Due to the lack of information on the cause of fatalities and serious injuries the research team does not believe they can estimate reductions for either of these factors from a change in ARFF standards.

Changes in ARFF standards may have resulted in the following reductions: Undetermined

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
11/20/2000	Miami International	KMIA	Landing-Taxied onto Taxiway				Unknown	No	133	1	3
	<b>Country:</b> United States		<b>ARFF Standards:</b> 14 CFR Part 139, Index E								
	<b>Aircraft Involved:</b> Airbus 300		<b>Operator:</b> American Airlines								
	<b>Summary:</b>		<p>On November 20, 2000, about 1222 eastern standard time, an Airbus Industrie A300B4-605R, N14056, registered to Wilmington Trust Company, and operated by American Airlines, Inc., as flight 1291, a Title 14 CFR Part 121 scheduled international passenger flight, from Miami, Florida, to Port Au Prince, Haiti, had a flight attendant receive fatal injuries during an emergency evacuation after the flight returned to Miami. Visual meteorological conditions prevailed at the time and an instrument flight rules flight plan was filed. The aircraft received minor damage and the airline transport-rated pilot, first officer, 5 flight attendants, 3 other crewmembers, and 100 passengers were not injured. One flight attendant received fatal injuries, 3 passengers received serious injuries, and 1 flight attendant and 18 passengers received minor injuries.</p> <p>Shortly after landing, the airplane stopped on the taxiway and the flight crew requested fire personnel to inspect the exterior of the airplane for any visible evidence of fire. At about 1220, after being cleared to taxi to the ramp, a flight attendant called the captain on the intercom and reported a smell of smoke in the middle lavatory. She said it smelled like rubber burning. Immediately following this communication, the captain stated that he noticed that one of the cargo compartment fire detection loop lights was illuminated. He informed the ground controller, "we have a fire and we are going to evacuate right here."</p> <p>The flight attendants experienced difficulty opening the cabin doors when the emergency evacuation was initiated. The captain was notified of this difficulty. While the captain was evaluating the problem, he said he heard a "whoosh" sound and then the cabin doors opened, emergency slides deployed and passengers evacuated the airplane.</p>								
	<b>Team Conclusion:</b>		<p>Due to pressurization problems, the aircraft returned to Miami and requested ARFF. No fire was reported in or around the aircraft. As they began to taxi to the gate, one of the cabin crew reported a smell of smoke and the pilot noticed a cargo compartment fire detection light illuminated. He ordered an evacuation but the doors failed to open. Suddenly there was an explosive decompression with one of the flight attendants being ejected from the aircraft.</p> <p>Since the ARFF equipment was initially on scene, all or part of the equipment would have followed the aircraft as it taxied to the gate. The firefighters may have aided the passengers during the evacuation. However, since the flight attendant was ejected from the aircraft due to the explosion, it is doubtful that the presence of ARFF could have prevented the fatality.</p> <p>Changes in ARFF standards would have resulted in the following reductions: None</p>								

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
2/7/2001	Bilbao Airport	BIO	Landing-Remained on Runway	4000	100	L	No	No	143	0	1

**Country:** Spain

**ARFF Standards:** Unknown

**Aircraft Involved:** Airbus 320

**Operator:** Iberia

**Summary:**

The aircraft Airbus A-320-B, registered EC-HKJ and operated by IBERIA was on a commercial flight from Barcelona to Bilbao on February 7th, 2001. It found turbulent conditions during the approach phase to its destination at around 22:00 h UTC. On the final approach phase flying below 200 ft radio-altitude the aircraft encountered strong and changing vertical and horizontal gusts while descending at a rate of around 1,200 ft/min (6 m/s). The aeroplane did not respond to the pilots' commands on the controls to pitch up the aircraft and to reduce the vertical speed on the flare, causing the aircraft to impact against the threshold of the runway in a slight nose-down attitude. Upon impact, the nose landing gear collapsed, but the aircraft remained within the runway and stopped after 1,100 meters of landing run with all four main gear tires burst. An emergency evacuation was carried out. A passenger was seriously injured and several other occupants received some bruises and injuries produced during the evacuation of the aircraft. The internal structural damages of the airframe were beyond economically viable repair and the aircraft was written off.

**Team Conclusion:**

The aeroplane did not respond to the pilots' commands on the controls to pitch up the aircraft and to reduce the vertical speed on the flare, causing the aircraft to impact against the threshold of the runway in a slight nose-down attitude. Upon impact, the nose landing gear collapsed, but the aircraft remained within the runway. There were some reports of possible confusion during the evacuation. Inside the aircraft there was a group of around 40 elderly people who were reportedly run over by the younger passengers that did not respect orders or follow procedures. A passenger was seriously injured and several other occupants received some bruises and injuries produced during the evacuation of the aircraft.

There was no fire. The Firefighting Service (SEI) entered the runway within 40 seconds and went to the area where the aircraft stopped. They positioned a vehicle at either side of the aeroplane, and sprayed the landing gears and the engines with retardant foam.

Changes in ARFF standards would have resulted in the following reductions: None

10/8/2001	Milano-Linate	LIN	Runway Collision	1510	165	R	No	Yes	114	114	0
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**Country:** Italy

**ARFF Standards:** Annex 14 Category 8

**Aircraft Involved:** McDonnell Douglas 87 & Cessna 525

**Operator:** SAS / Private Aircraft

**Summary:**

On October 8, 2010 a Boeing MD-87 operated by SAS while on takeoff run on Runway 36R at Milano Linate airport collided with a Cessna 525-A which taxied onto the active runway. After the collision the MD-87 continued travelling down the runway, the aircraft was airborne for a short while, and came to a stop impacting a baggage handling building. The Cessna 525 A which was coming from the West Ramp, remained on the runway and was destroyed by the post-impact fire. The occupants of the two aircraft and four ground staff working inside the building suffered fatal injuries. Four more ground staff suffered injuries and burns of various degrees.

**Team Conclusion:**

Until the ARFF responded to the reported building fire, no one was aware that an aircraft was involved. All persons on the MD 87 died from traumatic collision injuries. One person on the Cessna was killed by traumatic injuries and the other three by a combination of traumatic injuries and smoke absorption. It was almost 20 minutes after the collision before there was confirmation of the second aircraft involved. The Italian judicial magistrate found that there was no possibility that, given the fire exposure, the three smoke victims could have lived more than 3 minutes after the accident.

Changes in ARFF standards would have resulted in the following reductions: None

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
10/29/2001	Dulles International Airport	KIAD	Landing-Taxied onto Taxiway				Unknown	No	149	0	1
<b>Country:</b> United States		<b>ARFF Standards:</b> 14 CFR Part 139, Index E									
<b>Aircraft Involved:</b> Boeing 757		<b>Operator:</b> American Airlines									
<b>Summary:</b>		On October 29, 2001, about 1950 eastern standard time, a Boeing 757-223, N640A, operating as American Airlines flight 785, performed an unscheduled landing and emergency evacuation at Washington/Dulles International Airport, Dulles, Virginia, after a threatening note was found by a passenger. The note was immediately given to a flight attendant, who informed the flight crew of its contents. The flight crew reported that after they reviewed the note, they declared an emergency and diverted to Washington/Dulles International Airport. The airplane landed uneventfully at 1945, and was taxied onto a taxiway where the captain instructed the flight attendants to conduct an emergency evacuation using the slides. All eight slides deployed normally; however, during the evacuation, one passenger broke her ankle while exiting the bottom of the slide. She was transported to the hospital, treated for her injuries, and returned to the airport to continue on the flight.									
<b>Team Conclusion:</b>		There is no mention of ARFF involvement in the accident record. Since the captain declared an emergency, it is probable that ARFF was pre-deployed when the aircraft landed and present on the taxiway when the evacuation began. However, no information on how many firefighters were deployed or their location relative to the aircraft.									
		Changes in ARFF standards would have resulted in the following reductions: None									

