Tactical Considerations in ARFF:

The “Smart Approach”

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1.0 INTRODUCTION

Aircraft Rescue and Fire Fighting (ARFF) is a highly specialized component of the fire service. An aircraft accident presents itself with a plethora of unique hazards which threaten the aircraft occupants, the community, the environment and the emergency responders. ARFF crews must respond quickly and with precision to minimize loss of life, injuries and dangers. Fortunately, serious accidents are fairly rare, but that benefit means that experience can only be built through training and learning from others rather than from actual accident experience.

As an industry, we have developed sufficient knowledge and experience to approach each challenge presented during an aircraft incident with brains rather than brawn. We should be working safer, rather than harder. We can operate more efficiently, conserving agent, minimizing damage, protecting evidence, all to produce an outcome that provides the best possible outcome, and one that provides a new benchmark for learning.

1.1 SCOPE

Sometimes tradition interferes with progress. Just because, “we’ve always done it that way” does not make it the best way. This paper will explore elements of the “Smart Approach” in response techniques, tactics, strategies and procedures that are currently commonly used by ARFF Fire Fighters. We will evaluate new technologies and develop scenarios wherein combinations of these technologies could possibly produce favorable outcomes. We will evaluate tactics used in other areas of emergency management and draw from the best practices to assemble some common sense approaches to emergency response and management of aircraft incidents and accidents. We are all committed to advance the science of aviation safety, fire prevention and protection. Perhaps through collaboration we can agree upon some “Best Practices” that do just that.

1.2 TARGETS OF STUDY

Topics to be discussed using the “Smart Approach” are:

- Integrating Safety Management Systems (SMS) into Emergency Planning
- Airfield Response Plans
- Advanced Technology Integration and ARFF
- Lessons Learned, Historical Aviation Accident Review
2.0 INTEGRATING SMS INTO EMERGENCY PLANNING

Safety means different things to different people. In Webster’s New World Dictionary, the definition for safety is as follows: “the quality or condition of being safe; freedom from danger, injury, or damage; security.” In the fire service, when we think of safety, the first thing that comes to mind is that important component of every command structure and Incident Action Plan. The role of a “Safety Officer” in Incident Command is taken very seriously. In fact, the Safety Officer wields the power to stop an emergency operation without consulting the Incident Commander if he or she deems the operation as unsafe.

ARFF Firefighters are charged with the safety of our airport community and the flying public that choose to fly through our jurisdiction. To those people, there is an expectation of safety. They simply desire and expect that they can reach their final destinations safely. They understand that there is some risk involved in traveling, albeit a minor risk; there is a chance that a person will be injured or killed while traveling. They typically accept that risk because it is so small. If, in fact, an accident or injury occurs, they have another expectation that qualified, competent responders will quickly respond to assist them.

The definition of Safety as per ICAO is “the state in which the risk of harm to persons or of property damage is reduced to, and maintained at or below, an acceptable level through a continuing process of hazard identification and risk management.”. The ICAO definition seems to specifically relate to safety management. This definition recognizes that the activity (unsafe acts) is not reduced to zero, but instead to an acceptable level. It clearly suggests that safety is measured against the established acceptable level.

The FAA defines Safety Management System (SMS) as the formal, top-down business-like approach to managing safety risk. It includes systematic procedures, practices, and policies for the management of safety (including safety risk management, safety policy, safety assurance, and safety promotion).

Neither of these definitions significantly differs from how we in the fire service define safety and implement safety systems. We have our own language, of course, but the underlying mission is the same. We understand that providing emergency services comes with a level of risk. We use that acceptable level of risk in our risk analysis, which is performed routinely in the development of Incident Action Plans (IAPs).

Safety systems, like safety rules and procedures, are only as good as the level to which they are followed. That typically correlates directly to the level of importance placed on safety by the highest levels of organizational management. Everyone shares the desire to be safe, but routinely society accepts cutting corners on safety. Examples of this might be rolling slowly through a stop sign, or not buttoning the top button on our fire fighting PPE. It doesn’t seem like a big deal and is not likely that anybody will notice or care; nothing terrible is likely to occur as a result. The greatest failure identified by this mini risk assessment is the conclusion that our safety systems are tolerant of cutting corners on safety.

