Technology
Efficiency and Effectiveness

Aircraft Rescue and Fire Fighting Efficiency
Relates to the Use of New Technology

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NFPA Aviation Fire Risk Conference, Singapore Aviation Academy January 2005

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ABSTRACT:

Technologies which can enhance efficiency and effectiveness are being rapidly developed to improve the airport fire fighting response. Developing new technology takes time, money and in some cases education to convince fire fighters that these new technology should be embraced. The fire fighting services has deep traditions and many times older fire fighters are unwilling or unable to give new ideas, tools and techniques a fair chance in the fire house. Changing attitudes and educating fire fighters often proves time consuming and frustrating for manufacturers who embark on programs to develop technologies that may prove to increase efficiency and effectiveness. Many fire fighter voice concerns that newer technologies could lead to manpower reductions.

Technologies have been recently tested which can improve the effectiveness of existing water loads and provide fire fighters with quicker fire knock-down and enhanced application techniques. These technologies include; Extendable Reach Booms and Piercing Nozzles, High-capacity extendable bumper turret systems, High-Pressure Compressed Air Foam, High Pressure Spray and Vapor Thruster Nozzle. Recent technology developments have been focused on maximizing the effectiveness of agent carried on the first responding vehicles by offering more efficient application.

AIRPORT FIRE FIGHTING

The Federal Aviation Administration assisted by the United States Air Force performed pioneering research in the overall effectiveness and capabilities of the elevated boom with cabin skin penetration device in addition to several other new technologies. This was a revolutionary effort with a goal to vastly change the way fire fighters might fight interior aircraft fires, as well as fight post crash fuel spill fires using these newly developed technologies. Developing new technology takes time, money and in some cases education to convince fire fighters that these new technology should be embraced. The fire fighting services has deep traditions and many times older fire fighters are unwilling or unable to give new ideas, tools and techniques a fair chance in the fire house. The phase "*we have done it this way for thirty years, why change now*", often reflects the attitudes of older more opinionated fire fighters in the fire house.

Changing attitudes and educating fire fighters often proves time consuming and frustrating for manufacturers who embark on programs to develop technologies that may prove to increase efficiency and effectiveness. Many fire fighter voice concerns that newer technologies could lead to manpower reductions. Currently there are no known examples of airports in the US who have reduced fire fighting manpower after purchasing new equipment and technology.

INTERIOR FIRE FIGHTING SITUATION

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. Fire fighters put themselves at great personal risk when attempting any interior fire with hand-held attack lines.

Upon arrival to any accident site in which a post crash fuel fire exists the aircraft rescue and firefighting (ARFF) services immediately start to apply cooling foam. The fire fighters mission is to suppress these outside fires as quickly as possible, thus providing an escape path from the aircraft and then aid in the evacuation of passengers as necessary. These requirements often prevent a timely early interior fire suppression attempt. In many cases the cabin fire has already reached high flashover temperatures and is destroying the aircraft interior seats and furnishing materials before the fire fighters are able to enter the aircraft.

Air Canada Flight 797 Mc Donald Douglas DC-9 at Greater Cincinnati in June of 1983 and a more recent accident of a Value Jet McDonnell Douglas DC-9 in Atlanta Hartsfield in 1995 are examples of accidents in which fire fighters responded to aircraft accidents which principally had little or no static pool fires but had fully involved fast growing interior Class A material fires. In both accidents fire fighters had difficulty in gaining entrance of the cabin areas for hand-line extinguishment. Following an aborted takeoff of a Trans World Airlines Lockheed L-1011 at John F. Kennedy, Jamaica, New York, in July of 1992, fire fighters had difficulty extinguishing a tail engine internal fuel fire, which consumed the aircraft's interior. As recently as September of 1996, fire fighters fought an interior cargo fire involving a Federal Express McDonnell Douglas DC-10 freighter aircraft for over six hours at Steward Airport, New York.

Fire fighters can usually extinguish the post-crash static fuel fire with today's modern extinguishing agents. But accident data demonstrates that fire services have difficulty dealing with any post-crash interior fire. Significant interior fires cannot be extinguished using external aircraft fire-fighting tactics used by fire fighting services today. Recent historically significant accident data demonstrates the need to provide an increase in cabin protection, survivability, and extinguishment of the post crash interior fire. The new Airbus 380 will have full passenger seating on both levels of the aircraft. With as many as 10 to 12 slides deployed on each side of the aircraft, it will provide challenges to fire fighters to gain access into the aircraft.

