Aircraft Accidents that Caused Major Changes to Emergency Response Equipment and Procedures

Presented by:

Mark T. Conroy
Senior Fire Protection Engineer
National Fire Protection Association, USA

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Crash of United Airlines Flight 232, Sioux Gateway Airport, 19 July, 1989

The Flight
A DC-10 was en-route from Denver to Chicago on July 19, 1989 when a loud noise was heard in the aircraft's tail mounted engine. Unknown to the cockpit crew at the time, the engine fan assembly had failed, sending engine parts through the right horizontal stabilizer. The flight crew quickly realized that they had lost all three hydraulic systems that powered the aircraft's flight controls. The aircraft could now only be controlled using the throttles. The captain began emergency landing procedures and discovered that the nearest airport was the Sioux City Gateway Airport.

The Airport
The Sioux City Gateway Airport is a Category 6 airport. Aircraft rescue and fire fighting (ARFF) services for a DC-10 would match that required for a Category 8 airport (see NFPA 403, Standard for Aircraft Rescue and Fire Fighting Services at Airports for information on airport categories). The extinguishing agent required for a Category 8 is more than double that required for a Category 6. Three ARFF vehicles would be needed for a Category 8, versus 2 for a Category 6.

ARFF Services
The airport is a joint use airport which means that it is used for both civilian and the Air National Guard (military). The ARFF services for the airport are provided by the Air National Guard. The airport fire department had available, the following vehicles:

P-19 ARFF vehicle with 1000 gallons of water and aqueous film forming foam (AFFF)

P-4 ARFF vehicle with 1500 gallons of water and AFFF
P-13 ARFF vehicle with 350 pounds of dry chemical and 500 pounds of Halon 1211
P-18 Tanker truck with 2000 gallons of water for replenishment of the ARFF vehicles
P-10 Rescue Vehicle

Pre-Accident Positioning of Vehicles
Upon receiving information on the in-flight emergency, the 5 ARFF vehicles were dispatched. Additionally, 4 city fire department vehicles were dispatched. The responding vehicles received information that the aircraft might not reach the airport and that it could crash approximately 5 miles south of the airport. Therefore, some of the city vehicles were traveling on the interstate highway in anticipation of the aircraft crashing off-airport. They were later updated that the aircraft would make it to the airport and would land on runway 31. The ARFF vehicles took positions along that runway. The city vehicles including two engine companies, a command vehicle and an ambulance responded to their pre-assigned standby positions on the airport property prior to the crash.

Adding to the safety concerns was the location of two A-10 fighter aircraft that had just landed and were at the end of runway 31 in the direct path of the DC-10 if it were to either need the full length or overshoot the runway.

Impact and Wreckage
At the last minute, the fire department was informed that the aircraft would not make it to runway 31 and it was coming in on runway 22 which had been closed for some time and was no longer used for take-off and landing. Some of the ARFF vehicles were actually on runway 22 and had to move quickly to get off. Before all units had a chance to reposition, the aircraft touched down and began to break-up in a massive fireball rolling down the runway. The center section of the aircraft, which contained most of passengers, became inverted and ended up in a corn field, more than 3700 feet from the point the aircraft initially touched the runway.

The Response
The firefighters proceeded cautiously in the ARFF vehicles through the trail of wreckage in order to avoid injuring or killing survivors. After briefly inspecting the large tail section, they proceeded to the center section. On the way to the center section, firefighters noticed passengers still strapped in their seats and many walking along the runway.

Firefighting
Upon arrival at the center section, a large fire was encountered, which was mostly on the exterior of the wreckage. The fire was primarily under the right wing area and along the front end of the fuselage. The wind from the north helped keep the fire away from the fuselage. Foam was applied and the fire was initially knocked down. The fire department was careful not to move the vehicles into the muck as they were sure they would get stuck which would inhibit repositioning of the vehicles and replenishment of water.

