Sparse alternatives to self-evacuation push the ARFF community to expand lifesaving capability.

RESCUE ME

BY WAYNE ROSENKRANS

Controversy has smoldered for decades around the question of what constitutes adequate personnel, equipment, procedures, training and emergency response planning to prepare aircraft rescue and fire fighting (ARFF) services to rescue aircraft occupants after a survivable accident involving one or more large commercial jets.[1]

Technology has placed enormous extinguishing power, speed and precision in the individual firefighter's hands, and also has opened opportunities to reinvent rescue capabilities. It remains to be seen, however, whether societies will be open to paying for envisioned safety enhancements amid signs of a global economic downturn. Some airports historically have seen new ARFF requirements as threats to their commercial viability.

On the ARFF specialists' side are stakeholders who, for more than a decade, have pressed governments for a rescue-oriented overhaul of existing regulations. A 2008 U.S. example was lobbying by the International Association of Fire Fighters (IAFF) for a federal law requiring the Federal Aviation Administration (FAA) to update ARFF standards in the Federal Aviation Regulations (FARs). This provision, however, was removed from a bill considered in the Congress.[2]

New Rescue Tactics

The pilot-in-command is the highest authority for the decision to order an evacuation, but if the airplane crew appears unable to initiate an evacuation after an attempt by the ARFF incident commander to convey information about imminent fire danger, the firefighters typically will operate emergency door release mechanisms from the outside and possibly provide interior access vehicles, or a conventional elevated platform or passenger airstairs.

If fire or threat of fire already is present, the ARFF personnel will protect evacuees primarily by creating a foam blanket covering a rectangular area that is proportional to the length of the airplane, and by applying extinguishing agents to prevent fire from extending into the fuselage. If the ARFF incident commander also orders a rescue operation, hand-held hose lines — often called *handlines* — that discharge foam or water streams will be used to protect evacuees and ARFF personnel, to extinguish new fires and to maintain the foam blanket to suppress any fuel-fed fire.

Guidance material developed by the U.S. National Fire Protection Association (NFPA) contains a few examples of best practices for such rescues — with a caveat. "Interior aircraft fire situations can differ widely; therefore, explicit guidance regarding extinguishment techniques is not possible," the association said. "One rescue team method consists of four ARFF personnel equipped with full personal protective equipment and self-contained breathing apparatus. Two of the [firefighters] are handline operators and

© Chris Sorensen Photography

Los Angeles Fire Department firefighters practice moving a survivor during LAX Air Exercise 2007, a full-scale simulated fatal crash of a Boeing 747 designed to test Los Angeles International Airport's emergency response plan.

precede the other two, who are equipped with appropriate hand-held tools needed for forcible entry, extrication and access to hidden fuselage fires behind panels, floors and compartments. A procedure preferred by some fire departments is to provide an additional handline operator, similarly attired and equipped with self-contained breathing apparatus, operating behind the rescue team with a spray stream as their protection throughout the entire operation."[3]

Direct interior fire attack with water streams becomes imperative any time fire breaches an intact fuselage (Table 1, p. 24). This is a critical moment, one in which decisions may differ among ARFF incident commanders — especially ordering entry by firefighters or piercing the fuselage with a high-reach extendable turret and skin-piercing nozzle to inject water while occupants are evacuating and/or firefighters are entering.

"For an interior fire, a vehicle equipped with a high-reach extendable turret … and a fuselage-piercing nozzle can apply a water spray right into the cabin," said Keith Bagot, the FAA's ARFF research and development project leader. "The ARFF vehicle can pull directly up to the plane and deploy its turret immediately. High-reach extendable turret technology is now installed on over 650 ARFF vehicles around the world."[4] On an FAA ARFF research vehicle, for example, the boom reaches 65 ft (20 m), 15 ft (4.6 m) farther than a previous model, to suppress a fire inside airplanes, including anywhere on the upper deck of the Airbus A380 or Boeing 747.

Water injection to cool a hot cabin interior, however, has yet to be attempted for an actual passenger aircraft fire.

The tactic has been used effectively for some freighter fires after the occupants evacuated. The concern within the ARFF community — expressed by attendees at a U.S. workshop on freighter fires (*ASW*, 01/08, p. 36) — is the possibility of steam-inhalation injury causing deaths among the survivors.