HISTORICAL ACCIDENT FIRE DYNAMICS

In the late fifties and early sixties, large post crash static fuel fires were the most common fire threat that fire fighters faced, when responding to the earlier generations of transport accidents. Very little survivability of these accidents existed because commercial aircraft contained high volatile aviation gasoline for fuel. Aircraft fire services were predominately dependent on using protein-based low quality foams for extinguishing these earlier post-crash fuel fires. The need to improve on fire control and rapid extinguishment led to the development of the modern high performance Aqueous Film Forming Foams (AFFF) that are predominately used by airport fire services in the United States today.

Present transport aircraft can endure significant impact and still remain relatively intact. Today, aircraft fires are not generally the large catastrophic post crash explosive spill fires that fire fighters were faced with thirty years ago.

CURRENT AIRCRAFT FIRE SCENARIOS

Commercial aircraft today usually carry Jet A petroleum fuel, with its higher temperature flash point. The integrity of the fuselage is usually maintained on impact and the fire encountered by fire services is more typically a three-dimensional running fuel fire. These post-crash spill fires are more moderate in size. They may also have an accompanying post-crash interior fire. In fact, there is increasing data[1] that confirms that there has been an increase in airport fire responses in which there is actually little or no exterior fire, but an event has occurred which resulted in the aircraft interior to quickly be involved in a fire. 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 with a three dimensional running fuel fire and an interior fire.

FIRE CONDITIONS

AFFF is a static pool fire suppressant that is not effective in fires, which continue to re-feed flowing fuel to the fire. The large fuel bays of modern aircraft typically provide significant protection on impact, but on occasions, fuel tanks are breached or ruptured which can provide a continuing new source of raw fuel for the fire. This type of fire is typically much more difficult for responding fire services to extinguish. In addition, many recent accidents included interior fires ignited by electrical system, fuel, and even oxygen enriched fire sources.

INTERIOR FIRE REQUIREMENTS

Rescue crews trying to get into the aircraft should never impede passenger evacuation. The rescue fire fighting services should position themselves at the lower ground level of escape slides and assist passengers and direct them to safety. Assuming in an accident situation that there is a need for interior fire suppression, these types of fires are difficult to extinguish and at best a time consuming task. If there is a need for interior fire suppression then the earliest injection of water into the cabin interior environment should then be the stated strategic goal if fire services are to be successful. In most accident situations, emergency doorways and exits are opened prior to emergency crews arrival to provide egress form the aircraft by evacuating passengers. A more successful approach might be to use a piercing nozzle to slow advancing interior fires and provide additional survivability time for trapped passengers.

The responding fire services usually consume several minutes of this critical time element in their actual response to the accident. Current fire fighting strategies call for advancing manpower through existing doorway openings with hand-held attack lines. The fire fighters put themselves at great personal risk when attempting any interior fire attack with hand lines. Many fire fighters are advocating the use of hand-held piercing nozzle devices for combating interior cabin fires. Working off a ladder even on a narrow body aircraft would have the fire fighter approximately 10 to 12 feet into the air. This new aircraft

[1] National Transportation Safety Board (**NTSB) Accident Data from 1980-2000-**

design with its sheer size and second level passenger seating will present even greater challenges for airport fire fighters. The second level floor sill height of a Boeing Model 747 is approximately 22 feet off the ground. It is reported that the new Airbus A380 will have an upper level sill height 28 feet. This new aircraft design with its sheer size and second level passenger seating will present even greater challenges for airport fire fighters.

TECHNOLOGY EVOLUTIONS TO REVOLUTIONS:

Recently, truck manufacturers and the ARFF equipment industries have developed technologies, which can enhance efficiency and improve the fire fighting capabilities of ARFF services at airports around the world. High pressure spray and vapor spray suppression are two new examples of promising technology which could have hugh implications for future firefighting.. Examples of some of the technologies developed in the last decade to improve fire fighting services response are as follows:

Infra Red Cameras systems: are now required on all FAA funded heavy rescue vehicles and are designed to improve the response and operation of ARFF crews in low-visibility conditions. They will also provide a substantial increase in the ability to locate people, other aircraft, vehicles, and debris at the emergency site. Its ability to see through flames, smoke, and fog in daytime and nighttime conditions will give ARFF vehicles a increase in effectiveness in every phase of the emergency operations.