2.1 SAFETY CULTURE

We recognize the need for safety and, in general, follow most of the safety rules of which we are aware. Each of us can think about examples within our own organization that we follow selectively. If we intend to truly embrace safety, and to integrate safety, we need to raise the level of safety emphasis within our organization and establish a true safety culture. The best illustration of a success in establishing a culture is the security culture that exists at airports today. We know the security rules and would not violate them. One would not show up for work without one’s security badge and expect to get on the AOA. One would never leave a security door open or let a stranger piggyback through a SIDA door. When you and everybody else put the same value on safety rules, you may well have been successful in developing a safety culture.

2.2 EMERGENCY MANAGEMENT AT AIRPORTS IN AN SMS ENVIRONMENT
Effective and efficient management is best achieved when the stakeholders themselves are involved in developing, testing and implementing a plan. This is true in every case, whether it be management of an aircraft arrival at the gate, an aircraft accident, an airport security plan, or a Safety Management System.

When a team approach is used for developing safety policy and objectives, a number of benefits are quickly realized, including the development of important relationships. Aviation is highly competitive, but when these business adversaries meet at the safety table, there is one primary goal. The stakeholders in safety share methods and ideas, working together to develop inter-operative plans, which better serve the airport community as a whole. The benefits to this approach include:

1. The development of a “Safety Culture”, which universally raises safety awareness and results in a reduction of accidents and injuries.
2. The tendency of the “Safety Culture” to interface naturally with the “Security Culture” which already exists at most airports.
3. Enhancement of emergency operations through established relationships, communications, asset sharing and a spirit of cooperation.

The most significant lessons learned through the management of the most challenging events in the last decade relate to interoperable emergency management models. The terrorist events of September 11, 2001, and the devastating havoc caused by Hurricane Katrina and Rita clearly outlined the need for a standard template for emergency management and Incident Command, which resulted in the National Incident Management System (NIMS). This system requires that all emergency responders be trained to the same incident management model, i.e., everyone is readily reading from the same script and speaking the same language during the active phase of emergency management.

For a number of reasons, airlines and airport support companies deal with rapid turnover of employees. This increases the challenge in maintaining updated contact lists, and keeping employees trained in emergency procedures. A successful SMS requires constant interaction with representatives from every employer. Safety Committees conducting risk analysis, training, safety audits, and safety promotion continuously keep a line of communications open throughout the airport community, working together in problem solving. Each group learns and better understands the culture of the other stakeholders. The Police, Fire and Airport Operations Departments are critical members of this team.

Similar to NIMS on the national level, an effective SMS provides an environment for the stakeholders to reap benefits for emergency managers at the airport level, who depend upon instant communications, immediate response for information and assets, and “mutual aid” from other airport stakeholders.

2.3 ARFF ROLE IN DEVELOPING SAFETY CULTURE

The role of ARFF in developing a Safety Culture at your airport is a natural extension of your normal role. ARFF should be taking the lead in a pro-active approach to community safety services. The airport is your community. It consists of two primary groups. The first is the flying public and the visitors who pass through the airport. These numbers vary from airport to airport, but it is on a relative scale with the response activity and emergency services personnel and assets on hand. The working community at the airport is the second group. These are the community’s stakeholders. They have a vested interest in making your airport a safer place to make their living.

Fire prevention programs have been launched by nearly every fire department in the world. It is a natural, based on our primary mission, firefighting. Response to accidents probably makes up a larger portion of our runs than actual fire calls. Shouldn’t accident prevention and safety programs be one of the standard services provided by our departments? There are incidents causing injuries and damage on our airport ramps every day!

Ramp accidents and incidents causing injuries and damage are a problem that airports need to take more seriously. Industry-wide experts estimate that the airlines lose more than $5 billion a year to ramp damage, typically collisions between ground service vehicles and parked aircraft or jet ways. Because accidents also result in cancelled flights, lost ticket revenue, added costs for passenger lodging, and overtime for repairs, even minor ramp incidents can cost...
airlines $250,000 or more. Indeed, the Flight Safety Foundation estimates that for every dollar of aircraft damage, the actual cost to airlines is five times that amount, or more. One airline reported that $77 million in aircraft damage from ramp operations produced about $540 million in actual lost revenue.