11/30/2001	Skein Airport	ESNS	Landing-Veeroff	1250	400	L	No	No	13	0	1
<b>Country:</b> Norway		<b>ARFF Standards:</b> Annex 14, Category Unknown									
<b>Aircraft Involved:</b> British Aerospace Jetstream 31		<b>Operator:</b> European Executive Express									
<b>Summary:</b>		The company, European Executive Express AB (EEE), operated a route between Skien Airport Geiteryggen (ENSN) and Bergen Airport Flesland (ENBR) using the aircraft type Jetstream 31. On Friday, 3 November 2001, SE-LGA (radio call signal EXC 204) was on its way to Skien with a crew of two and 11 passengers. During the flight, ice was observed on the aircraft's wings, but the ice was considered to be too thin to be removed. During descent towards runway 19 at Geiteryggen the aircraft's ground proximity warning system (GPWS) sounded a total of three times. The aircraft was then in clouds and the crew did not have visual contact with the ground. The warnings, combined with somewhat poorly functioning crew coordination, resulted in the crew forgetting to actuate the system for removing ice from the wings. The subsequent landing at 1828 hrs was unusually hard, and several of the passengers thought that the aircraft fell the last few metres onto the runway. The hard landing caused permanent deformation of the left wing so that the left-hand landing gear was knocked out of position, and the left propeller grounded on the runway. The crew lost directional control and the aircraft skewed to the left and ran off the runway. The aircraft then hit a gravel bank 371 metres from the touchdown point. The collision with the gravel bank was so hard that the crew and several of the passengers were injured and the aircraft was a total loss.									
<b>Team Conclusion:</b>		ARFF response was prompt and adequate. The First Officer's injury (a broken ankle) was caused by impact with a gravel bank after the aircraft departed the runway.									
		Changes in ARFF standards would have resulted in the following reductions: None									

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
1/14/2002	Sultan Syarif Kasim II Airport	WIBB	Takeoff-Overrun	790	0	CL	No	No	103	0	1
	<b>Country:</b> Indonesia			<b>ARFF Standards:</b> Annex 14 Category Unknown							
	<b>Aircraft Involved:</b> Boeing 737			<b>Operator:</b> Lion Air							
	<b>Summary:</b>	On January 14, 2002, at 03:15 UTC a B737-200 registered PK-LID tried to take-off from Syarif Kasim II, Pekanbaru, Riau. Feeling the A/C was unable to leave the ground the flight crew aborted take-off, the aircraft went off the runway, hit the fences, and stopped at 240 m from the end of the runway 18.									
	<b>Team Conclusion:</b>	This Boeing 737 aircraft had 103 people on board (including the flight crew) when it crashed on takeoff, slid off the runway and hit a fence. The fire brigade responded to the crash bell in 1 minute 35 second. The men observed thick black smoke coming up from the detached No.1 engine that was under the aircraft belly. They responded by spraying with 11000 liters of water. The firemen observed that the passengers went out from the emergency exits while none of the slides were deployed.									
		The rear right door was 2m from the ground and the third attendant deemed it usable, but the emergency slide failed to inflate. Instead, the attendant allowed people to jump from the door to the ground. In the process, a woman broke her leg – the only serious injury sustained in the incident.									
		The evacuation started before the ARFF crews arrived and was in progress when they arrived. There was only 1 serious injury and that involved a passenger that jumped from the back door where the emergency chute did not deploy. It is doubtful that a change in ARFF standards would have prevented this injury.									
		Changes in ARFF standards would have resulted in the following reductions: None									

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
1/24/2002	Indianapolis	KIND	Taxiway				No	No	75	0	1
<b>Country:</b> United States			<b>ARFF Standards:</b> 14 CFR Part 139, Index D								
<b>Aircraft Involved:</b> McDonnell Douglas 9			<b>Operator:</b> Northwest Airlines								
<b>Summary:</b>			<p>A passenger suffered a broken wrist when he fell off the side of the slide during an emergency evacuation. The airplane was positioned near the end of the runway with the engines shut down during an air traffic control delay. After approximately 15 minutes, the flight crew was informed by ground control that they should start their engines, as they would probably be released for takeoff soon. The captain reported they were unable to start the right engine. They performed the "clearing procedure" and then went on to start the left engine with no problem. They then attempted to start the right engine again. Airport Rescue and Firefighting (ARFF) personnel who were parked near the airplane reported to air traffic control that there were smoke and flames coming from the right engine. ARFF requested that the flight crew begin evacuating the airplane. All of the passengers were directed to the front of the airplane and the evacuation took place using the 1L and 1R doors. A witness reported that the injured passenger stepped out of the airplane onto the slide. The passenger bounced down the slide and went over the side of the slide approximately four to five feet above the ground.</p>								
<b>Team Conclusion:</b>			<p>The investigation revealed that Airport Rescue and Firefighting (ARFF) personnel were parked in a vehicle near NW 1118. It was these ARFF personnel who first reported the smoke and flames coming from the No. 2 engine. ARFF personnel began relaying information to the airplane through ATC. Upon seeing the smoke and fire, ARFF requested that the pilot shut down the engine. The flight crew informed ARFF that they performed the engine fire checklist and discharged one of the fire suppressant bottles. ARFF reported that the smoke was continuing to come from the engine. The flight crew shut down the left (No. 1) engine and ARFF informed the flightcrew that there was a tug coming out to tow the airplane back to the hangar. ARFF then reported that flames were still visible in the No. 2 engine and they were going to apply fire-fighting agent to the engine. They requested that the flight crew begin evacuating the airplane. The flight crew initiated an evacuation. All of the passengers were directed to the front of the airplane and the evacuation took place using the 1L and 1R doors. One passenger exiting through 1R fell over the side of the slide and broke a bone in his arm and suffered ligament damage to his knee.</p>								

Changes in ARFF standards would have resulted in the following reductions: None

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
3/31/2002	Charlotte Douglas International	KCLT	Landing-Remained on Runway				Yes	No	245	0	5
	<b>Country:</b> United States		<b>ARFF Standards:</b> 14 CFR Part 139, Index D								
	<b>Aircraft Involved:</b> McDonnell Douglas 11		<b>Operator:</b> Delta Airlines								
	<b>Summary:</b>	The captain contacted Air Traffic Control (ATC) and told them that their No. 2 engine was on fire and that they intended to land at the nearest suitable field. ATC responded that Charlotte was 35 miles away with a 10,000 foot runway. He asked for radar vectors and an immediate descent into Charlotte. As they completed the descent and approach checklists he told the crew to expect an emergency evacuation upon landing and directed the first officer to so inform the flight attendants. The remainder of the approach, touchdown and landing roll occurred within normal parameters. He brought the airplane to a stop on the runway. The engine fire indication remained illuminated. They completed the items on the evacuation checklist. He then ordered an evacuation of the airplane.									
	<b>Team Conclusion:</b>	The ARFF crew had been notified and was standing by. Once aircraft had stopped, the pilot ordered an evacuation of the 245 people on board the aircraft.									
		Based on the information in the accident report and the excerpt from Survival Factors Factual Report in the docket, there were 13 firefighters at the scene and heavy rain was making the slides very slippery. Several of the serious injuries probably occurred before firefighters were in place to aid in the evacuation.									
		Changes in ARFF standards would have resulted in the following reductions: None									