Extendable Reach Booms and Piercing Nozzles: The analysis of aircraft accidents involving external fuel fires has shown that, although external fires are often effectively extinguished, secondary fires within the fuselage are difficult to control with existing equipment and procedures. *In particular, there is a need to improve post crash interior fire survivability by developing better post crash cabin interior fire suppression techniques***.** Large amounts of smoke-laden toxic gases and high temperatures in the passenger cabin can cause delays in evacuation and pose a severe safety hazard to the fleeing passengers. The fire fighters put themselves at great personal risk when attacking any interior fire with hand lines. Historically, there has been no proven method to get early water intervention into the cabin interior within a few minutes of arrival of fire fighting crews. Dedicated rescue crews with specialized mobile stairways or lifting truck platforms for emergency egress into the cabin takes time to get in place and have not proven to be effective.

There is a need to improve post crash interior fire survivability through better cabin interior fire suppression techniques. The FAA, along with the United States Air Force (USAF) and the San Antonio (Texas) Fire Department have successfully tested an elevated waterway system with a boom-mounted cabin skin piercing system. At present, more than 300 airports in the United States and worldwide have upgraded their fleets with elevated boom-type devices. Fire services responding with vehicles equipped with elevated boom devices could make a significant early contribution to controlling any interior fires. ARFF responders can use elevated boom devices with their high reach and low ground attack agent distribution to gain quicker control of post crash external pool fires. Earlier control of external fires can provide additional valuable minutes of evacuation time for passengers. Strategically positioned to make a cabin skin penetration, these devices have the potential to extend survivability for passengers who cannot themselves self-evacuate and provide a safer situation for fire fighters to enter the aircraft after the evacuation of passengers has been accomplished. The French Department of Aviation at Charles DeGaul International Airport performed a similar large-scale evaluation of an elevated boom and cabin skin penetrator mounted on a Sides manufactured rescue vehicle. This test was similar to the FAA test. Fire services responding with vehicles equipped with elevated boom devices could make a significant early contribution to controlling any interior fires.

The high reach extendable turret (HRET) and aircraft skin piercing nozzle performed extraordinarily well in both efforts. The HRET proved to be superior to current designed airport trucks in its ability to use various attack modes, increased accuracy, faster extinguishing times, and safer delivery systems. The piercing nozzle demonstrated the control, suppression, and elimination of interior fire dynamics, fire growth and reduced high interior cabin fire temperatures, including the ability to provide rapid positive pressure smoke ventilation.

Research performed by the FAA and the USAF pointed the way to a whole new approach on how to fight aircraft post crash fires taking advantage of elevated or extendable booms capabilities. It became evident in early testing of the elevated devices that the lower to the ground agent was applied to the surface of the fuel, the more rapidly the fuel vapor could be suppressed. Thus the fire could be extinguished with considerably smaller quantities of extinguishing agent and in much less time then had previous been possible.

Low ground attack.

High angle application.

Extension into harms way.

Agent Application: For many years fire fighters were taught to apply extinguishing agent in a wasteful manner. The procedure was called the raindrop method. It was found to be ineffective and very inefficient. Fifty per cent of agent applied to the fire never reached the fuel surface. It was carried up vertically into the thermal heated smoke. The FAA/USAF jointly participated in a large-scale fire test program to evaluate new fire fighting technologies. One specific area of research related to the most efficient angle of application for fire fighting extinguishing agents. Data produced from the comprehensive testing indicated that the raindrop method of application was not the most effective method for applying extinguishing agent to a large post crash fuel fire.

In the *Series 1 Tests*, only the agent angle of attack was changed in the fire fighting event. In the large scale fire tests results below, note that as the angle of agent application was raised, the time of fire control increased.

Approach Mode	Large Scale AFFF Delivery Tests Fire Surface –3, 850 SF Average 90% Fire Extinguishment Time (Sec) Nozzle Elevation		
	45°	30°	0°
Frontal @0.07 GPM/SF	56	43	31
Side @ 0.07 GPM/SF	67	63	68
Frontal 0.13 GPM/SF	50	42	22

Table 1, Test Series 1 Roof Turret Elevation Angle

In large pool fires the rescue trucks must be repositioned or elevated turret angles must be used to deliver agent to the far side of the fuselage. Elevating the turret delivery system angles is very inefficient and can increase extinguishment times by 100% or more. Agent directed down onto the fuel surface tended to splash and disturb the film forming over the fuel surface. Total extinguishment of far side fire areas is not possible without application of inordinately large agent quantities. Vehicle repositioning interrupts agent flow, which can permit burn-back and immediate loss of fire control.