Water Supply
As it was, replenishment from the tanker at the scene became impossible due to an internal malfunction of the delivery system. An internal stiffener in a pump hose had shifted and blocked water delivery from the tanker. Replenishment of the ARFF vehicles was accomplished from two pumpers that later arrived, but not before the fire intensified and spread into the interior of the fuselage. Due to this water supply problem, the fire was not was not brought under control until about 2 hours after the crash. Spot fires persisted throughout the night.

Initially roof turrets were used to apply foam and later hose lines from the vehicles were used in areas difficult to reach with the turrets. The hose line attack helped protect survivors that were exiting the front of the wreckage. A roof turret on one of the vehicles appeared to malfunction during initial use, but it was later discovered that the firefighter had simply left it in hydraulic mode, and was trying to move it manually.

The Cornfield
A large group of passengers had self-evacuated and had congregated together at the edge of the cornfield. It was later discovered during the interviews with survivors that the cornstalks made them become disoriented. The cornstalks also made it difficult for search and rescue activities.

Transportation of Injured
Once the magnitude of the accident became apparent, all available ambulances were requested to the scene. Thirty four ambulances from 28 agencies, from up to 60 miles away responded. Additionally, nine helicopters arrived from different agencies to help transport the injured to the two local hospitals.

Survival Aspects
Of the 296 people onboard, 111 died and 185 survived (see Figure 1). Of the 185, forty-seven were seriously injured, 125 had minor injuries, and 13 reported no injuries. Passenger seating was provided in 38 rows in this configuration of a DC-10. The setup was typical with the first class section taking up rows 1-8 and coach seating (2/5/2 seat arrangement per row) in the remainder. The upside-down center section in the cornfield contained rows 9-30, which was where most of the surviving occupants of the aircraft were seated. It therefore made sense to focus firefighting efforts to this area. Although this portion of the aircraft was eventually destroyed by fire, the early fire suppression activities are credited with saving many lives. Thirty-three of the 35 passengers, who died from asphyxia/smoke inhalation, were in rows 22-30. The egress path was to the front of the wreckage and these 35 people were seated in the back. Twenty-four of them did not receive traumatic blunt force injuries and may have been overcome by the smoke before they had a chance to reach the opening in the front. Also contributing to the high survival rate was “brace-for-impact” instructions given by the flight attendants.

