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Rapid Response of Airport Emergency Services Hindered by Weather and Other Factors

Current U.S. Federal Aviation Regulations and International Civil Aviation Organization requirements for emergency response times are less stringent than those in the equivalent U.S. National Fire Protection Association standards. Nevertheless, poor weather conditions or aircraft accidents that end in rivers, bays or other bodies of water adjacent to airports are likely to increase response times by emergency services.

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A majority of aviation accidents occur at airports or in their immediate vicinities. Compared with accidents that occur en route, airport accidents generally involve relatively slow speeds, and many are survivable. The likelihood of surviving such an accident is greatly increased if on-airport emergency services are available and if they are able to respond rapidly.

It has been standard practice since the 1930s to provide some degree of emergency response at most of the world's major airports. During World War II, military services demonstrated the importance of rapid response. Fire trucks and ambulances were usually located at the base of the control tower and were on their way before an accident aircraft had come to rest. Ambulances often transported survivors to a hospital within minutes of an accident.

In 1952, the U.S. National Fire Protection Association (NFPA) published NFPA 403, *Airport Rescue and Fire Fighting Services at Airports*, which contained suggestions for fire protection that should be provided at commercial airports. During the 1960s, the International Civil Aviation Organization (ICAO) gave rescue and fire-fighting services the status of suggestions, which were in Annex 14, the ICAO reference for "International Standards and Recommended Practices for Aerodromes."

In 1970, the U.S. Congress passed the Airport and Airways Development Act. This act required the FAA to set up standards for airport certification, including "the operation and maintenance of adequate safety equipment, including fire-fighting and rescue equipment capable of rapid access to any portion of the airport used for the landing, takeoff or surface maneuvering of the aircraft." Reports published during the period by the U.S. Air Line Pilots Association (ALPA) showed that more than half of the nation's commercial airports had little or no emergency equipment.

Also in 1970, ICAO upgraded its emergency equipment requirements in Annex 14, Chapter 9. The FAA in 1974 required airports, for the first time, to be certificated. Certification requires provision of a minimum amount of emergency equipment.

In 1978, NFPA assigned its 403 document the status of a recommended practice. In 1988, NFPA 403 became a standard, and the FAA has upgraded the appropriate requirements in the U.S. Federal Aviation Regulations (FARs) Part 139.

Boeing Commercial Airplane Group statistics show that, for the worldwide commercial jet fleet between 1959 and 1994, the phases of flight occurring at or near airports — taxi, takeoff, final approach and landing — accounted for 67.6 percent of accidents. Accidents during the takeoff phase and during the final approach were 12.8 percent and 19.7 percent of the total, respectively, or 32.5 percent together.[1] (Figures refer to aircraft of greater than 60,000 pounds [27,216 kilograms] maximum gross weight and exclude turboprop accidents.) Because most accidents in the two phases occurred in the immediate vicinity of airports, but not on runways, it is clear that emergency response must be able to arrive quickly at locations adjacent to runways as well as at runways.

NFPA 403[2] defines two areas for emergency response in which "particular attention should be given to the provision of ready access." The Rapid Response Area (RRA) is within a rectangle "that includes the runway and the surrounding area extending to but not beyond the airport property line." Its width is 500 feet (approximately 150 meters) outward in each direction from the runway centerline, and its length is 1,650 feet (approximately 500 meters) beyond each runway end.

But a takeoff or landing accident can occur beyond the RRA or even beyond the airport boundary. A larger area, the Critical Rescue and Fire Fighting Access Area (CRFFAA), represents the area in which emergency equipment based at the airport can be called on to respond. Its width is the same as that of the RRA, but its length is 3,300 feet (approximately 1,000 meters) beyond each runway end, and can extend past the airport boundary.

Fast Response Enhances Survivability

A fire-involved accident must be rapidly contained or extinguished, especially when survivors are trapped inside an aircraft. In a water-involved accident, victims must be rescued before drowning or suffering hypothermia. In all cases, trauma victims must be rapidly transported to emergency medical facilities. Speed is essential.

The ICAO *Airport Services Manual*,[3] and Annex 14, Chapter 9.2.17, state that "the operational objective of the rescue and fire-fighting service should be to achieve response times not exceeding three minutes and preferably not exceeding two minutes, to any part of the movement area, in optimum conditions of visibility and surface conditions." ICAO Annex 14 also requires response to all parts of the movement area as intended in the 1970 Airport and Airways Development Act.