8/11/2002	John F. Kennedy International	KJFK	Landing-Remained on Runway				Yes	Yes	386	0	2
	<b>Country:</b> United States		<b>ARFF Standards:</b> 14 CFR Part 139, Index E								
	<b>Aircraft Involved:</b> Boeing 747		<b>Operator:</b> Iberia Airlines								
	<b>Summary:</b>	The airplane sustained a No. 2 engine fire during the initial climb after takeoff and the flight crew performed an emergency landing, with a subsequent evacuation. During the evacuation, the slide/rafts at doors 4R and 5R did not operate as intended and all 369 passengers and 17 crewmembers evacuated through doors 1R, 2R, and 3R. Examination of the 4R slide/rafts revealed a fractured inflation hose in the area of the regulator end swivel wire groove. Examination of the 5R slide/raft did not disclose any abnormalities, which would have precluded normal operation.									
	<b>Team Conclusion:</b>	The aircraft returned and landed at JFK after sustaining an engine fire after takeoff. Landing was without incident, and the aircraft was met by five ARFF units. An evacuation of the 386 occupants was accomplished with one serious injury (a fractured ankle) occurring while using the escape slide, and another passenger suffering respiratory failure at the triage area in the terminal. There is no information in the accident report on how the fractured ankle was sustained, but it likely occurred on the escape slide.									
		Changes in ARFF standards would have resulted in the following reductions: None									



Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
8/28/2002	Phoenix-Sky Harbor	KPHX	Landing-Veeroff	7650	205	R		No	159	0	1
	<b>Country:</b> United States		<b>ARFF Standards:</b> 14 CFR Part 139, Index D								
	<b>Aircraft Involved:</b> Airbus 320		<b>Operator:</b> American West								
	<b>Summary:</b>	On August 28, 2002, at 1844 mountain standard time, an Airbus Industrie A320-231, N635AW, operating as America West Airlines flight number 794, landed on runway 08 at the Phoenix Sky Harbor International Airport, Phoenix, Arizona. While decelerating about midfield, the airplane veered right and exited off the side of the runway. Thereafter, the airplane crossed the apron area east of intersection B8 and experienced the separation of its nose gear strut assembly upon traversing the dirt infield area south of the runway, where it slid to a stop on its nose. The airplane was substantially damaged.									
	<b>Team Conclusion:</b>	Accident report does not describe how the passenger sustained the serious injury but apparently it occurred during the evacuation which was completed prior to ARFF arrival. On arrival at the scene ARFF personnel secured the scene, treated injured persons, consulted with crewmembers, and verified that all occupants had deplaned. There was no fire.									
		Changes in ARFF standards would have resulted in the following reductions: None									
11/9/2002	LaGuardia	KLGA	Apron				No	No	79	0	1

**Country:** United States

**ARFF Standards:** 14 CFR Part 139, Index D

**Aircraft Involved:** McDonnell Douglas 82

**Operator:** American Airlines

**Summary:**

On November 9, 2002, about 1350 eastern standard time, a McDonnell Douglas MD-82, N452AA, operated by American Airlines as flight 710, performed an emergency evacuation after landing at LaGuardia Airport, Flushing, New York. According to a representative of American Airlines, the airplane landed uneventfully and taxied toward the parking area. While waiting on the ramp, the flight crew started the airplane's auxiliary power unit (APU) and about 30 seconds later, the cabin began to fill with smoke. The captain ordered an emergency evacuation utilizing the airplane's four evacuation slides. All slides functioned normally; however, during the egress a passenger sustained a fractured bone in her right foot.

**Team Conclusion:**

There is no mention of ARFF in the accident record. Since problems did not occur until aircraft was on the ground, it is fair to assume that ARFF was not pre-deployed. It is doubtful even with revised ARFF standards that ARFF would have reached the aircraft before the evacuation was completed.

Changes in ARFF standards would have resulted in the following reductions: None

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
1/8/2003	Charlotte-Douglas International	KCLT	Other	7600	1650	L	No	Yes	21	21	
	<b>Country:</b> United States		<b>ARFF Standards:</b> 14 CFR Part 139, Index D								
	<b>Aircraft Involved:</b> Beech 1900D		<b>Operator:</b> US Airways Express								
	<b>Summary:</b>		On January 8, 2003, about 0847:28 eastern standard time, Air Midwest flight 5481, a Raytheon (Beechcraft) 1900D, N233YV, crashed shortly after takeoff from runway 18R at Charlotte-Douglas International Airport, Charlotte, North Carolina. The 2 flight crewmembers and 19 passengers aboard the airplane were killed, 1 person on the ground received minor injuries, and the airplane was destroyed by impact forces and a postcrash fire. Flight 5481 was a regularly scheduled passenger flight to Greenville-Spartanburg International Airport, Greer, South Carolina.								
	<b>Team Conclusion:</b>		The aircraft was destroyed and all of the occupants suffered fatal injuries on impact.								
	Changes in ARFF standards would have resulted in the following reductions: None										

3/6/2003	Tamanrasset Airport	TMR	Other	600		L	No	Yes	103	102	1
	<b>Country:</b> Algeria		<b>ARFF Standards:</b> Annex 14 Category 7								
	<b>Aircraft Involved:</b> Boeing 737		<b>Operator:</b> Air Algerie								
	<b>Summary:</b>		During takeoff from runway 02 at Tamanrasset Aguenar aerodrome, a sharp thump was heard just after rotation. The left engine had just suffered a contained burst. The airplane swung to the left. The captain took over the controls. The airplane lost speed progressively, stalled and crashed, with the landing gear still extended, about one thousand six hundred and forty-five meters from the takeoff point, to the left of the runway extended centerline.								
	The spilled fuel burst into flames on first impact with the ground. The airplane was completely ablaze when it stopped. In accordance with the procedures, the fire fighters were on standby. They set off as soon as they noticed that the airplane was in difficulty. The chief flight attendant was found collapsed over the center console (inside the cockpit). The other cabin attendants as well as the passengers were in their places, with seat belts attached. The severe fire that broke out immediately after impact left them no chance of survival.										
	<b>Team Conclusion:</b>		Boeing 737 with 2 flight crew, 4 cabin crew and 97 passengers had its left engine "burst" on takeoff from Tamanrasset Aguenar aerodrome in Algeria. The aircraft crashed on the airport and went through a fence. At the time of the accident, the airport had 3 ARFF trucks in service and at least 4 firefighters and one supervisor. According to the accident report, all but one passenger died on impact with no chance of survival. The lone survivor was ejected from the plane and was seriously injured.								
	Changes in ARFF standards would have resulted in the following reductions: None										

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
3/26/2003	LaGuardia	KLGA	Landing-Taxied onto Taxiway	4300		R	Unknown	No	83	0	1
<b>Country:</b> United States		<b>ARFF Standards:</b> 14 CFR Part 139, Index D									
<b>Aircraft Involved:</b> Boeing 717		<b>Operator:</b> Air Tran Airways									
<b>Summary:</b>		The Boeing 717 was on final approach when the display units (DUs) in the cockpit blanked, and the cockpit darkened. In addition smoke was smelled in the cockpit, and cabin. In the cabin, the emergency light illuminated for a few minutes, and then all lights extinguished and the cabin was dark. The landing gear was lowered. When the wing flaps were positioned to 40 degrees, a landing gear aural warning commenced and continued until power was removed after landing. The captain reported when the event initiated, he directed his vision outside the cockpit where it remained until after landing. The co-pilot reported that he also directed his vision outside of the cockpit in the final 20 seconds of approach. Neither pilot made use of the standby instruments or used a flashlight to check instruments. The captain commanded an emergency evacuation after he cleared the runway and stopped. When interviewed, the flight attendants reported that during the emergency evacuation, they did not check conditions outside of their doors prior to opening them. In addition, cabin emergency lighting was not turned on by the flight attendants, and the flight attendant at the tail cone station was unable to deploy her slide.									
<b>Team Conclusion:</b>		First Officer on a Boeing 717 aircraft declared an electrical emergency and requested ATCT to send equipment (ARFF) when aircraft was on approach. Based on the Survival Factors report, 8 ARFF units responded to the aircraft after its landing. At the Port Authority of New York and New Jersey airports, the police and the fire personnel are cross trained and basically form one department.									
		No details on serious injury other than it occurred during evacuation. Survival Factual reports state that a female passenger fractured her left ankle using the left forward exit. She was hospitalized for 7 days.									
		Changes in ARFF standards would have resulted in the following reductions: None									