Summary and Conclusions of Test Series 1 - Optimum rescue vehicle approach mode conditions that should be considered: Frontal and tail approach; 0.13 GPM/SF AFFF (Aqueous Film Forming Foam) application rate; 0^o, seat of the fire, agent delivery angle parallel to the ground.

The side attack of a Large Frame Aircraft Fire is extremely inefficient and should not be conducted, unless it the only choice for setup. Nose to tail setup allows agent to be applied to protect the fuselage and evacuation slides and allows fire to be swept away from the evacuation corridors.

Approach Mode	Large Scale AFFF Delivery Tests Fire Surface –3, 850 SF Average 90% Fire Extinguishment Time (Sec) Delivery Method			
	Raindrop		Rain-drop	Seat of The Fire
	45^o	30^o	Average	0^o
	Roof Turret		*Bumper Turret*	
Frontal@ 0.07 GPM/SF	56	43	50	31
Frontal @0.13 GPM/SF	50	42	46	27
Total Extinguishment Times	116	85	96	53

Table 2, Test Series 2
Raindrop vs. Seat Of Fire Evaluation Tests

Series 2 Tests - A second series of tests was developed to examine Raindrop vs. Seat of Fire AFFF delivery methods using the following test parameters: 3,927 square foot fire area; water fire surface; 1,000 gallon JP-8 precharge; AFFF delivered from a Crash Fire Rescue (CFR) roof turret at a rate of 0.13 GPM/SF; AFFF delivered from a CFR bumper turret at a rate of 0.07 GPM/SF; 0^o, 30^o, and 45^o nozzle delivery elevations at each AFFF delivery rate; and frontal attack ARFF vehicle fire scene approach.

Three tests were conducted for each approach mode, each flow rate, and each nozzle delivery angle with the following results: 0^o, seat of the fire agent delivery angle is shown to be clearly superior to raised turret elevations or the raindrop delivery technique. For 0.07 GPM/SF, increasing the turret elevation to 45^o increased extinguishment time by 81%. For 0.13 GPM/SF, increasing the turret elevation to 45^o increased extinguishment time by 127%. The average extinguishment time for 45^o and 30^o elevation raindrop agent delivery approaches is 81% higher than for the seat of the fire technique. The average extinguishment times of these tests are summarized at Table 2.

Another test consideration was the vehicle driver-operator visibility. Roof turret applications at 30^o and 45^o elevations caused considerable windshield obstruction. Poor visibility caused the target to be directly obscured by the agent plume and by agent blow-back that was deposited on the vehicle windshield. Fire fighters could neither see how effective they were, nor where the agent was going. Visibility improved at a 0^o delivery angle, but some target obscuration and agent blow-back and deposited on the windscreen still occurred. Maximum driver-operator visibility occurred when the bumper turret was used in a 0^o, seat of the fire, agent delivery mode.

Forty-five degree application results in the greatest reach for roof turrets but agent loss occurs in the fire plume and disrupts the surface of the fuel by splashing the film surface buildup process.

Point of attack application from roof turrets accelerates agent but leads to over spray on windshield, which causes waste of agent. Because of obscured vision, fire fighters could not see what effect the agent was having on the fire.

Parallel to ground application accelerates agent across the fuel surface. This type of low ground attack allows a 10 degree power cone spray effect that disperses agent more rapidly.

Test summary and conclusions: Optimum LFA crash vehicle approach mode conditions are frontal and tail approach, 0.13 GPM/SF AFFF application rate, 0^o, seat of the fire, agent delivery angle. Bumper turret delivery provides optimum visibility. This approach mode can be executed only if a 250 GPM/SF flow rate is sufficient for the crash-fire scenario. The raindrop agent delivery approach is extremely ineffective and wastes significant quantities of AFFF. Low parallel ground agent application (extendable boom) accelerates the flow of aqueous film across the fuel surface. Technologies, which deliver low ground agent application, are the most effective, as the agent doesn't get lost in the rising heat and smoke plume. Visibility is not lost or interrupted by agent over spray on the windshield. The elevated boom in the ground attack mode places the agent at or near ground level. This technology will be the most effective in initial fire knockdown.

High-capacity extendable bumper turret systems: FAA/USAF large-pool fire fighting research has shown that low ground application of extinguishing agents produces better results than the raindrop method that was used for many years in AFFF applications. A more direct method where the agent is applied from a low ground position based on a high-capacity extendable bumper turret location reduces agent loss or waste due to window over-spray conditions from high-capacity roof turret application methods. In addition to the window over-spray problem, there is a significant improvement in fire knockdown and control applications when the agent is precisely supplied using low, parallel-to-the-ground application sweeps. Tests results validated a 38% improvement in fire extinguishing when bumper turrets were used at same rate as roof turrets. Thus, the FAA has modified its advisory circular series for large rescue vehicles to allow fire services to include these types of high-capacity extendable bumper turret systems.