NFPA 403 specifies that the response time of the first fire-fighting vehicle must be two minutes or less to any point on the operational runway, or 2 1/2 minutes to any point on the RRA, under optimum visibility and surface conditions. This requirement, the standard says, is because "approximately 85 percent of the accidents as historically recorded in the CRFFAA occurred within the boundary of the RRA ... ."

The NFPA two-minute response assumes that the rescue vehicle performance complies with the standards of NFPA 414, *Standard for Aircraft Rescue and Fire Fighting Vehicles*, the fire-fighting agent quantities comply with NFPA 403 and the fire fighters meet the professional standards of NFPA 1003, *Airport Fire Fighter Professional Qualifications*.

Three Minutes Stretch into More

FARs Part 139.319 only requires a response to the midpoint of the farthest runway serving air carriers within three minutes by the first vehicle and four minutes for all other required vehicles. This means that if the accident occurs in the overrun area, the fire trucks might have to travel farther than the runway midpoint before intervention could begin; a typical long runway, poor weather conditions, darkness and rough terrain beyond the runway could increase response time in excess of the time required by ICAO, and far in excess of estimated survival times of aircraft occupants reported by the FAA Technical Center at Atlantic City, New Jersey, U.S.

Efforts are being made to reduce the severity of airport accidents and incidents by improving the overrun areas where the majority of these situations occur. In February 1984, a Scandinavian Airlines System (SAS) McDonnell Douglas DC-10 overran Runway 4R at John F. Kennedy International Airport (JFK), New York, New York, U.S., after touching down about 4,700 feet (1,440 meters) beyond the threshold of the 8,400-foot (2,560-meter) runway. The aircraft plunged into Thurston Basin, a tidal waterway some 600 feet (183 meters) past the departure end of the runway. Despite substantial damage to the DC-10, the passengers and crew evacuated the airplane with a few minor injuries. Following the accident, the FAA conducted tests of a soft-ground arresting system.

This system, which was first used in England in the late 1960s, consists of a bed of hardened foam or similar material laid in the overrun area to rapidly decelerate an aircraft without damage to the aircraft or injury to its occupants. One such material, known as Foamcrete, has been successfully tested by the FAA and will be installed in runway overrun areas at JFK in 1996.

Fire Increases Urgency of Response Time

Because aircraft carry large quantities of fuel in close proximity to large numbers of occupants, the problems of containing and extinguishing aircraft fires have been the subject of extensive research and development during the past 70 years, especially since World War II, when the lives of many military aviators were saved by emergency crews. New extinguishing agents, more sophisticated fire trucks and improved training have increased survival of aircraft occupants.

"The principal objective of a rescue and fire-fighting service is to save lives in the event of an aircraft accident or incident," according to the ICAO *Airport Services Manual*. "This contingency must assume at all times the possibility of and need for extinguishing a fire which may:

- "Exist at the time an aircraft is landing, taking off, taxiing, parked, etc.; or,
- "Occur immediately following an aircraft accident or incident; or,
- "Occur at any time during rescue operations."[3]

How long victims can survive a crash fire depends on:

- The integrity of the fuselage;
- The quantity of fuel spill;
- The fire-fighting vehicle capability; and,
- The speed and accuracy with which the extinguishing agent can be applied.

Tests conducted by the U.S. National Aeronautics and Space Administration (NASA) and by the FAA show that an airplane's aluminum skin can burn through in as little time as one minute, and acrylic windows will melt in less than three minutes. Glass-fiber insulation provides some additional protection for the occupants after the aluminum holding it melts away.

With rapid response and prompt application of extinguishing agent, escape from a major aircraft fire is possible. This was demonstrated when a Continental Airlines McDonnell Douglas DC-10 ran off the runway in Los Angeles in March 1978. [Three tires failed during the takeoff roll, and the takeoff was rejected just before the airplane reached V_1. The left main landing gear collapsed and fire erupted in the left wing area. The aircraft skidded to a stop about 664 feet (203 meters) past the departure end of the runway.] Response time was less than 30 seconds and the equipment was manned by well-trained and experienced fire fighters. As a result, all the occupants safely evacuated the aircraft, except two senior citizens who fell off a wing into a fire area.