4/16/2003	Dallas-Ft Worth International	KDFW	Taxiway				No	No	56	0	1
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**Country:** United States

**ARFF Standards:** 14 CFR Part 139, Index E

**Aircraft Involved:** McDonnell-Douglas 82

**Operator:** American Airlines

**Summary:**

On April 16, 2003, at 1158 central daylight time, a McDonald Douglas DC-9-82 (MD-82), N452AA, operating as American Airlines Flight 2439 (AAL 2439), was not damaged when it encountered smoke in the cabin while taxiing after landing at the Dallas/Fort Worth International Airport (DFW), Texas. During the evacuation of the aircraft, one passenger sustained minor lacerations and scrapes on the right hand, and another passenger sustained a broken right ankle. The passenger with the broken ankle underwent surgery for the injury, and was hospitalized for a period exceeding 48 hours.

**Team Conclusion:**

The captain ordered an evacuation on the taxiway after landing in response to a report of smoke in the cabin. Although ARFF was notified there is no mention of their response in the accident report. The single serious injury was a broken ankle sustained during the evacuation; it is unlikely that ARFF could have prevented the injury.

Changes in ARFF standards would have resulted in the following reductions: None

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
6/23/2003	Tampa International	KTPA	Apron				No	No	174	0	3
	<b>Country:</b> United States		<b>ARFF Standards:</b> 14 CFR Part 139, Index E								
	<b>Aircraft Involved:</b> Boeing 757		<b>Operator:</b> Delta Airlines								
	<b>Summary:</b>	The airplane was pushed back from the gate and the left engine was started with no discrepancies reported. During the starting of the right engine, numerous passengers saw torching aft of the tailpipe. A commotion ensued which drew the attention of three of the four flight attendants who reported seeing an orange glow either inside or outside the airplane. The captain later reported there were no abnormal engine indications in the cockpit, but he then secured the right engine. The captain secured the left engine after simultaneously noticing passengers on the ramp and illumination of entry door lights. A flight attendant reported a male passenger (who was bigger than her) approached her at door 2L and attempted to open the door by partially rotating the 2L door handle. The door did not open completely but was 'cracked.' The flight attendant eventually opened the door fully and locked it against the fuselage. The male passenger exited immediately, followed by several other passengers. She then opened the 2R door and passengers exited it as well. Passengers also evacuated the airplane via the 3L and 3R doors, which a flight attendant opened.									
	<b>Team Conclusion:</b>	On pushback from gate, flight attendants reported glow near right engine. A male passenger initiated an evacuation and flight attendants opened other doors and deployed slides. ATC notified ARFF resulting in large response by 12 ARFF personnel and eight vehicles, which on arrival found approximately 150 passengers on ramp moving to the terminal. There were three serious injuries from evacuation. There was no fire.									
		Changes in ARFF standards would have resulted in the following reductions: None									

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
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7/2/2003	Sydney Aerodrome	SYD	Apron					Yes	368	0	5
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**Country:** Australia **ARFF Standards:** CASR 139.H

**Aircraft Involved:** Boeing 747 **Operator:** QANTAS

**Summary:** On 2 July 2003, the Boeing 747-438 aircraft, registered VH-OJU, operating on a scheduled flight from Singapore, arrived at Sydney at 0511 Eastern Standard Time, during the airport's curfew period. There was a tailwind of around 12 knots when the aircraft landed. The pilot flying selected auto brake setting three and idle reverse thrust in accordance with the curfew requirement. However, during the landing roll the reverse thrust was inadvertently de-selected. On arrival at the terminal, the pilot in command (PIC) observed a BRAKE TEMP advisory message and notified the ground engineers. At that point, a fire ignited on the right wing landing gear. The flight crew were advised and the PIC ordered an evacuation of the aircraft. On receiving the evacuation announcement, the cabin crew commenced the evacuation drill deploying the aircraft's escape slides. The upper deck left (UDL) door and doors 2 left (L2) and 4 right (R4) escape slides, did not deploy. During the evacuation, the over-wing slide at door right 3 (R3) deflated while in use. As a result of the evacuation, one flight crew member and three passengers were seriously injured.

**Team Conclusion:** ARFF alerted through ATCT and arrived within four minutes of being notified. Aircraft was evacuated by time ARFF arrived.

According to terminal surveillance video, the evacuation of passengers was completed within 90 seconds. One flight crew member and three passengers were seriously injured. The most serious injury was to the passenger seated on the right (R3) over-wing slide at the time it deflated. Landing heavily on the tarmac she received a fractured vertebra that required surgery. One passenger sustained a fracture to her arm and another fractured her foot. Both were as a result of using the escape slides. The copilot, on descending the upper deck right (UDR) slide, holding a 3 kg BCF fire extinguisher, found that he was unable to control his speed and stability. During his descent he released the fire extinguisher, but momentum propelled him forward, subsequently landing heavily on his shoulder, fracturing his collar bone.

The research team concluded that different ARFF standards would not have had any impact on the outcome of this accident since the aircraft evacuation was completed in 90 seconds and ARFF was not pre-deployed. Furthermore, it is doubtful that even if ARFF was on site that the injuries to the passenger on the collapsed slide or the co-pilot would have been avoided.

Changes in ARFF standards would have resulted in the following reductions: None

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
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12/4/2003	Bodø Airport	ENBO	Landing Undershoot	185	32	R	Yes	No	4	0	2
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**Country:** Norway **ARFF Standards:** Annex 14 Category 6  
**Aircraft Involved:** Dornier 228 **Operator:** Kato Airlines

**Summary:** Kato Airline flight KAT603, an aircraft of the type Dornier 228-202 with registration LN-HTA, was to fly a regular scheduled flight from Røst airport (ENRS) to Bodø airport (ENBO). There were two passengers and two pilots on board. There was a strong westerly wind, and when the plane approached Bodø extensive lightning activity developed quickly. The lightning struck the aircraft's nose area and passed to the tail. The only connection between the control column in the cockpit and the elevator was lost. This aircraft type has electric pitch trim which adjusts the tail surface angle of attack and after a period the pilots regained limited control of the aircraft's nose position by using this. The pilots declared an emergency. The aircraft's remaining systems were intact and the pilots succeeded in bringing the plane in for landing. During the first landing attempt the airspeed was somewhat high. The aircraft hit the ground in an approximate three-point position and bounced into the air. The pilots concluded that the landing was uncontrollable because the elevator was not working. The landing was aborted and the aircraft circled for a new attempt. Wind conditions were difficult and the next attempt was also unstable in terms of height and speed. At short final the aircraft nosed down and the pilots barely managed to flare a little before the aircraft hit the ground. The point of impact was a few metres before the runway and the aircraft slid onto the runway. Emergency services quickly arrived at the scene. The two pilots were seriously injured while both passengers suffered only minor physical injuries. No fuel leakage or fire occurred. The aircraft was written off.

**Team Conclusion:** The aircraft had been struck by lightning, resulting in a failure of the elevator control rod. The crew managed to land the aircraft using the electric pitch trim, but the landing was very hard and both pilots sustained serious spinal compression injuries. ARFF had been alerted before the aircraft landed and responded promptly.