The arrival of any airplane with uncontrolled in-flight fire also can be extremely challenging for ARFF personnel. Complications include near-simultaneous demands for protecting an immediate evacuation and interior fire fighting without time to wait for the self-evacuations to finish.

"Entry [by ARFF firefighters also] will permit an inrush of fresh air into a possibly overheated or unstable atmosphere that could rapidly accelerate the fire," the NFPA said. "Toxic gases will be present, so ventilation and a thorough search for survivors should take place immediately and simultaneously with the fire-fighting effort."

Because trapped occupants may be encountered, rescue teams keep close at hand an arsenal of rescue saws, pneumatic chisels, hydraulically powered spreaders, high-pressure smoke-evacuation fans and other equipment such as compressed air bags that can shift the position of an unstable aircraft or provide shoring in a safe attitude.

Contentious Issues

One rescue-related point of contention between firefighters and the FAA is the "two-in, two-out" policy in the respiratory protection standard of the U.S. Occupational Health and Safety Administration (OSHA). Applying the policy would create a need for more firefighters on duty.

"This standard requires that firefighters engaged in fighting interior structural fires work in a buddy system that requires at least two workers in the structure and at least two workers outside in case a rescue of the firefighters is needed," the FAA said. "In a legal memorandum developed jointly by the FAA and OSHA … 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 establish an escape route for the crew and passengers, the 'two-in, two-out' rule does not apply to ARFF."

The U.S. Department of Defense adopts many NFPA and OSHA standards, however, including the two-in, two-out rule for its ARFF personnel.[5]

Small Airport Rescues

The FAA issued a final rule, effective in June 2004, to expand certification requirements to 37 previously non-certificated airports serving scheduled air carriers.[6] This was done by amending the FARs for airports in Part 139 and those for air carrier operations in Part 121. As a result, new requirements were applied to airports serving scheduled air carrier operations in aircraft designed for more than nine passenger seats but fewer than 31 passenger seats.

"Part 139 does not limit the airport operator from providing more ARFF coverage than required," the agency said in its final rule. "The firefighter and pilot labor organizations believe the [rule] did not go far enough. … The FAA agrees that some Part 139 ARFF standards may need revisions. The Aviation Rulemaking Advisory Committee has created an ARFF Working Group to review Part 139 ARFF standards and to propose new regulatory language, as appropriate." In late 2008, the FAA Web site added, "As this work is ongoing, the FAA has decided to wait to comprehensively update all ARFF standards."

A coalition of industry organizations other than airports and airlines in the late 1990s said, "Current [FARs] do not provide for firefighters to rescue passengers or extinguish fires inside an airplane."[7] The Air Line Pilots Association, International in 2000 elaborated on this with respect to new large transport aircraft: "The trend in the near future appears to be that the largest airplanes will have greater passenger loads distributed among two decks. This will necessitate that more passenger area remain survivable, however; it will also demand that fire fighting services are able to extinguish fires deep within a damaged fuselage structure."[8]

The FAA's ongoing work on ARFF standards likely will address concerns of the U.S. National Transportation Safety Board (NTSB), which in 2001 repeated, "The Safety Board concludes that ARFF units may not be staffed at a level that enables ARFF personnel, upon arrival at an accident scene, to conduct exterior fire fighting activities, an interior fire suppression attack and a rescue mission."[9]

The International Civil Aviation Organization (ICAO), too, has been pursuing — through a working group of the Aerodromes Panel — "some fine-tuning" of guidance material to amend the ARFF standards and recommended practices published in 1990, and amended in 1995. In a recent meeting, however, the working group considered the ICAO *Airport Services Manual, Part 1, Rescue and Fire Fighting* to be sufficient guidance material for civil aviation authorities.[10]

Rescue Experts

The FAA and ICAO both participate on the NFPA's Technical Committee on Aircraft Rescue and Fire Fighting. FAA and ICAO ARFF specialists are familiar with, and helped create, the new way of thinking about rescue that is reflected in the NFPA's 2008–2009 standards and guidance. The technical committee's perspective begins with the premise that, although protecting aircraft occupants has the highest priority, fire control many times is what makes survival possible for aircraft occupants.