One of the most frequent arguments heard against a reduced response time is the FAA regulation requiring a 90-second evacuation time for all commercial air carrier aircraft. If the occupants are going to evacuate the aircraft in 90 seconds, then why must the fire equipment arrive 30 seconds after the occupants have, presumably, escaped?

But this evacuation time is based on evacuation testing. The test subjects are all in good physical condition; they expect the evacuation order; they have not been subjected to the trauma of an accident; they are not hindered by cabin debris, seats and other interior furnishings; and they have not been injured. The result is that evacuation times can exceed 90 seconds in actual accidents. In some accidents, occupants have been immobilized by injuries or trapped by debris, and would have been unable to escape without the aid of the emergency services.

And there have been accidents in which occupants were rescued after fires of greater than 90 seconds duration had been extinguished, including the 1988 Delta Boeing 727 accident at Dallas–Fort Worth and the 1987 Continental DC-9 accident at Denver.

[On Aug. 31, 1988, Delta Flight 1141 crashed shortly after lifting off from Runway 18L at the Dallas–Fort Worth International Airport, Texas, U.S. The B-727 struck the instrument landing system (ILS) localizer, then struck the ground just past the localizer before coming to rest about 3,200 feet (976 meters) past the runway end. The U.S. National Transportation Safety Board (NTSB) found that the flight crew had attempted to take off without wing flaps and slats being properly configured. Twelve passengers and two crew members died in the accident.

[At Denver Stapleton Airport, Colorado, U.S., the Continental DC-9 took off on Nov. 15, 1987, after a 27-minute delay following deicing. The takeoff roll was accomplished without incident, but following rotation, the airplane crashed off the right side of Runway 35L. The NTSB found that failure to have the airplane deiced a second time had led to upper-wing surface ice contamination and a loss of control during the rapid rotation.]

Factors governing emergency response capability include, among others, location of the emergency equipment relative to a probable accident site and emergency vehicle performance capabilities and access routes.

Location of Fire Station Is Critical

Fire station location requirements have changed. For many years the critical response area was defined as the operational movement area — all runways, taxiways and terminal ramp areas. In the days of piston engines there were many ramp fires during engine starts. Because these were the most frequent airport fires, fire stations were often located adjacent to the terminal. With the use of jet engines and kerosene fuels, ramp fires are now rare. The most critical response area is now the operational runway.

Many fire stations have been located wherever land was unsuitable for other purposes, with little consideration for response capability. For example, when a passenger terminal was extended at Atlanta Hartsfield International Airport, Atlanta, Georgia, U.S., a fire station in a prime response location was moved to a remote catering-cargo complex some distance from runways and taxiways. But airport planners were able to compensate for the increased response time by building a new access road to the firehouse and adding faster fire-fighting vehicles.

The rescue equipment should be located near the midpoint of the active runways. If multiple fire stations are used, they should be located where vehicles can respond to the runway overrun areas in two minutes or less. Given an immediate alarm with the fire equipment housed at the optimum location adjacent to the runway, a response time of two minutes is possible.

ICAO Annex 14, Chapter 9.2.24, recommends that fire stations be located so that access into the runway area is direct and clear for rescue and fire-fighting vehicles, requiring a minimum number of turns. For the minimum response time, it is essential that all responding vehicles have acceleration rates that meet the criteria of NFPA 414, and that vehicles be capable of maintaining top speed while responding to the accident site.

Large fire trucks full of water and with a high center of gravity cannot make sharp turns without slowing significantly from top speed. "Response routes from the fire station(s) should be designed with the least number of turns required and with any turning angle being not more than 45 degrees," says NFPA 402M, *Aircraft Rescue and Fire Fighting Operations*. High-speed merge areas can minimize slowing for turns.

FAA Advisory Circular (AC) 150/5335-4, *Airport Design Standards — Airports Served by Air Carriers — Runway Geometrics*, recognizes the need for access roads, but only in the extended runway safety area. Ideally, a wide area around the runway area should contain no difficult-to-traverse terrain such as hills or valleys; if, however, such terrain does exist in the runway area, access roads should be built so that no terrain features prevent rapid access by emergency vehicles.