Changes in ARFF standards would have resulted in the following reductions: None

5/9/2004	Luis Muñoz Marin International	KSJU	Landing-Veeroff	4317	217	L	No	No	26	0	1
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**Country:** United States **ARFF Standards:** 14 CFR Part 139, Index D  
**Aircraft Involved:** ATR 72 **Operator:** American Eagle

**Summary:** On May 9, 2004, about 1450 Atlantic standard time, Executive Airlines (doing business as American Eagle) flight 5401, an Avions de Transport Regional 72-212, N438AT, skipped once, bounced hard twice, and then crashed at Luis Muñoz Marin International Airport, San Juan, Puerto Rico. The airplane came to a complete stop on a grassy area about 217 feet left of the runway 8 centerline and about 4,317 feet beyond the runway threshold. The captain was seriously injured; the first officer, 2 flight attendants, and 16 of the 22 passengers received minor injuries; and the remaining 6 passengers received no injuries. The airplane was substantially damaged.

**Team Conclusion:** Although not officially pre-deployed, an ARFF specialist in an ARFF vehicle was sitting off to the side about 1500 feet from the approach end of Runway 8. He saw the plane bounce. After the second bounce, the plane pitched up sharply. He alerted the ARFF station and started to follow the plane. When the plane stopped, he arrived and he saw black and white smoke coming from the left engine so he hosed it down. There was no fire. The flight attendant indicated that when she opened the rear door for the evacuation that ARFF personnel were waiting outside the aircraft and assisted people off the aircraft. Four additional ARFF vehicles and 5 additional ARFF personnel responded to the accident. Mutual aid units were on site within 20 minutes of the accident (five more trucks and 11 EMT's).

Only the captain sustained serious injuries. His seat failed which probably resulted in him not being properly restrained and led to his serious injuries. A different ARFF response would not have prevented this injury.

Changes in ARFF standards would have resulted in the following reductions: None

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
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12/29/2004	Austin-Bergstrom International	KAUS	Landing-Remained on Runway				Yes	No	60	0	1
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**Country:** United States

**ARFF Standards:** 14 CFR Part 139, Index D

**Aircraft Involved:** Bombardier CL-600

**Operator:** Mesa Airlines

**Summary:**

During the takeoff roll, both flight attendants observed a haze in the cabin. As the airplane rotated and began to climb, the haze thickened. At approximately 500 feet above ground level, the smoke detector in the rear lavatory sounded, the "smoke toilet" message was displayed in the cockpit, and a strong odor of smoke was present. The captain declared an emergency and returned to the airport. According to a statement provided by the flight attendants, after a safe and uneventful landing, the captain ordered an emergency evacuation utilizing the airplane's four exits. A passenger exited the airplane through a window exit and fractured a bone in her right foot. Company maintenance personnel examined the airplane and "found that an air conditioning pack had failed," which would have resulted in a haze in the cabin.

**Team Conclusion:**

It can be assumed that ARFF was deployed as the captain had declared an emergency. There was no fire. ARFF team controlled scene until plane was towed to gate. During the emergency evacuation there was one serious injury.

Changes in ARFF standards would have resulted in the following reductions: None

3/20/2005	Raleigh Durham International	KRDU	Landing-Remained on Runway				Yes	No	32	0	1
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**Country:** United States

**ARFF Standards:** 14 CFR Part 135, Index D

**Aircraft Involved:** Embraer 135LR

**Operator:** American Eagle

**Summary:**

According to the captain, shortly after takeoff there was a foul oil smell spreading throughout the cockpit and cabin. The captain declared an emergency and returned to Raleigh Durham International Airport. The flight was cleared for an approach to and an emergency landing on runway 23R. After the airplane stopped on the runway, the captain ordered an emergency evacuation of the airplane. The flight attendant opened the passenger cabin door and the forward galley door and passengers evacuated the airplane. During the evacuation, one passenger received serious injuries.

**Team Conclusion:**

ARFF is not mentioned in the accident report. Assumption is that since the captain declared an emergency that ARFF was pre-deployed. This assumption is supported by statement in captain's report that mentions aircraft on ground was under control of Crash Fire Rescue. Flight Attendant's report also mentions that ARFF was present. No information as to how many firefighters were present.

Evacuated through main cabin door. Passenger sat and jumped down from main door and sustained a compound fracture to one of her legs when she hit ground.

Changes in ARFF standards would have resulted in the following reductions: None

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
5/10/2005	Minneapolis-St Paul	KMSP	Apron				No	No	145	0	1
	<b>Country:</b> United States		<b>ARFF Standards:</b> 14 CFR Part 139, Index E								
	<b>Aircraft Involved:</b> McDonnell-Douglas 9 & Airbus 319		<b>Operator:</b> Northwest								
	<b>Summary:</b>	On May 10, 2005, at 1936 central daylight time, a McDonnell Douglas DC-9-51, N763NC, collided with an Airbus A-319-114, N368NB, during taxi into the gate resulting in substantial damage to both airplanes near gate G10, at Minneapolis/St. Paul International Airport (MSP), Minneapolis, Minnesota. Visual meteorological conditions prevailed at the time of the accident. Both airplanes were evacuated after the collision. The DC-9 captain received serious injuries.									
	<b>Team Conclusion:</b>	The DC-9 had lost hydraulic pressure but landed without incident. During taxi to the gate, the DC-9 struck the A319's right wing from behind, resulting in the one serious injury to the DC-9 captain. Both aircraft were evacuated and ARFF responded after the collision. There were no other serious injuries.									
	Changes in ARFF standards would have resulted in the following reductions: None										
8/2/2005	Toronto- Lester B. Pearson	CYYZ	Landing-Overrun	1000	0	CL	No	Yes	309	0	12

**Country:** Canada**ARFF Standards:** CAR Part III, Section 303**Aircraft Involved:** Airbus 340**Operator:** Air France**Summary:**

The Air France Airbus A340-313 aircraft (registration F-GLZQ, serial number 0289) departed Paris, France, at 1153 Coordinated Universal Time (UTC) as Air France Flight 358 on a scheduled flight to Toronto, Ontario, with 297 passengers and 12 crew members on board. On final approach, they were advised that the crew of an aircraft landing ahead of them had reported poor braking action, and Air France Flight 358's aircraft weather radar was displaying heavy precipitation encroaching on the runway from the northwest. At about 200 feet above the runway threshold, while on the instrument landing system approach to Runway 24L with autopilot and autothrust disconnected, the aircraft deviated above the glideslope and the groundspeed began to increase. The aircraft touched down about 3800 feet down the runway. The aircraft was not able to stop on the 9000-foot runway and departed the far end at a groundspeed of about 80 knots. The aircraft stopped in a ravine at 2002 UTC (1602 EDT) and caught fire. All passengers and crew members were able to evacuate the aircraft before the fire reached the escape routes. A total of 2 crew members and 10 passengers were seriously injured during the crash and the ensuing evacuation.

**Team Conclusion:**

ATC sounded the alarm at 2002 to both airport fire hall and surrounding departments. The south fire hall had been watching the landing and responded before the alarm arriving at 2003. The initial response team comprised 15 members and four major foam vehicles. All passengers and crew were able to exit the aircraft before fire blocked the escape routes. Nine people were seriously injured during the crash and three more were injured during the evacuation.

Change in ARFF standards would have resulted in the following reductions: None



Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
8/21/2005	Kansai International Country: Japan	RKIX	Taxiway				Yes	No	194	0	1

**ARFF Standards:** Unknown

**Aircraft Involved:** Airbus 330

**Operator:** Qantas Airways

**Summary:**

On August 20 (Saturday), 2005, an Airbus Industrie A330-303, operated by Qantas Airways, took off from Narita International Airport at 21:38. At around 23:05, a warning was displayed on the electronic centralized aircraft monitor (ECAM) indicating the presence of smoke in the cargo compartment(s). The crew made the decision to change their destination to Kansai International Airport and, at 00:51 on August 21, the aircraft landed at the airport. Subsequently, at around 00:58, on its way to a parking spot, a passenger emergency evacuation was conducted using escape slides on the taxiway. During the evacuation, one passenger was seriously injured and eight passengers sustained minor injuries.