Even worse, according to experts, are the number of ramp workers injured every year. At 14 in 100, the rate of injuries to ramp workers is far higher than for many other industries. Human error is the primary cause of ramp accidents, as reported by the International Air Transport Association, where about 92% of incidents can be traced to the failure to follow procedures, lack of adequate training, and airfield congestion. Reducing ramp damage contributes to a positive bottom line in an industry that is struggling financially.

ARFF Firefighters do not recognize the value proposition that comes with our career choice. “People”, in general, respect firefighters and what we represent. Most people, at one time or another, have dreamed of being a firefighter. Most people have, at some point in their life, admired and respected the job we do. Most people have had a glimpse into the “firehouse culture”, either through movies like “Backdraft”, or through a friend or family member that wears our uniform. As a result, most people have a little envy for the camaraderie, the brother(sister)hood and the culture. They have seen the pumper parked at the Supermarket, while the uniformed crew is filling a shopping basket for the crew dinner. They smile at the friendly banter and exchange they hear from the crew as they peruse the aisles. They grin at the quantity of food that fills the basket. They would be even more envious if they knew that soup, salad, chicken parmesan with linguini, green bean casserole, garlic bread, soda and brownies with ice cream was going to cost each member about five bucks for all he/she could eat.

We in the fire service are problem solvers. We can see exactly what is happening in the aviation industry and on our airports. By assuming a role of leadership, we may be able to slow this trend of accidents, injuries and energize the airport community to develop a safety culture. By reaching out to the airline community, and developing partnerships in safety, we can bring these fierce competitors to the firehouse table where the common goals and problems can be identified. What will become immediately apparent is that these stakeholders embrace the idea of working with the fire department. They enjoy coming to the fire station and meeting in our environment. They take pride in becoming a part of a pro-active safety service and identifying with the fire service. Never underestimate the power of a spaghetti dinner served in the firehouse kitchen, or a fire department T-shirt!

2.4 COMMUNITY RESOURCE MANAGEMENT (CRM)

Wikipedia definition: “Crew (or Cockpit) Resource Management (CRM) training originated from a NASA workshop in 1979 that focused on improving air safety.” The NASA research presented at this meeting found that the primary cause of the majority of aviation accidents was human error, and that the main problems were failures of interpersonal communication, leadership, and decision making in the cockpit. A variety of CRM models have been successfully adapted to different types of industries and organizations, all based on the same basic concepts and principles. It has recently been adopted by the fire service to help improve situational awareness on the fire ground.

Although first used in Aviation, the acronym CRM is used by a number of industries. Customer Relations Management, Cultural Resource Management, Composite Risk Management, Client Resource Management, and Continuous Resource Management are just a few of the 85 definitions for CRM found in a Google search.

We in aviation fire protection need to expand this definition one more time. We stand in the unique position of having an understanding of Cockpit Resource Management, as well as the Fire Service model of Crew Resource Management. A hybrid of these cultures that suits the needs of our response jurisdiction is Community Resource Management (CRM). By drawing our community together, working together to develop a safety culture, sharing our experiences, our successes and our failures, we build relationships that live long beyond that first firehouse dinner. These relationships will bear fruit every day, but never in such abundance as during the management of an emergency event. The daily benefits will be obvious as one reviews accidents and incident statistics, or simply by driving across the ramp and seeing the products of the Airport Community Based Safety Program in action.
3.0 AIRFIELD RESPONSE PLANS

Most aircraft response requires ARFF vehicles to travel onto the airfield in preparation for the arrival of the aircraft with a reported problem. This has become more difficult in recent years and the typical response in some ways is a direct contradiction of the basic rules we learned in Firefighting 101.

3.1 RUNWAY INCURSIONS

The runway incursion issue has been on the National Transportation Safety Board’s Most Wanted List since its inception in 1990. In the late 1980s, an inordinate number of runway incursions/ground collision accidents resulted in substantial loss of life, and the Board issued numerous safety recommendations addressing the issue.

The FAA has drawn conclusions as to the causes of runway incursions.

For Air Traffic Controllers (ATCs)
- Not scanning the runway.
- Coordination errors—not exchanging critical information with other controllers.
- Communication errors—not catching all read-back errors.