Low ground attack

Good visibility

More agent on fuel surface

Dual Agent Application: A new method has been developed to provide primary agent and secondary dry chemical applications simultaneously. Developed to address the oil well fire crises in the Middle East in the mid-nineties, the new nozzle system called Hydro-Chem™ entrains the dry chemical powder into the master stream delivery system. This has resulted in better performance in combating three-dimensional running fuel fires. Measured results have shown the ability to deliver dry chemical precisely at distances of as much as 200 feet in USAF/FAA joint tests. This is a 100% improvement over present dual-agent application nozzles. Extinguishing three-dimensional running fuel fires has always been an extremely difficult task for ARFF fire fighters.


Spraying dry chemical into the master stream allows quick knockdown of large fires.

High-Pressure Compressed Air Foam: Several new devices, which can produce high-expansion foam applications, have been introduced to the ARFF community. The delivery systems being produced use both AFFF and various types of high-expansion, protein-based form derivatives. They expand the foam to approximately a 20 to 1 foam expansion rate. Thus, they typically produce about four times the foam product as normal AFFF systems. The initial interest in these types of applications was driven by a desire to develop a small compact system to provide quick knockdown and suppression of smaller type fires in which a full ARFF type vehicle might not be available on site. This equipment has now been modified to supply both small Rapid Intervention Vehicle (RIV) applications as well as installation on major rescue vehicles. High-pressure compressed air foam systems are just one example of ARFF fire protection proposals being considered as authorities look at pending regulations planned for the smaller commuter markets. Compact systems could be deployed on site, which would provide some level of fire protection at airports that do not presently have such protection, yet may be operated by airline personnel if needed. Additionally these High Energy Cold Foam devices have proven to be very effective in combating running fuel fires or three-dimensional fires. They have shown to far exceed the results obtained using traditional dry chemical powder extinguishing agents currently in rescue service inventories at airports.


Small systems can produce large quantities of finish foam product.

High Pressure Spray- The USAF and the FAA have been revisiting an old technology with a new spin. High pressure spray application is not new to the fire service. It has been tried in wild-land fire applications for many years. But recent successful research has included a 200 gallon per minute, 1500 pound pressure stream application utilizing the benefits of the elevated boom Snozzle™ as well as the low ground application of the Rhino™ delivery bumper systems. Precise location of high pressure 1500 pounds per minute water spray with Halotron1™ clean agent injected into the high pressure spray stream has demonstrated the ability to extinguish very large and complex running three dimensional fuel fires.

Utilizing the combination of the technology advanced delivery systems, high pressure water spray and the Halotron1™ clean agent has proven the ability to extinguish very large and difficult running fuel fires and at the same time maintaining a clean agent capability. The current test truck configuration showed the ability to extinguish the same fire size and extinguishing time of a standard USAF vehicle with approximately 2/3 less water and foam concentration. This is significant since this means the truck could remain in service for several more minutes before requiring re-supply.

Vapor Thruster Nozzle- A new nozzle system has been developed which has shown to have little to no back pressure. This is advantageous to the fire fighters who might be required to fight an interior hand-line attack. Fighting nozzle back pressure along with pulling needed hose line down the isles of an aircraft can quickly wear down the fire fighters. The Vapor Thruster Nozzle™ utilizes a high pressure air source that injects energy into the spray stream. It breaks up and atomizes the water stream into a fine mist vapor spray. This high pressure air source provides a homogenous spray of very fine mist under the low pressure of the trucks normal 200 pounds per minute system. This fine mist spray absorbs heat calories from the associated interior fire thus extinguishing the fire quickly and effectively. Injecting high pressure air into the spray stream gives the spray stream a further boost of energy and it can be thrown approximately 15 to 20 feet further than standard truck turrets and nozzle systems. Thus, giving the fire fighter further reach with both hand line and truck master stream applications. Thruster nozzles can be utilized in the same manner as a traditional nozzle. Thus, fire fighters can easily select vapor suppression or standard agent application.

RECENT TECHNOLOGY SUCCESS

Until recently there was no operational situation that required the penetration of the cabin with an elevated boom and piercing device. In fact elevated devices had been used to fight numerous engine and brake fires but had not been used for any post crash fuel spill fires except under research conditions. Decisions on purchasing these new technologies have been based on research assumptions and determinations that were focused on FAA and USAF studies. This all changed with a recent aircraft accident in Memphis, Tennessee.