**Team Conclusion:**

The A-330 diverted to Kansai International Airport. While taxiing to its assigned parking spot after a normal landing, an aircraft evacuation was conducted on a taxiway. One passenger was seriously injured, she was released on the lower portion of the L3 slide by her parent who until then was holding her from behind. The passenger slid out of the parent's arms and struck her lower back against the ground, fracturing the pelvis.

The RKIX ARFF response was 18 vehicles including 6 rescue vehicles and 31 staff. ARFF was pre-positioned for landing and accompanied aircraft while taxiing.

Based upon the number of ARFF responders and the fact that they were pre-deployed and escorting the aircraft during taxiing, the research team concluded that different ARFF standards would not have had any impact on the outcome of this accident.

Changes in ARFF standards would have resulted in the following reductions: None

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
9/5/2005	Polonia Airport	WIMM	Takeoff-Overrun	1771	0	CL	No	Yes	117	100	15

**Country:** Indonesia

**ARFF Standards:** Annex 14 Category Unknown

**Aircraft Involved:** Boeing 737

**Operator:** Mandala Airlines

**Summary:**

On 5 September 2005, at 03:15 UTC a Mandala Airlines B737-200 crashed during take off from Polonia Airport, Medan, North Sumatra. Following liftoff, the airplane was unable to climb away and settled back onto the runway. It then overran the departure end of the runway, and hit several approach lights and continued to travel through a grass area and over a small river. It subsequently impacted several buildings and vehicles before coming to rest on a public road about 540 m from the end of runway 23. At the airport there was a strong gusting wind from the northwest with heavy rain, resulting in a wet runway. The Automatic Terminal Information Service (ATIS) included a warning to pilots to expect significant windshear and severe turbulence on the approach.

**Team Conclusion:**

A post crash fire destroyed much of the airplane. When the fire brigade arrived, they realized that the crash site was outside the airport perimeter, and there is no access road to reach the accident site. The fire brigade returned to the apron and decided to use the city/ public road to reach the crash site with only one command car, ambulances and one fire truck to continue for the rescue.

The airport fire fighting unit arrived about 20 to 25 minutes after leaving the airport. They found it difficult to reach the crash site due to the traffic jam despite the Traffic Police attempts to clear the road for the rescue operations. The roads were jammed by the people on the street. When they arrived, the fire was still burning at the crash site. Several fire fighting units of the local government and ambulances participated in rescue operation. The local people, Police and others were involved in the first hour of the rescue, and later on the Indonesian Air Force and Army.

Of the 117 people on the aircraft, 95 passengers and 5 crew members were killed by the impact forces or post-impact fire (Note- the accident report did not provide a breakout between deaths resulting from impact versus thermal/smoke inhalation.) Fifteen (15) passengers were seriously injured, mostly suffering skin burn, broken legs and hands. People on the ground accounted for an additional 49 fatalities and 26 serious injuries.

The research team concluded that a more coordinated response between the ARFF and the surrounding communities' fire and rescue response units could potentially have resulted in saving several lives and some serious injuries attributed to fire. However, since the accident report did not provide any breakout of fatalities/serious injuries attributed to impact versus thermal/smoke inhalation, the research team was unable to assess the impact on accident outcome of the three ARFF standards under consideration in this study.

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
7/9/2006	Irkutsk Airport	IKT	Landing-Overrun	1020	100	R	No	Yes	203	125	41
<b>Country:</b> Russian Federation		<b>ARFF Standards:</b> Unknown									
<b>Aircraft Involved:</b> Airbus 310		<b>Operator:</b> Sibir Airlines									
<b>Summary:</b>		On July 8, 2006 at 22:44 UTC1 (7:44 local time on July 9, 2006), as it was landing at Irkutsk airport, an A-310 airplane, registration F-OGYP, operated by OAO Aviakompania Sibir [Sibir airlines], ran down the runway, overran the runway threshold and, at a distance of 2140 m and on a magnetic azimuth of 296 degrees from the aerodrome reference point, collided with barriers, broke apart and burst into flames. As a result of the accident 125 individuals died, including both pilots and 3 of the cabin crew; 60 passengers and 3 cabin crew suffered physical injuries of varying degrees of severity. 41 people received severe injuries.									
<b>Team Conclusion:</b>		The first fire truck arrived on the scene of the accident 75 seconds after the collision at a distance from the CRS of 1,557 meters. After 20 seconds, and in intervals of 5 seconds, 3 more trucks arrived and started to extinguish the fire. The efficiency and effectiveness of fire suppression was reduced because of the inability of the vehicles to approach the accident site directly (the fence and garages obstructed the way) and because of the insufficient power of the master stream nozzles and, consequently, the need to unroll the hose lines to ensure the supply of the fire extinguishing mixture.									
		The airport is classified as an ICAO Category 8 airport. It responded with 4 vehicles and 19 fire fighters, followed by other organizations on the airport and mutual aid. Based on the accident report, between 22:44:45 and 22:45:50, 67 people were evacuated by the cabin crew. Another 11 were rescued through the efforts of the Department Fire Brigade, the RSRB rescuers, and CRT personnel.									
		Of the 38 serious injuries, 23 suffered mechanical trauma due to high temperatures and carbon monoxide poisoning; 13 suffered from carbon monoxide poisoning; 2 suffered heat burns.									
		Changes in ARFF standards would have resulted in the following reductions: None									
8/27/2006	Blue Grass Airport	KLEX	Takeoff-Overrun	1800	127	L	No	Yes	50	49	1

**Country:** United States

**ARFF Standards:** 14 CFR Part 139 Index B

**Aircraft Involved:** Bombardier CL-600

**Operator:** Comair

**Summary:**

On August 27, 2006, about 0606:35 EDT, Comair flight 5191, a Bombardier CL-600-2B19, N431CA, crashed during takeoff from Blue Grass Airport, Lexington, Kentucky. The flight crew was instructed to take off from runway 22 but instead lined up the airplane on runway 26 and began the takeoff roll. The airplane ran off the end of the runway and impacted the airport perimeter fence, trees, and terrain. The captain, flight attendant, and 47 passengers were killed, and the first officer received serious injuries. The airplane was destroyed by impact forces and postcrash

**Team Conclusion:**

The aircraft came to rest approximately 1800 feet beyond the departure end of runway 26 off of airport property. The accident site was outside the FAA's standard runway safety area, as well as outside the NFPA's Rapid Response Area. There was no direct vehicular access from the airport property to the accident site. To reach the site vehicles had to travel 2 1/2 miles on public roads, dirt road with a significant incline, and terrain. During the overrun, the aircraft became airborne and struck at least two large trees which breached the fuselage and allowed an ignited fuel/air mixture from a rupture fuel tank to enter the cabin. The Coroner determined that 26 people died from blunt force trauma and 23 died from smoke inhalation or thermal injuries. Although this latter group survived the crash, the NTSB noted that all were found near their seats. The first officer survived the crash with serious traumatic injuries--he was extricated from the aircraft by a public safety officer who arrived on the site approximately 5 1/2 minutes after the alarm sounded.