Access roads should be at least two lanes wide. Single-lane roads do not permit both access and egress of emergency vehicles — such as ambulances — at the same time. A single-lane access road will result in massive traffic congestion at the accident site. Special consideration must be given for access into swamps or mud flats. Access roads should be capable of sustaining the weight of the largest emergency vehicle in all weather conditions.

ICAO Annex 14, Chapter 9.2.20, recommends that emergency access roads be constructed for a distance of 1,000 meters (approximately 3,300 feet) from the runway threshold, or at least within the airport boundary. Although airport authorities are only responsible for emergency response inside the airport boundary, careful planning of airport roads and gates, along with mutual-aid agreements with adjacent jurisdictions outside the airport, can result in faster response by both parties.

Water Rescues Present Further Challenges

Since the advent of the reliable jet engine, almost all water accidents and incidents occur at airports where runways terminate adjacent to the water's edge. There are many such airports throughout the world, and more are being constructed or have recently opened, such as the island airports of Macau and Osaka, Japan.

Most water accidents are overruns, undershoots or aborted takeoffs. Examples have occurred recently at LaGuardia and Hong Kong. [In September 1989, a USAir Boeing 737 overran Runway 37 at LaGuardia during an attempted rejected takeoff and came to rest in Bowery Bay. In a November 1993 accident, a China Airlines Boeing 747 making an instrument guidance system approach to Runway 13 at Kai Tak Airport, Hong Kong, overran the runway and fell into Hung Hom Bay.]

Accident statistics for 1993 indicate that of the reported airport-related accidents, seven involved overruns necessitating water rescue.[4] Because all of the aircraft involved in water accidents may not be equipped with water rescue devices except flotation seat cushions, rapid rescue is mandatory.

Although progress is being made toward rapid response for accidents involving fire, water response capability is inadequate. An ALPA survey of U.S. airports maintaining a water rescue capability found response times between 15 minutes and 30 minutes for the water beyond the runway to be accessed by rescuers.[5]

In the United States, most ACs and manuals on the subject refer to using outside agencies, e.g., the U.S. Coast Guard or local harbor police, for this type of rescue. But such services are usually based some distance from the airport and, despite their best efforts, may take too long to respond to accidents that occur in water within 3,000 feet (915 meters) of the runway end,.

Some airports located near water use rescue boats that are mounted on a trailer in the fire station. These must first be hitched to a tow truck and then transported to a designated launching area, which may be nowhere close to the accident site. They must then be backed into the water and launched. The time taken to reach the launch area and to launch the boat may be beyond the survival capability of aircraft occupants who are injured, aged, handicapped or nonswimmers.

Large rescue boats are in the water at some major airports, moored at a nearby dock and manned by airport fire fighters. Most of these boats are slow, but they are useful for large bodies of water such as Boston (Massachusetts, U.S.) harbor or San Francisco (California, U.S.) Bay and can accommodate a large number of survivors. A rescue boat at Hong Kong can carry more than 300 persons. Most large rescue boats are designed not only for overrun accidents but also for accidents that could occur in the approach areas up to 15 miles (24.1 kilometers) from shore. It is, however, the rapid response to a point 1,000 meters from the runway that is most critical at most airports, even if that point is located in water.

There are two solutions to these water-response problems. First, the runway overrun area can be graded off into the water to form an inclined ramp. This will accomplish two objectives:

- It will help minimize aircraft damage. Under present conditions, an aircraft undershooting the runway might tear the landing gear off on a sea wall or other obstruction at the water's edge. An aircraft overrunning the runway onto a graded area would be likely to enter the water with little or no damage to the fuselage, thus enabling it to float longer; and,

- The ramp will also provide a rapid-launch location for a rescue boat where an accident is most likely to occur.

Problems Spur Innovations

ALPA is considering a recommendation for development of an amphibious rescue vehicle that could be maintained in a fire house, driven at high speed down a runway, down an inclined ramp and into water without stopping. Using jet propulsion, the vehicle should be capable of land speeds of 55 miles (88.5 kilometers) per hour and water speeds of 20 knots. Jet propulsion for water operation would eliminate the need for propellers, which can injure survivors in the water and damage life rafts and personal flotation devices.