Memphis International Airport and Federal Express MD-10
Memphis, Tennessee

On December 18, 2003, a Federal Express MD-10 aircraft lost control on landing roll-out after the right landing gear broke off. A major fire developed on the right side of the aircraft immediately which included a large grass fire. The wind was blowing at approximately 35 mph from the tail to the nose of the aircraft. The aircraft came to rest with the nose stretched across an air field drainage ditch. Memphis City Fire Department, directed by Chief Boyd, and the Federal Express Fire Department, directed by Chief McCann, provided an unprecedented technology knockout in this event. Because there were no injuries sustained, the National Transportation Safety Board (NTSB) categorized the event as an incident and not an accident.

The following fire fighting equipment and personnel responded to the incident:

Memphis City Fire Department (MCFD)

Chief Mark Boyd, Incident Commander

A1	RIV with Chief Boyd
A-3	Oshkosh 3,000 gallon with an elevated waterway and a Snozzle and a bumper turret
A-2	Oshkosh 3,000 gallon with a Rhino high capacity extendible bumper turret and a roof turret
E-33	Backup structural truck (E-One 1500 GPM Class A Pumper) responding from Station 35.

Federal Express Fire Department (FedEx FD)

Chief Daryl McCann

A-35 Oshkosh 1,500 gallon with an elevated waterway and a Snozzle and a bumper turret
A-30 E-One Rapid Response Vehicle with 100 gallons of AFFF pre-mixed Foam and 500 lbs PKP.

The Memphis City Fire Department and the Federal Express Fire Department have taken a proactive position in providing fire protection at the busy Memphis International Airport and central hub for the Federal Express's massive cargo operation by embracing the latest airport fire fighting technologies. Their progressive attitudes toward their firefighting response capability resulted in never seen before positive results. They were able to not only extinguish a very difficult fire, but were able to prevent major damage on the opposite non-fire side of the aircraft. We have all seen the statistic where upwards of 30 to 40 thousand gallons of agent and water was used in an accident, only to result in a complete loss of the aircraft. Not so in this case. The MCFD/FedEx FD response was a textbook response and the final result was very different from what we are use to seeing. The whole left side of the aircraft, No.1 left engine, and the tail-mounted engine were salvageable. The left wing, tail section and their control surfaces, and all the avionics appeared to be in reusable condition. The most important thing is there were no fatalities and about 97% of all the valuable cargo was kept intact and was undamaged.

The crash alarm sounded at approximately 1300 hours December 18, 2003, MCFD responded to the accident site with two major ARFF vehicles. Per their operational procedure the FedEx Fire Department proceeded down taxiway Alpha from their fire station to the MCFD Station 33 to backfill or provides field fire protection so the airport could continue in service with their two vehicles. MCFD, under the direction of Chief Boyd, proceeded to the site and setup on the right rear of the aircraft. On scene Chief Boyd A-1 arriving in the RIV, accessed the fire situation and immediately realized that he had a McDonnell Douglas MD-10 with a major fire. He called for assistance from the FedEx Fire Department. The FedEx FD had just arrived at the Station 33's ramp as Chief Boyd arrived at the site. He made a timely decision to redeploy the FedEx FD to the crash site.

Recognizing the need for immediate re-supply, Chief Boyd directed the responding MCFD structural company truck E33 (E-One 1500 GPM Class A Pumper) to lay 5-inch hose lines from the closest hydrant which was approximately 500 feet away from the aircraft. The structural crew had to cross two drainage ditches and an adjacent air field parameter road to reach the ARFF trucks for re-supply. This smooth coordination and close cooperation at the event resulted in a quick knockdown of this very difficult right wing and right fuselage side fire.

Chief Boyd directed and positioned truck A-3 (Oshkosh 3,000 gallon/elevated waterway/high capacity extendible bumper turret) at about a 45-degree angle from the right aft wing to fuselage junction as close to the fire as they could get. The wind was blowing at 35 mph and sweeping the fire down and along the fuselage. Truck A-2 (Oshkosh 3,000 gallon/high capacity extendible bumper turret/roof turret) with the bumper turret positioned just off the right horizontal stabilizer and aft of the right wing and adjacent to A-3. The wing had suffered major structural and fire damage and extensive fuel was leaking out of the wing. The wing had been shattered on the ground in the area. With this right wing severely damaged and as can be expected, a three-dimensional running fuel fire developed under the wing. The landing gear had sheared off thus making it difficult to reach this fire as the wing lay on the ground. A large ground fire developed which involved the grass underneath both of these two ARFF Vehicles. Under truck nozzle protection was utilized and was definitely needed on this afternoon.