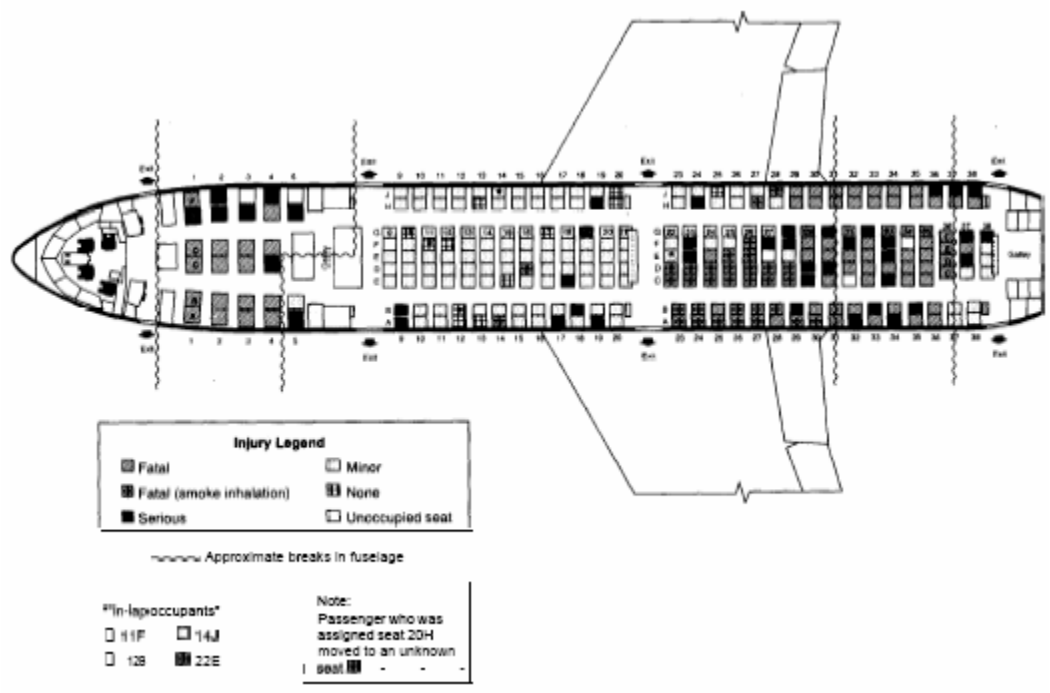

Figure 1 Aircraft Configuration and Occupant Injuries, Flight 232
(Copied from NTSB Accident Investigation Report)

Findings and Lessons

- It became readily apparent that the two A-10 fighter jets should not have been allowed to land after the in-flight emergency had been declared on the DC-10. The military aircraft with munitions attached stood in the path at the end of the runway originally designated as the target runway for the DC-10.

- The seatbelt cutting tool was utilized extensively to quickly cut through seatbelts of passengers still strapped to their seats.

- Although profits from the lease of the cornfields provide much needed revenue for the operations of the airport, the cornstalks obstructed the views of fire fighters and search and rescue teams. Obvious questions regarding crops of this height being allowed on airport property were raised.

- Communications were a problem at this accident, not unlike most accidents. There seemed to be too few frequencies and the available frequencies were over-utilized. At one point, the dispatch center operator connected several frequencies together, as he felt they all seemed to want to talk to each other, but he soon recognized his mistake and separated them.

- The full-scale disaster drill conducted in October of 1987 involving 90 casualties and the smaller drill in June of 1989, contributed to the success at the scene and at

the hospitals that received the injured survivors. The numerous routine tabletop exercises also are recognized as a contributing factor to the successes.

- The tanker truck had an obstruction in the hose and was not able to deliver water to the ARFF vehicle. This problem should have been discovered by full flow tests well before the water was needed at an accident scene. The small PVC plastic stiffener in the soft hose assembly was inadequate. Either a longer stiffener or a more appropriate hose should have been provided with the vehicle.

- A fire fighter did not recognize that the roof turret was not in the manual mode and fought the hydraulics to try to move it. Although much training was provided, his confusion was contributed to the stress of the situation.

- A large quantity of plywood was needed to walk on the inverted mid section of the aircraft. Large timbers were needed to shore up unsteady portions of the wreckage during the investigation.

- A forklift truck was used to hoist the cockpit to extricate the cockpit crew.

The Collision of a B-727 and a DC-9, Detroit Metropolitan/Wayne County Airport, 3 December, 1990

The Collision
A Northwest Airlines B-727 taking off from Detroit Metropolitan Airport collided with a Northwest Airlines DC-9 that was taxiing into position for takeoff. Of the 198 people onboard the two aircraft, 8 died and 36 were injured, 10 seriously.

Following snow and warming temperatures, a heavy fog had set in at the airport with a visibility reported between 1/8 to 1/4 mile. The cockpit crew of the DC-9 became disoriented and confused regarding their position and taxied their aircraft onto the active runway where the B-727 was in the takeoff process. The right wing of the B-727 was slashed open a gash in the right side of the DC-9 that ran the full length of the aircraft. The rear mounted engine of the DC-9 was also dislodged. Fire in the cabin of the DC-9 quickly developed and passengers and crew immediately began evacuating. The fire was reported to be very intense immediately after impact, inside the right rear cabin, directly near where the dislodged engine was located.

The Response
The airport fire department received an aircraft accident alert (formerly Alert III, see NFPA 402, Guide for Aircraft Rescue and Fire Fighting Operations) and immediately dispatched 13 ARFF personnel on 10 vehicles. The Detroit Airport is a category 9

airport, so there were two 4000 gallon ARFF vehicles and a 1500 gallon ARFF vehicle among the first responders.