This year, the NFPA's standard for ARFF services, first published in 1949, introduced a new definition of *aircraft rescue*: "Action taken to save or set free persons involved in an aircraft incident/accident by safeguarding the integrity of the aircraft fuselage from an external/internal fire, to support self-evacuation, and to undertake the removal of injured and trapped persons." Previous ARFF concepts did not distinguish so clearly the protection of escape paths for evacuees from the rescue of those who cannot self-evacuate.[11]

Technical committee specialists have forecast increased rescues of crash survivors because of worldwide fleet improvements such as aircraft design for crashworthiness, more robust passenger seats/restraints, combustion-resistant cabin furnishings, emergency escape-path marking and improved exit mechanisms, as well as crew training.

"If these design improvements are as successful as anticipated, the prompt and effective intervention by trained ARFF personnel becomes even more important [beyond 2008] because a greater number of aircraft accident survivors needing assistance can be expected," says the NFPA's current guidance on ARFF operations.[12]

The guidance emphasizes that an intact airframe typically provides no more than three minutes of survivable interior atmosphere during an exterior fuel fire, and that fuel-fed flames will cause burnthrough of aluminum skin in 60 seconds on typical commercial transport airplanes, although the time will be significantly longer for aluminum airplanes that have the latest fire-resistant thermal acoustic insulation (*ASW,* 4/08, p. 37) or fiber composite skins with fire-hardened windows (*ASW,* 9/08, p. 40).

"The analysis of aircraft accidents involving external fuel fires has shown that although external fires are effectively extinguished, secondary fires within the aircraft fuselage are difficult to control with existing equipment and procedures," adds Joseph Wright, an NFPA technical committee member. "Analysis of more recent aircraft accident data shows that fire services today are more likely to be responding to a complex accident with a moderate pool fire accompanied [by] a three-dimensional running fuel fire and an interior fire. … Firefighters put themselves at great personal risk when attempting [to extinguish] any interior fire with hand-held attack lines."[13]

The NFPA standards have introduced a comprehensive process called task and resource analysis, combining

Technologies available include, from left, the hydraulically powered spreader, ax, airstair-based interior access vehicle, rescue saw and high-reach extendable turret with aluminum skin-piercing nozzle.