Truck A-2 (Oshkosh 3,000 gallon/ high capacity extendible bumper turret /roof turret) proceeded to apply agent from its high capacity bumper turret at its lowest attack position and parallel to the ground, sweeping back and forth and applying agent along the fuselage. Truck A-3 (Oshkosh 3,000 gallon/elevated waterway/bumper turret), with its elevated waterway raised into the air, provided suppression on the forward and far away side of the wing area and fuselage. The crew was busy evacuating the aircraft from the cockpit windows. Chief Boyd (MCFD), Incident Commander, directed Captain Kiphut (FedEx FD) to position truck A-35 (Oshkosh 1,500 gallon/elevated waterway/bumper turret) to the rear of the left wing and to proceed to knockdown the lower fuselage fire using their bumper turret and the elevated boom in the bedded position. The truck was repositioned to the forward side of the wing shortly after that. The belly was ripped open and the fire was being fed from inside. After the fire was knocked down a bit, a bumper line was stretched from the front of the truck and the crew from A-30 (E-One Rapid Response Vehicle with 100 gallons of AFFF pre-mixed Foam and 500 lbs PKP) continued their efforts. After about one minute of hand line agent application from A-35's to the belly fire, they were given a new order. Chief Boyd A1 redirected them to make a direct penetration using the elevated boom with cabin skin penetration device into the aircraft forward of the left wing.

This response was a historic moment for ARFF fire fighting since up to that point no elevated device had ever been used in an actual interior fire situation. Until that time, elevated devices had only been used to combat interior fires under research conditions.

A-35 (Oshkosh 1,500 gallon/elevated waterway/bumper turret) with the attached penetrator point had already been redeployed forward of the wing but Captain Kipert ordered A-35 to be repositioned slightly closer to the engine. A large ditch prevented A-35 from moving in front of the No.1 engine nacelle. Engineer Bruner carefully repositioned truck A-35 in direct line with the left engine nacelle. The windshield of the truck was approximately 10 inches from the engine nacelle making it impossible to see over the nacelle. This was the closest position that they could get to the aircraft. Captain Kipert riding in A-35 carefully stepped out of the truck, approached the fuselage area, and directed operator Bruner from about 20 feet away to position the elevated device blindly from the cab position. Coordinating the extension of the boom together, they made the penetration approximately 14 inches above the window line forward of the forward left over wing exit. This was about 10 feet aft of the left main forward cargo door opening and directly across from where the aircraft skin was penetrated by the right wing fuel fire. Water and foam were injected into the fuselage interior for several minutes.

Examination of the aircraft fire skin damage after extinguishment reveled that the right forward skin area forward of the wing attachment root was penetrated by the fire in three places. The skin forward of the right wing was severely damaged and melted away for about a 25-foot area along the fuselage. Only the support stringers were left. The fire penetrated at the floor line at the air-conditioning grill distribution area. It further penetrated the sidewall fiberglass panels approximately five feet from the floor at an overlap seam in the interior. The final flame penetration source was about a 2 ft x 8 ft area along the ceiling of the aircraft approximately seven feet from the floor and forward of the wing root. This area only had the installation batten material hanging form the upper attachment point. The fiberglass interior panels were destroyed showing that a severe fire had gotten inside the fuselage. The penetration device mounted on A-35 (Oshkosh 1,500 gallon/elevated waterway/bumper turret) was fitted with an additional 15-inch extension for cargo fires. With the fuselage rotated upwards on an angle, this additional length allowed the penetrator to pierce the left cargo bin in this same upward angle approximately six-inches deep. As water was activated, the penetrator nozzle assembly self-adjusted itself, as it's supposed to, to a more level position utilizing its installed slip clutch mechanism. The piercing nozzle freed itself from the cargo bin and the majority of the water was distributed through the interior aircraft area. Soot was visibly washed from most of the bins in this area.

Video was taken from the A-3 (Oshkosh 3,000 gallon/elevated waterway/bumper turret) the elevated nozzle positioned on the right fire side of the aircraft. The video showed extinguishing foam agent coming out of the aircraft along the floor and each of the other penetration points of the aircraft. Little damage was seen on the actual bins closest to the fire's penetration side. Damage appeared to be nothing more than some distortion of the sidewall fiberglass panels. All of the cargo in the main deck cargo area was undamaged and was later distributed through normal channels of the FedEx operation.