Due to the poor visibility, neither the ATC tower nor the ARFF personnel could readily locate either aircraft. ARFF services proceeded cautiously in the fog. They found the B-727 aircraft and applied foam to suppress vapors to the spill from the damaged wing-tank on the aircraft. The driver of one ARFF vehicle pulled up to the cockpit and communicated with the pilot. Since radio communications would have to go through ATC and the pilot had the cockpit window open, the ARFF vehicle operator spoke to him through his open driver's window. The ARFF vehicle driver told the pilot that he applied foam to the spill and there was no fire around the aircraft. The ARFF vehicle remained with the B-727 but was later ordered to help at the DC-9.

While most of the equipment went directly to the B-727, the small pumper vehicle operator came upon the DC-9 located about 2100 feet down the runway. All ARFF services except one ARFF vehicle which temporarily stayed with the B-727 were then directed to respond to the DC-9. The aircraft was fully involved in fire at that point.

Upon arrival at the DC-9, the ARFF crews extinguished a fire at the detached aircraft engine and a small spill fire under the tail section of the aircraft. They then positioned the vehicles to make hose line attacks. They laddered up to the left overwing exits and attempted an attack. They quickly abandoned the attack due to the intense heat of the fire. The fire soon breached the aft section of the fuselage and quickly consumed the interior of the aircraft. Once the flames broke through the skin of the aircraft, firefighters were able to apply foam and promptly suppress the fire. The eight victims of the fire were located and removed from the aircraft. The fire in the aircraft was suppressed without replenishing water in any of the ARFF vehicles.

Findings and Lessons

- Firefighters connected hoses to a hydrant near the DC-9 to replenish ARFF vehicles. The water supply to the hydrant had been shut off without notifying the fire department. Normally, this hydrant would have been checked for flow before connecting.

- Upon arrival to the DC-9, no occupants were observed leaving the aircraft and none were apparent. Those that survived self evacuated. The fire department made a decision not to risk entering the aircraft when intense heat was encountered at the overwing exits.

- Since this experience involved limited visibility in fog, technologies were researched to help improve response under these conditions. A driver enhanced vision system is now employed on most modern ARFF vehicles which is described in NFPA 414, Standard for Aircraft Rescue and Fire Fighting Vehicles as follows:

The driver's enhanced vision system (DEVS) aids the three difficult aspects of poor visibility response: navigating to the accident site, locating the accident, and negotiating terrain and obstacles on the way to the accident site. DEVS is an integrated system consisting of three systems: navigation, tracking, and low visibility enhanced vision. DEVS can be implemented as a stand-alone system on an ARFF vehicle with no tracking/communication capability or as a fully integrated system with an emergency command center (ECC). The three DEVS system components are as follows:

1. *Navigation. The navigation system provides the ARFF vehicle driver with the vehicle's location and serves as an aid in navigating to the accident site.*
2. *Tracking. The tracking system can be tightly integrated with the navigation system through data link. Tracking capability serves as an aid to the ARFF vehicle driver in locating and navigating to the accident site. This capability will reduce driver communications workload and improve the situational awareness of the driver and command or dispatch personnel.*
3. *Low Visibility Enhanced Vision. The low visibility enhanced vision system uses a forward looking infrared (FLIR) device or other comparable state-of-the-art low visibility enhanced vision technology. Low visibility enhanced vision capability will improve visual awareness in smoky, foggy, or dark environments by sensing thermal radiation instead of visible light.*

- Many of the fire fighters at the Detroit Airport at the time were also volunteer structural fire fighters at their local town fire departments. The experience with structural firefighting enabled them to have the knowledge and experience to confidently approach the window exits by laddering up onto the wing and comprehending the situation enough to not attempt an entry.

- The forward left door of the aircraft was used by many of the occupants for evacuation. The slide did not deploy as nobody had been able to locate the lanyard to inflate the slide. The deflated slide slowed the evacuation. Emergency responders had to deal with extra injuries as people were using that exit without the slide.