Examples of Survivable Airplane Accidents Influencing ARFF Rescue Capability

Date	Location	Aircraft Type	ARFF Response[1]	Evacuated/ Rescued[2]	On-Board Fatalities
Aug. 27, 2006	Lexington, Kentucky, U.S.	Bombardier CL-600	11 M, 3 AP, 2 AV	0, 1	49
A public safety officer — cross-trained as a police officer, firefighter and emergency medical technician — arrived at the cockpit wreckage about 5.5 minutes after the crash alarm and was assisted by a police officer in rescuing the first officer, who had life-threatening, blunt force injuries. The entire cabin interior was on fire. About 11 minutes after the crash alarm, two ARFF trucks, each staffed by one firefighter, arrived and began applying extinguishing agent. The fire was controlled in three minutes by these trucks using one high-flow turret, one bumper turret, handlines and a high-reach extendable turret. The captain had been killed by nonsurvivable blunt force injuries. The flight attendant and several passengers in the forward cabin area had a "relative lack" of blunt force injuries and smoke inhalation. Several passengers seated in the aft cabin also had some blunt force injuries, and most showed evidence of smoke inhalation. These two groups of forward and aft cabin fatalities had survived the impact for an undetermined length of time; all were found close to their seats.					
Aug. 2, 2005	Toronto	Airbus A340	1 M, 15 AP, 8 AV	309, 0	0
All passengers and crew evacuated within about two minutes despite rapidly increasing smoke and the fact that four of eight exits were unusable or unsafe, the TSB said. Two crewmembers and 10 passengers sustained blunt force injuries during impact and/or serious injuries during evacuation. One passenger required ARFF assistance to move away from the exterior of the burning airplane because of a leg fracture. Firefighters entered the airplane via the front door and searched the flight deck and the first six rows of passenger seats for survivors before complying with the ARFF incident commander's order to evacuate because of danger from the explosions that were occurring. About one hour 39 minutes after the crash, ARFF personnel had accounted for 297 passengers and had received a manifest to confirm total passengers on board. The normal minimum ARFF personnel on duty was 11 people. The ARFF crews expended an initial quantity of water from their vehicles that was 65 percent greater than required by applicable regulations; additional water then was transported to the crash site to extinguish the fire.					
June 1, 1999	Little Rock, Arkansas, U.S.	McDonnell Douglas MD-82	17 M, 4 AP, 3 AV	134, NR[3]	11
Two flight attendants on the forward jump seats were unable to assist in the evacuation because of serious injuries. The ARFF response occurred in "blinding rain and wind" and involved delays finding and reaching the crash site. NTSB said, "The passenger in 27E [who had potentially survivable injuries but died in the cabin] remained on the airplane and therefore needed to be rescued from the wreckage. However, the four ARFF personnel that responded to the accident were not available to enter the airplane because they were involved in positioning the fire trucks and operating the fire-suppression equipment. Thus, an interior search of the aircraft could not be conducted until off-airport firefighters arrived on scene about 0022 [about 31 minutes after the crash]." The first officer could not evacuate the airplane on his own because his left leg was fractured. ARFF responders cut through metal and stepped on the center pedestal to extricate him from the flight deck wreckage. Firefighters also rescued some survivors from the first class section. The incident commander told NTSB that the first priority of ARFF personnel is fire control to provide an escape path and that after the fire is controlled, ARFF personnel assume rescue responsibilities and search the airplane interior for survivors. After the accident, six more ARFF personnel were hired and minimum on-duty personnel was increased to six.					
Nov. 19, 1996	Quincy, Illinois, U.S.	Beech 1900C and Beech King Air A90	14 M, 7 AP, 4 AV	0, 0	14
The impact forces were at a survivable level for the occupants of both airplanes when the 1900C collided with the King Air. Three nearby pilots were the first to reach the site, where both airplanes were on fire about 1,800 ft (549 m) from an unstaffed ARFF truck. The speed of fire precluded any rescue of the King Air occupants. The 1900's captain survived the collision and spoke to the would-be rescuers through an open cockpit window, but they could not open the forward airstair door and she died with all the other occupants. "If properly staffed, that truck should have been able to reach the accident site in no more than one minute," the NTSB said. "Firefighters might then have been able to extinguish or control the fire, thereby extending the survival time for at least some of the occupants of the Beech 1900C." Only off-airport firefighters were on duty at the time of the accident, consistent with airport certification regulations at the time. After arrival, they brought the fires under control within 10 minutes.					
Feb. 1, 1991	Los Angeles, California, U.S.	Boeing 737 and Fairchild Metroliner	1 M, 10 AP, 4 AV	65, 1	34
After the landing 737 collided with the Metroliner in position for takeoff, four ARFF units extinguished most of the pool fire under the 737 fuselage in about one minute and assisted the last six or seven surviving 737 occupants as they evacuated. Although not recognized immediately, the Metroliner had been crushed under the 737 with no survivors. Three firefighters then left their vehicles and began interior rescue operations in the 737, including extricating the first officer through a cockpit window. The captain was trapped by the wreckage and "appeared lifeless." The fire intensified rapidly and burned through the cabin roof. Several firefighters attacked the cabin fire with handlines through the R1 door, entered and remained in the cabin until the fire was extinguished. Their efforts included discharging 600 lb (272 kg) of Halon 1301 without effective suppression, and they were unable to advance more than a few seat rows because of the fire intensity. The NTSB said, "The rapid availability of adequate numbers of ARFF-trained firefighters … allowed ARFF personnel to implement an interior fire attack immediately."					

ARFF = Aircraft rescue and fire fighting; M = minutes; FAA = U.S. Federal Aviation Administration; AP = ARFF personnel; AV = ARFF vehicles; NR = Not reported; NTSB = U.S. National Transportation Safety Board; TSB = Transportation Safety Board of Canada

Notes

1. Actual response time, initial number of firefighters and initial number of ARFF vehicles responding from the airport's ARFF service.
2. Number of airplane occupants evacuated, including evacuations assisted by firefighters, and number of occupants who could not self-evacuate and had to be rescued by ARFF personnel or other first responders.
3. The 134 evacuees include an unspecified number reported as rescued by ARFF personnel.

Sources: NTSB, TSB

Table 1

qualitative analysis with quantitative risk assessment. Unlike the FAA and some other regulators, the NFPA has published a table of mandatory minimum total ARFF personnel — from two to 15 people — to be on duty to respond to the crash alarm based solely on the airport category, which is derived from calculation of minimum response times and the quantities and rates of extinguishing agent discharge. The task and resource analysis provides a structured method for airports and their ARFF services to determine how many additional firefighters, beyond generic minimums, should be on duty based on specific local conditions and risk factors.