Changes in ARFF standards would have resulted in the following reductions: None

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
3/7/2007	Adi Sucipto Airport	WARJ	Landing-Overrun	825	75	R	No	Yes	140	21	12
<b>Country:</b> Indonesia		<b>ARFF Standards:</b> Annex 14 Category 3									
<b>Aircraft Involved:</b> Boeing 737		<b>Operator:</b> Garuda Indonesia									
<b>Summary:</b>		On 7 March 2007, a Boeing Company 737-497 aircraft, registered PK-GZC, was being operated by Garuda Indonesia on an instrument flight rules (IFR), scheduled passenger service, as flight number GA200 from Soekarno-Hatta Airport, Jakarta to Adi Sucipto Airport, Yogyakarta. The aircraft overran the departure end of runway 09, to the right of the centerline at 110 knots. The aircraft crossed a road, and impacted an embankment before stopping in a rice paddy field 252 meters from the departure end of runway 09. The aircraft was destroyed by the impact forces and an intense, fuel-fed, post-impact fire. There were 119 survivors. One flight attendant and 20 passengers were fatally injured. One flight attendant and 11 passengers were seriously injured.									
<b>Team Conclusion:</b>		The B-737 came to rest beyond the airport perimeter fence and was quickly engulfed in fire. ARFF vehicles were unable to get close enough to the aircraft to effectively combat the fire; the wreckage continued to burn for over two hours. The airport was supposedly in compliance with ICAO ARFF standards but the accident investigation team found a number of discrepancies. The inability to reach the crash site, the insufficient foam agent on the off-airport fire vehicles, and the uncoordinated ARFF response may have exacerbated the number of fatalities and serious injuries, but it is likely that a number of those fatalities and injuries would have occurred regardless of the ARFF response. A reasonable estimate would be that one-fourth of the fatalities and injuries might have been prevented by an ARFF response that met ICAO standards.									
		Compliance with ICAO ARFF standards may have resulted in the following reductions: 0 to 5 fatalities									

12/7/2007	Chicago-O'Hare	KORD	Landing-Taxied onto Taxiway	9950	300	L	Yes	No	264	0	1
<b>Country:</b> United States		<b>ARFF Standards:</b> 14 CFR Part 139, Index E									
<b>Aircraft Involved:</b> Boeing 777		<b>Operator:</b> United Airlines									
<b>Summary:</b>		On approach for landing, about 13 miles from the airport, the flight crew was informed that the cabin was filling with smoke. The captain declared an emergency in order to get the airplane on the ground as soon as possible. The first officer performed a normal landing and turned off on the first high-speed taxiway. The captain elected to initiate an emergency evacuation due to the uncertainty of the situation and the possibility of a fire on-board. There were 264 people on board. During the evacuation, one 68 year-old passenger sustained a fracture of a vertebra.									
<b>Team Conclusion:</b>		No mention of ARFF in accident report. Since smoke was present some 13 miles prior to landing, it would seem that ARFF would have been notified and pre-deployed.									
		Changes in ARFF standards would have resulted in the following reductions: None									

Date of Accident	Airport	Airport Loc ID	Type of Accident	X Coord	Y Coord	XY Coord	ARFF Pre-Deployed	Fire	Total Souls on Board	Total FTL	Total SI
1/17/2008	London Heathrow	LHR	Landing Undershoot	100	135	R	No	No	152	0	1

**Country:** United Kingdom

**ARFF Standards:** CAP 168 Appendix 8

**Aircraft Involved:** Boeing 777

**Operator:** British Airways

**Summary:**

Aircraft undershot on approach for landing on Runway 27L at London Heathrow Airport. It initially touched down 1080 feet short of the runway on centerline. The aircraft movement continued and it came to rest 100 feet past the runway threshold and 135 feet to the right.

**Team Conclusion:**

A Boeing 777 on a flight from the Far East landed short of the runway. The cabin crew initiated an emergency evacuation which was completed shortly after the arrival of ARFF crews. The first ARFF vehicle arrived 1 minute and 43 seconds after ATC notification. There was no fire. One passenger was seriously injured by parts of the right main landing gear penetrating the fuselage.

Changes in ARFF standards would have resulted in the following reductions: None

12/20/2008	Denver International Airport	KDEN	Takeoff-Veeroff	6200	1200	L	No	Yes	115	0	6
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**Country:** United States

**ARFF Standards:** 14 CFR Part 139, Index E

**Aircraft Involved:** Boeing 737

**Operator:** Continental Airlines

**Summary:**

On December 20, 2008, at 1818 MST, Continental flight 1404, a Boeing 737-500 (registration N18611) departed the left side of runway 34R during takeoff from Denver International Airport (DEN). One of the five crewmembers was seriously injured, and five of the 110 passengers were seriously injured. There were 45 minor injuries, and no fatalities. The airplane was substantially damaged and experienced post-crash fire. The weather observation in effect at the time of the accident was reported to be winds at 290 and 24 knots with gusts to 32 knots, visibility of 10 miles, a few clouds at 4000 feet and scattered clouds at 10,000 feet. The temperature was reported as -4 degrees Celsius.

**Team Conclusion:**

The aircraft veered off the runway on takeoff and came to rest approximately 6200 feet from the runway threshold (as measured along the runway centerline) some 1200 feet to the left of the centerline. This site is approximately 300 to 500 feet behind fire station #4. ARFF response was hindered by initial information as to the accident location. Although firefighters from ARFF station #4 were closest to the site, they were not the first to arrive on the scene due to the initial accident location information. There was a post-crash fire. The aircraft was evacuated by the time the first ARFF vehicle reached the site. DEN has 25 firefighters on duty every day, staffing two structural firefighting companies and seven ARFF vehicles. These fire companies do not respond to any other city incidents. Six people received serious injuries during the accident--five were injured during the crash sequence and one was injured during the evacuation. The research team concluded that different ARFF standards would not have had any impact on the outcome of this accident.

Changes in ARFF standards would have resulted in the following reductions: None

## **APPENDIX B**

### **GRAPHICAL DEPICTION OF ACCIDENT LOCATIONS RELATIVE TO A GENERIC RUNWAY**

This appendix contains three figures that depict the final location of the aircraft involved in the accident relative to a generic runway using an X-Y coordinate system. X depicts the distance along the runway centerline or extended centerline while Y is the perpendicular distance from the runway centerline or extended centerline to the aircraft wreckage. Accidents that occurred on taxiways other than exit taxiways or on aprons are not depicted.

Where an accident aircraft came to rest on a runway and no Y distance was provided in the accident report, the aircraft was placed on the centerline. If the report indicated that the aircraft was right or left of centerline without specifying a distance the aircraft was placed on the respective edge of the runway.

In some cases the pilot of an aircraft with an emergency was able to taxi off the runway onto an exit taxiway before the aircraft was stopped. If a Y distance was not provided in the accident report, the aircraft was placed at 250 feet from the runway centerline which should be the approximate location of the holding position marking.

Different symbols are used to denote different types of accidents, e.g., a landing overrun vs. a takeoff overrun. For the reader's reference, the typical Runway Safety Area for an air carrier runway (1000 feet beyond end of runway and 250 feet either side of centerline) is shown, as well as the maximum dimension for the Rapid Response Area (1650 feet beyond each runway end and 500 feet either side of centerline) is shown—in actuality the size of the RRA could be substantially smaller since RRA ends at the airport property line.