- Although the tailcone was not jettisoned externally by fire fighters because the cabin was deemed untenable, it was recognized that this is an important exercise to be performed or explained in training prior to an accident with an aircraft of this type.

Communications between the aircraft and the ARFF vehicles went through ATC. A new FAA Advisory Circular provides information on assigning a discrete frequency for aircraft to communicate directly with ARFF vehicles (see FAA Advisory Circular 150/5210-7C, Aircraft Rescue and Firefighting Communications).

Runway Overrun Crash of American Airlines Flight 1420, Little Rock Airport, 1 June, 1999

The Overrun
American Airlines flight 1420, an MD-80, attempted to land shortly before midnight at Little Rock National Airport. There was severe weather in the area including thunderstorms and high winds. The aircraft was difficult to control in the stormy weather and poor visibility conditions. The aircraft overran the runway, struck an approach lighting system (ALS) and broke apart.

Communications
The ACT tower normally resumes contact with an incoming aircraft just after it lands. ATC repeatedly attempted to contact Flight 1420 over a period of several minutes before notifying the airport ARFF services that they had lost contact with the MD-80 approaching runway 4R.

The Response
Approximately 5 minutes after receiving the call from ATC, all four firefighters on duty in the 3 ARFF vehicles reached the approach end of the runway. Upon finding no sign of an aircraft, the decided to do a sweep of the runway. All 3 vehicles proceeded down the runway in the driving rain at a speed of about 50 kilometers (30 miles) per hour. Switching to high beam headlights only made visibility worse. Halfway down the runway, the fire fighters could smell burning material but they could still not see the downed aircraft. By the time they reached the end of the runway, they could see the glow of the aircraft on fire through the heavy precipitation in the distance. At this point they knew the aircraft was either in the river or on the flood plane. An aircraft accident alert was declared at this time and a full response was requested from central dispatch to the northern end of runway 4R. The ATC transcript indicated that this communication was 3 minutes and 5 seconds after they communicate that there was no aircraft at the approach end of the runway. Since there was a 7.5 meter (25 foot) slope to the flood plane, which was covered in boulders, going directly to the aircraft was not possible. They had to turn around and go back up the runway about 275 meters (300 yards) to a gate and follow a narrow road to the crash site on the flood plane.

The Impact with the ALS
The collision of the aircraft with the ALS caused the plane to break apart. Two breaks occurred, a partial separation at rows 11/12 and a major break occurred just forward of the center wing section as the two pieces separated and were at ninety degree angles to each other. There was also a large opening in the fuselage around the left side of the first class section and the cockpit. Fuel from the aircraft ignited and fire quickly spread into the cabin rear section.

Firefighting
Before reaching the downed aircraft, the ARFF team encountered about 60 survivors that had self evacuated. Although fire fighters were able to extinguish the exterior fire in about a minute, fire eventually consumed the interior of the aft section of the aircraft. Because wind was blowing the fire away for the front section, fire did not enter the interior of the front section and occupants were later removed or extricated from that section.

After first responders handled the initial fire knockdown, fire fighters from downtown arrived with additional equipment and assisted at the scene and setting up a triage area.

Evacuation and Extrication
Prior to the fire spreading into the rear cabin, passengers and crew were able to self evacuate. Evacuation of the rear section was through the overwing exits. Very few occupants exited through the break in the fuselage. Survivors that were mobile and were able to move quickly got out of the tail section before fire consumed it.

Evacuation of the forward section was through the opening in first class section and through gap in the fuselage at row 12, but most got out through the first class section hole.

The first officer suffered a broken leg in the crash and was extricated from the twisted metal by firefighters. Fire fighters also removed several surviving passengers from the first class section.