For Pilots
- Not following acknowledged ATC instructions. For example, reading back ATC instructions correctly and then doing something different, such as failing to “hold short” of runway or failing to hold in position on runway as instructed.
- Losing orientation during taxiin. For example, getting lost in good or poor visibility conditions.
- Communication errors. For example, misunderstanding the clearance and not asking for clarification from ATC, reading back ATC instructions incorrectly, or taking off or landing without a clearance from ATC.

For Vehicle Drivers and Pedestrians (authorized to be on the airfield)
- Not following acknowledged ATC instructions. For example, failing to hold short of a runway as instructed.
- Entering or crossing the runway without ATC authorization.
- Often a chain of events, not one action, causes a runway incursion. The actions of air traffic controllers, pilots, vehicle drivers and pedestrians are operationally linked. The actions of one impact the others.

The Federal Aviation Administration (FAA) has since taken action to inform controllers of potential runway incursions, improve airport markings, and install the Airport Movement Area Safety System (AMASS) and Airport Surface Detection Equipment Model X (ASDE-X). These systems are an improvement, but are not sufficient as designed to prevent all runway incursions.

FAA Certalert # 07-10 “Vehicle Pedestrian Deviation Runway Incursions” was released with a number of recommendations to airports. In the opening of that Certalert, the FAA states, “A large number of Runway Incursions involve airport employees, to include ARFF, law enforcement and airport operations staff, and these incursions are preventable with proper training and supervision.”

The Certalert does not really state how big a contribution ARFF vehicles made to the incursion problem. In fact during the 16 month period of this study, 16 ARFF Vehicles were involved in runway incursions at U.S. Airports. With an average of one per month, we were a major part of the problem. At the time of this study VPD was a term used by the FAA to identify Vehicle or Pedestrian Deviations.


Runway incursion is used generically here. All of the incursions below involved ARFF vehicles.
1/11/06 VPD (ONT) After EJA 977, Cessna C750, crossed the landing threshold Runway 26L, a crash vehicle entered the runway after the C750 passed it’s position and without authorization. No loss of separation reported. In addition, Southwest (SWA) 1720, B737, on 1½ mile final Runway 26L was issued a go around.

2/23/06 VPD Cleveland-Hopkins Intl, OH (CLE) ARFF 20 (airport fire vehicle) had pre-coordinated a simulated alert 3 emergency response at the intersection of Runway 6R and Taxiway November. The command vehicle, ARFF 20, was to be escorting ARFF 14 and ARFF 15 when the simulation began. At the pre-coordinated time ARFF 20 contacted the tower and requested to proceed to Runway 6R via Taxiway November. ARFF 20 was issued proceed to Runway 6R and hold short of Runway 24L. The clearance was read back correctly, including the hold short instructions. ARFF 14 and ARFF 15 entered Runway 24L at Taxiway KILO as N288RE, Gulfstream, GLF4 was committed on his takeoff roll. N288RE departed Runway 24L and lifted off approximately 350 feet prior to the vehicles on the runway and pass over them at approximately 50 feet. AMASS was in limited MODE.

03/19/06 V/PD Charleston Intl, SC (CHS) Crash and Rescue vehicles responding to an aircraft emergency were authorized to cross Runway 3 at Taxiway F. During the crossing, an additional airport vehicle, not Crash and Rescue, joined the crossing queue. The unauthorized vehicle was then recalled by the sponsoring agency. The vehicle turned around, re-crossed Runway 3 at Taxiway F, and exited the movement area. No conflicts reported.

4/17/06 V/PD Willard Airport Champaign, IL (CMI) Fire1, airport vehicle, was conducting a runway check when instructed to proceed on Runway 32R hold short Runway 4. Readback was correct. Subsequently, Ground Control (GC) saw Fire 1 approaching Taxiway B (the intersection prior to Runway 4) and repeated the hold short Runway 4 instruction. This transmission was blocked by other traffic and GC saw Fire 1 cross Runway 4 via Runway 32R. N4146R, Piper PA28A, had lifted off Runway 4 after doing a touch and go and was 100 feet vertical and 400 feet horizontal approaching the intersection as the vehicle passed through the intersection of Runways 4 & 32R.