The three figures are:

Figure B-1. Accidents in Runway Approach Area

Figure B-2. Accidents on or Abeam the Runways

Figure B-3. Accidents in Runway Departure Area

Figure B-1 Accidents in Runway Approach Area

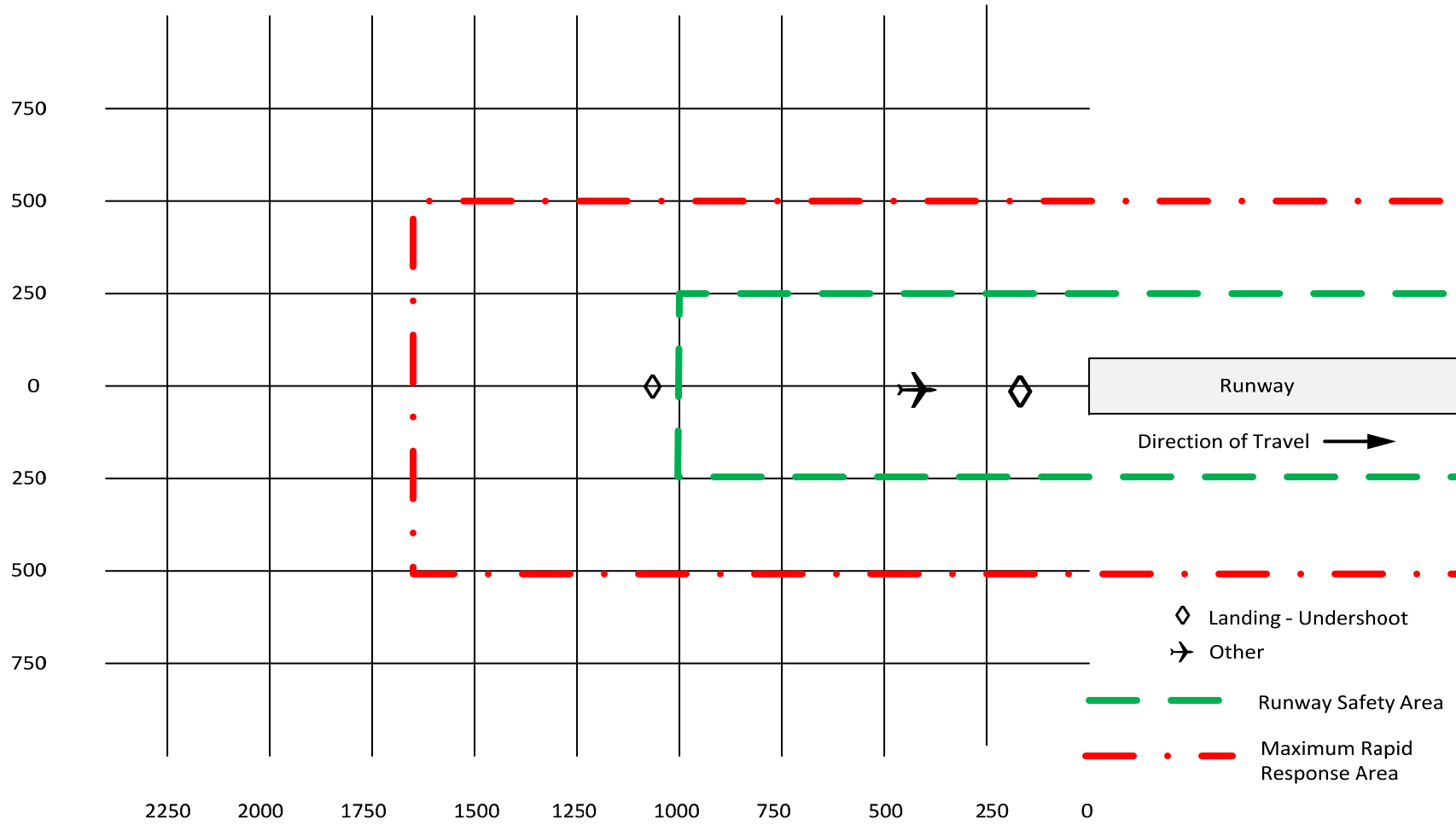
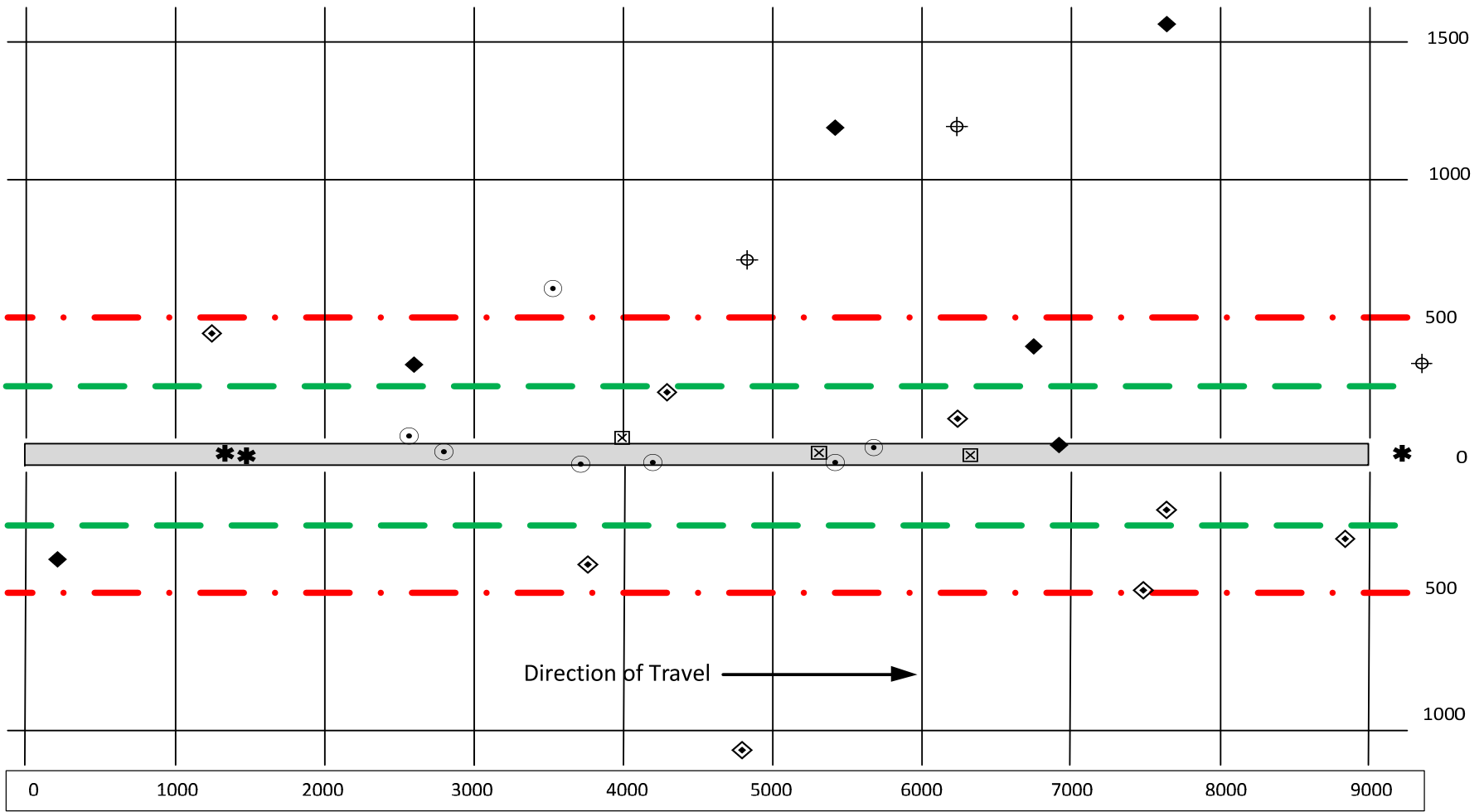


Figure B-2 Accidents on or Abeam the Runways



- |                              |                              |                                   |
|------------------------------|------------------------------|-----------------------------------|
| ◇ Landing – Veer Off         | * Takeoff – Remain on runway | — — — Runway Safety Area          |
| ⊠ Landing – Remain on runway | ⊕ Takeoff – Veer Off         | - · - Maximum Rapid Response Area |
| ⊙ Runway Collision           | ◆ Other                      |                                   |



Figure B-3 Accidents in Runway Departure Area