Fatalities
The Pilot was killed on impact with the ALS. There were 10 other fatalities. Passengers in 3A, 8A, 17B, 18A, and 18B died of traumatic injuries. Five passengers in 19A, 19B, 19D, 27E, and 28D died of asphyxia/smoke inhalation. Three of these passengers were at the opening where there fire entered the rear section of the cabin. The two other smoke inhalation fatalities were quite a ways back in the cabin and further analysis would need to be conducted to determine if age or other factors contributed to their inability to self evacuate. Figure 2 shows the relationship to the fatalities and the break points on the aircraft. Passengers in first class in 3A, 3B, 4A, 4B, 5A, and 5B were ejected from the aircraft while still strapped in their seats. Also at the center section break, passengers in 17A, 17B, 18A, 18B, 18D, 18E, and 18F were ejected from the aircraft while still strapped in their seats. Comparing those that died with those that were ejected, four of the 13 passengers ejected form the aircraft died of traumatic blunt injuries, the others that were ejected, survived.

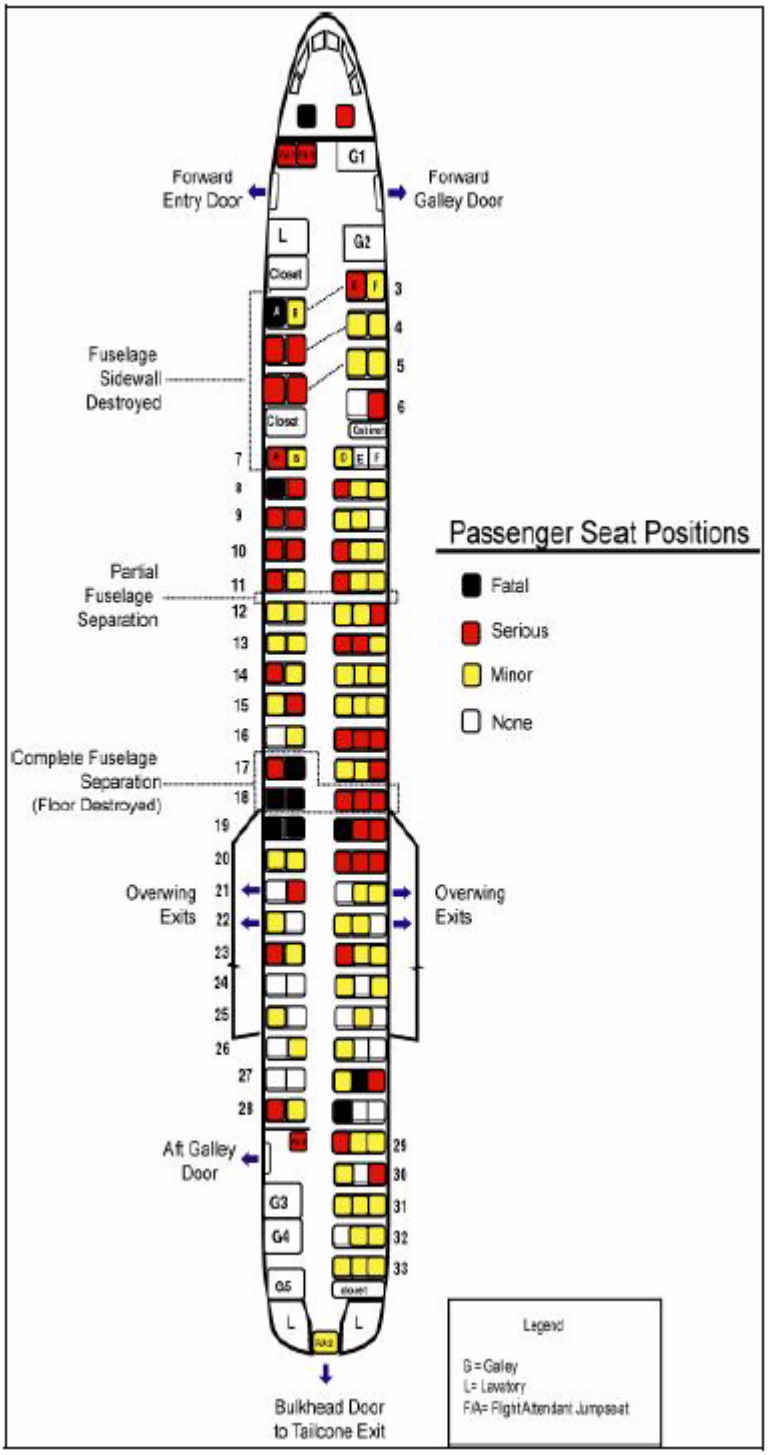

Figure 2 Aircraft Configuration and Occupant Injuries, Flight 1420
(Copied from NTSB Accident Investigation Report)

Findings and Lessons

- Several fire department personnel were talking to the media. The fire department originally told the media that that went to the wrong end of the runway before doing a sweep and finding the aircraft at the departure end of the runway. What they meant was that it was not a mistake on the fire department's part; they received information from ATC that directed them to the approach end. It would be normal to report there and then conduct a sweep if the aircraft was not found. The media took the information out of context and created an unnecessary problem with not reporting it accurately. Assigning a public information officer to release timely and accurate information is paramount in an accident like this.

- Records of survivors were not kept as they left the crash site do to the weather conditions. Initially they were transported to the fire house and then transferred to an off-airport theater which was a short distance away. Family members quickly found out that their loved ones were at the theater and they simply went and picked them up. This was done before records were created on survivors at the theater. It was days before everyone that survived was accounted for.

- Due to the limited availability of ambulances, some Priority II casualties were transported to the hospitals in the front seat of ambulances.