The vehicle, as with all water-rescue boats, should be equipped with a quick-loading platform to expedite recovery of survivors from the water. There should be sufficient flotation devices (such as flotation platforms or life rafts) to accommodate the maximum number of occupants carried on the largest aircraft regularly scheduled into the airport.

To disperse fuel spilled into the water around the aircraft or for limited fire-fighting operations, the vehicle should be equipped with a water pump and turret-mounted nozzle. Output should be 500 U.S. gallons (1,893 liters) per minute. Adequate foam solution, compatible with salt or fresh water as required, should be carried too.

Regulations and advisory manuals for rapid-response airport water rescue are scarce. The ICAO *Aerodrome Manual*, Volume I, Chapter 13, only refers to spilled fuels on the water and the use of divers to recover victims. NFPA 402M, Chapter 10, discusses water rescue but does not mention response time, which is the vital element. [The author believes that revisions of NFPA 403 should require a three-minute response time for water rescue equipment to any point in the CRFFAA.]

Weather May Increase Response Times

ICAO Annex 14 calls for response times based on optimum visibility and surface conditions. The FARs, too, only require the response standard to be met in clear daylight. ICAO notes, however, that response in less than ideal meteorological conditions should be met if guidance devices are available.

Nevertheless, accidents occur in poor weather and reduced visibility. Because of advances in aircraft avionics, it is now possible for aircraft to land and take off in almost zero-zero visibility, and emergency crews need to be able to operate in the same conditions.

In low visibility, it necessary to determine where the accident is located and to see well enough to navigate to the site. Response during adverse weather with poor surface conditions is being studied at the FAA Technical Center, where one of its crash trucks has been equipped with a forward-looking infrared (FLIR) system and a global positioning system (GPS).

The FLIR enables the vehicle to navigate on the airport at speeds greater than 50 miles per hour in darkness and low visibility. The GPS tells the operator where the truck is located on the airport, within a few feet. These devices have great potential for improving rescue response in poor weather.

The rapid response of ambulances, doctors and emergency medical technicians provides another important factor in an emergency rescue operation. Triage, stabilization, first aid and removal of injured survivors to hospitals must be expeditious. Excess time required for an injured person to reach a trauma center can mean the difference between life and death.

No airport using only its own resources is medically equipped to deal with a major accident involving many casualties. At most, some airport firefighters are trained as emergency medical technicians. Some airports maintain only a limited quantity of medical supplies. In an accident, outside medical services are essential, and every effort must be made permit these services instant access to the accident site.

The responses of other services such as the Red Cross, clergy, customs, etc., although secondary to the success of the intervention, are also important factors in accident response. Their roles are specified in detail in the Airport Emergency Plan as required by the FAA Part 139, NFPA 424, *Airport/ Community Emergency Planning*, and the ICAO *Disaster Planning Manual*, Part 7.13.

NFPA 422, *Guide for Aircraft Accident Response*, provides guidelines to determine the response capabilities of the various agencies aiding in an aircraft accident. This guide contains sample report forms that can be used to critique emergency response capability, and to determine the adequacy of the emergency equipment and the effectiveness of the extinguishing agent used. By obtaining these data, airport emergency plans can be updated, emergency equipment can be upgraded and aircraft rescue and fire-fighting safety can be improved.♦

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About the Author

B. Victor Hewes, a retired Delta Air Lines captain, began his flying career in England in 1935. During World War II he completed two tours of operations as a fighter and bomber pilot, flying Spitfires, Hurricanes and Mosquitos. After the war he moved to the United States and joined Delta as a copilot/flight engineer, and then obtained captain ratings on McDonnell Douglas aircraft from the DC-3 to the DC-9, as well as the Convair 340, 880, 990 and C-46. At the time of his retirement he was a senior international captain flying the Lockheed Martin L-1011 across the North Atlantic.

In parallel with his flying career, Hewes was involved with flight and airport safety issues. He was chairman of the International Civil Aviation Organization (ICAO) fire and rescue panel; chairman of numerous safety committees for the U.S. Air Line Pilots Association (ALPA); safety chairman and vice president of the International Federation of Air Line Pilots Associations; a director of the U.S. National Fire Protection Association (NFPA); and chairman of the NFPA Airport Fire and Rescue Committee. He is a member of the ALPA Accident Survival Committee.

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