Criticality of rescue also has led the NFPA to call for the availability of no fewer than two vehicles that simultaneously can conduct the fire attack and handle rescue-related contingencies.

In the 2008–2009 guidance material, the equation for calculating the minimum water quantity to be carried to the accident site by ARFF vehicles includes, for the first time, a variable representing water for handlines used for containment and extinguishment of fire during aircraft interior operations.

Exceeding Minimums

Many U.S. airports serving scheduled airlines exceed the minimum ARFF requirements of the FARs and/or the NFPA minimum standards. A 2008 survey by Airports Council International–North America (ACI–NA) noted, however, that this means ARFF departments vary widely in size and capabilities. "Of the [47] airports that responded, the largest ARFF department included 200 personnel while the smallest department employs just three personnel. There was also a great range in the number of minimum daily on-duty staffing; the largest department had a minimum staff requirement of 42 individuals, and the smallest reported a minimum staff requirement of just one officer."[14]

The survey showed that at the airports handling an average of five operations a day by air carrier airplanes 200 ft (61 m) in length or longer, the average minimum on-duty staffing was about 20 people, and the average reported total ARFF personnel was about 84 people. For airports handling an average of five operations a day by air carrier airplanes less than 90 ft (27 m) in length, the average minimum on-duty staffing was about two people, and the average reported total ARFF personnel was about 12 people.

"The overall average of reported staffing would be between one and two [ARFF] personnel per vehicle," ACI–NA said. "Currently, only eight [respondent airports] have an interior access vehicle, the most common vehicle noted in the survey being airstairs."

Advanced ARFF vehicles change the rescue possibilities with global positioning system–based navigation with moving map displays and ARFF vehicle position, ground radar transponders and forward-looking infrared (FLIR) video camera systems.

Airports that opt to conform to NFPA standards must consider providing a rescue truck dedicated to carrying rescue equipment suitable for conditions found at airports used by operators of relatively large representative aircraft such as the Airbus A300/A340-300/A380-800 and the Boeing 757/767-300/747-200.

Notes

1. The NTSB defines a *survivable accident* as "an accident in which the forces transmitted to the occupant(s) through the seat and restraint system do not exceed the limits of human tolerance to abrupt accelerations and in which the structure of the occupants' immediate environment remains substantially intact to the extent that a livable volume is provided for the occupants through the crash sequence."

2. IAFF. "Dangerous Airport Fire/Rescue Standards Jeopardize Lives, Fire Fighters Say." News release, April 30, 2008.
3. NFPA. "NFPA 402: Guide for Aircraft Rescue and Fire-Fighting Operations, 2008 Edition." June 24, 2007.
4. FAA. "Fire and Rescue: The Emergence of Aircraft Rescue and Fire Fighting Technologies." *R&D Review,* Issue 2, 2007.
5. DOD. Instruction 6055.06. "DOD Fire and Emergency Services Program." Dec. 21, 2006.
6. FAA, U.S. Department of Transportation. "14 CFR Parts 121 and 139 Certification of Airports; Final Rule." Federal Register, Feb. 10, 2004.
7. Coalition for Airport and Airplane Passenger Safety. "Surviving the Crash: The Need to Improve Lifesaving Measures at Our Nation's Airports." IAFF, 1999.
8. Phillips, Thomas J. "Airbus A380: Meeting the Challenge in 2006." Paper presented to the NFPA International Forum on Emergency and Risk Management, Singapore. January 2005.
9. NTSB. Safety Recommendation Letter A-98-41 through -42. June 25, 1998.
10. ICAO. *Airport Services Manual,* Part 1, "Rescue and Firefighting." Third Edition 1990. Nov. 14, 1995.
11. NFPA. "NFPA 403: Standard for Aircraft Rescue and Fire-Fighting Services at Airports, 2009 Edition." Sept. 5, 2008.
12. NFPA. NFPA 402.
13. Wright, Sr., Joseph A. "Aircraft Rescue and Fire Fighting Efficiency Relates to the Use of New Technology." Paper presented by Bernard Valois to the NFPA International Forum on Emergency and Risk Management, Singapore.
14. ACI. "ARFF Procedures Survey." February 2008.