- The roads to the accident scene in the flood-plane are single lane roads. A traffic pattern was created where incoming ambulances and rescue vehicles would enter from the southeast and then depart from the northwest.

- A trailer with medical supplies was donated to the fire department years before the accident. The backboards were needed and used at this accident. Without this available resource, they would have been not enough backboards.

- The critical stress debriefing was conducted by the fire chief with little training in the area.

- Injured passengers were transported to the fire house in need of medical attention. Medical response personnel were at the crash site with their equipment, leaving the fire house ill equipped to handle the needs of survivors.

- The procedures for declaring an "aircraft accident alert" were revised to immediately declare an alert upon notification of a missing aircraft.

- ATC initially provided delayed and sketchy information regarding the potential location of the downed aircraft. Following this accident, the fire department intended to work to improve communications with ATC for the future.

Closing Remarks

Aircraft accidents and incidents will continue to occur despite efforts to determine probable causes and make adjustments to avoid them. Investigations and periodic reviews of emergency response actions are necessary to learn from actual occurrences. The information presented today was developed from a combination of on-scene interviews and from reviewing the accident investigation reports produced by the NTSB. It is hoped that this information will be shared with the organizations represented by the delegates attending the conference to help improve readiness and responses to future occurrences

Resources

1. Aircraft Accident Report, United Airlines Flight 232, McDonnell Douglas DC-10-10, Sioux Gateway Airport, Sioux City, Iowa, July 19, 1989, Report No. NTSB/AAR-90/06
2. Aircraft Accident Report, Northwest Airlines, Inc., Flights 1482 and 299, Runway Incursion and Collision, Detroit Metropolitan/Wayne County Airport, Romulus Michigan, December 3, 1990, Report No. NTSB/AAR-91/05
3. Aircraft Accident Report, Runway Overrun During Landing, American Airlines Flight 1420, McDonnell Douglas MD-82, N215AA, Little Rock, Arkansas, June 1, 1999, Report No. NTSB/AAR-01/02

References

1. NFPA 403, Standard for Aircraft Rescue and Fire Fighting Services at Airports, 2003 Edition
2. NFPA 402, Guide for Aircraft Rescue and Fire Fighting Operations, 2002 Edition
3. NFPA 414, Standard for Aircraft Rescue and Fire Fighting Vehicles, 2001 Edition
4. FAA Advisory Circular 150/5210-7C, Aircraft Rescue And Firefighting Communications, July 1, 1999