MCFD and FedEx FD had control of the fire in about 10 to 12 minutes. They used a combined total of about 5,000 gallons of water from the three responding trucks to gain control of the fire. An additional ten minutes and approximately 750 to 1,000 gallons of extinguishing agent were used to subdue the stubborn-three dimensional running fuel fire on the right wing root area using hand lines from A-35 (Oshkosh 1,500 gallon/elevated waterway/Snozzle/bumper turret) and the 5-inch hoseline feed from E-33 (Backup structural truck E-One 1500 GPM Class A Pumper) supported by the MCFD engine company. E-33 was attempting to put out some residual fire on the right side of the aircraft. They did not have any more water at that time so the 1 ¾” preconnect from A-35 was taken under the aircraft and given to the E-33 crew. They knocked down most of the remaining fire with hand line fed from A-35. Other E-33 personnel initiated the re-supply of the ARFF vehicles from the 5-inch refill line. None of the initial responding vehicles were drained before fire control was established. The combined control and overall event took approximately 20 to 25 minutes.

The aircraft had approximately 25,000 pounds of fuel left on board the aircraft when landing at Memphis International Airport. The left wing being elevated appeared to contribute to the fuel fire. Fuel appeared to be leaking from lines in the belly and wheel well areas in the area of the cross feed fuel lines. The lower right wing was severely damaged in this area. The flaps and control surfaces were consumed by the fire in this area.

A 20-foot extension ladder was taken off the top of A-35 (Oshkosh 1,500 gallon/elevated waterway/bumper turret) and the crew door was laddered for entry. E-33 (Backup structural truck E-One 1500 GPM Class A Pumper) personnel entered the aircraft, determined that all personnel had gotten out, and checked for interior fire extension. There was none found. This particular aircraft had a crew of three and four passengers on board. They all evacuated through the pilot and co-pilot’s emergency direct vision (DV) windows.

Chief Boyd then asked A-35 (Oshkosh 1,500 gallon/elevated waterway/bumper turret) to back away from the aircraft and standby. He was concerned about the possibility that the left landing gear might collapse and the aircraft could fall and hit the truck. Approximately 20 minutes later A-35 was redeployed to the MCFD Station 33 to refill and standby. A-30 (E-One Rapid Response Vehicle with 100 gallons of AFFF pre-mixed Foam and 500 lbs PKP) was told to return to the FedEx ramp and standby at the FedEx Fire station.

This response was a remarkable effort. Both the Memphis City Fire Department and the Federal Express Fire Department worked as single, cohesive, competent unit. Chief Boyd and Chief McCann should be commended on their departments’ fine, professional performance. This did not come about by accident. Each shift’s assignments had been changed around so that both departments and their personnel mirror each others working time on and days off. Thus, all the people involved in this event from each department were familiar with each other. They trained together and knew what assets each others department would provide. Both organizations had been proactive in acquiring the latest technology. The most important element of this response was that they all trained on their new equipment and were all effective and efficient in its operation. The results speak for themselves: all aircraft crew and passengers were safely evacuated and a major portion of this valuable aircraft was saved. The entire cargo was saved from the aircraft fire and 97 % of it was undamaged and sent on its way. This was truly an historic event in aviation fire fighting. One local ARFF response with a worldwide impact!

CONCLUSION

The FAA and the USAF have tested and evaluated many new technologies that are now commercially available for airport firefighting. In particular the elevated boom with piercing nozzle has not only been comprehensively tested in research but has also proved itself in a real aircraft accident situation. In December of 2004, the Memphis Airport and Federal Express Fire Departments extinguished a large post crash fuel spill fire and also used the cabin skin piercing device to save over 98% of the MD10's valuable cargo in a major accident. As more opportunities arise to utilize these new technologies their efficiency and effectiveness will continue to be demonstrated.

Changing attitudes and educating fire fighters has proven to be time consuming and frustrating for manufacturers who embark on programs to develop technologies that may prove to increase efficiency and effectiveness. Fire fighter should not overly concern themselves that newer technologies could lead to manpower reductions as this has not proven to be the case.

Technologies which can improve interior fire fighting with vapor suppression nozzles that have reduced back pressure will prove to be more effective and easier to handle. Vapor suppression nozzles and high pressure spray applications will grow over time to be the agent application method of choice. Maximizing the agent application of first responding vehicles extends their time in duty before they require reservicing.