5/22/06 V/PD Cleveland-Hopkins Intl, OH (CLE) During the course of an emergency response, ARFF 16 (Fire 16) was instructed to cross Runway 24L and, “proceed on Runway 24R” where the emergency aircraft was landing. Ground Control saw Fire 16 cross and clear Runway 24L at Taxiway P. Approximately 1½ minutes later,
AMASS alarmed indicating that Runway 24L was occupied. Continental 1504, Boeing B737, was on landing roll on Runway 24L at Taxiway Lima 1. Ground Control and Local Control saw Fire 16 on Runway 24L at Taxiway P. Ground Control instructed Fire 16, “Proceed straight ahead, sir. Get off the runway for me.” Fire 16 acknowledged and complied. Continental 1504 exited Runway 24L at Taxiway K. Closest proximity (measured from Taxiway P to Taxiway L1) was reported as 4,500 feet. Distance from Taxiway P to Taxiway K scaled to approximately 3017 feet.

5/25/06 VPD General Mitchell Intl, Milwaukee, WI (MKE) Rescue 8, airport vehicle, crossed Runway 25L hold line without authorization. No conflicts reported.

5/31/06 VPD Williams Gateway Airport, Phoenix, AZ (IWA) Foam 215, airport vehicle, was instructed to proceed to Runway 30R via Taxiways A & P, hold short Runway 12L. Foam 215 did not acknowledge until prompted by Ground Control. Read back was correct but Foam 215 entered Runway 12L at Taxiway P (near approach end) without authorization. Traffic was N4181J, Piper PA28, touch and go Runway 12L. Awaiting further information.

6/12/06 VPD Ronald Reagan Washington National Airport, Wash DC (DCA) RED 331 (2 fire trucks and a white fire vehicle) called Ground Control (GC) executing an alert 3 exercise that had been coordinated with ATCT. GC instructed RED 331 to proceed as requested, hold short of Runway 01. RED 331 responded “OK”. Emergency vehicles started moving towards Runway 01 at Taxiway Foxtrot when GC again instructed RED 331 to hold short of Runway 01 twice. RED 331 did not acknowledged these hold short instructions. Two of the fire vehicles did not hold short and conflicted with Delta (DAL) 1953, MD88, on final Runway 01. DAL 1953 was sent around at ¼ mile. No loss of separation reported. The two fire vehicles crossed Runway 01 at Foxtrot, one prior to DAL being sent around and the other after DAL went around.

7/30/06 VPD Miami Intl, FL (MIA) Truck 11, Miami Dade fire rescue truck, crossed onto the edge of Runway 12 at Taxiway U without authorization or contacting ATCT. Continental Express (BTA) 2509, EMBRAER E145, on ½ mile final Runway 12, was sent around.

8/9/06 VPD Chicago O'Hare Int'l, IL (ORD) Rescue equipment was engaged in a standby alert. Procedures for this alert require all fire trucks to remain clear of all runways. ATCT saw fire truck Squad 7 approaching Runway 27L and queried the rescue lead if all equipment was holding short. The response was positive. Squad 7 entered Runway 27L at Taxiway M3 and drove westbound on the runway approximately 700 feet until exiting at Taxiway T. Relevant traffic was SkyWest 6899, type not reported, who was at 1 ½ miles Runway 27L final when Squad 7 crossed the hold line. SkyWest 6899 was given instructions to go around at 1 mile. No conflicts reported.

9/8/06 VPD Bishop Intl Airport, Flint, MI (FNT) Rescue 40, airport vehicle completed runway check on Runway 27 and exited at Taxiway Charlie. Local Control (LC) instructed Rescue 40 to contact Ground Control (GC) for movement on Charlie. Rescue 40 did not contact GC and proceeded east on Charlie and crossed Runway 18 without authorization. No conflicts reported.

9/9/06 VPD Norman Y Mineta San Jose Intl, CA (SJC) Engine 20B and 2 other emergency vehicles responding to an alert for Runway 29 were instructed to cross Runway 30L at Bravo. Engine 20B driver read back “crossing Runway 30L at Bravo, be advised we are going to take Charlie down to our location”. N3799Q, Beech BE35, distress aircraft, was cleared to land any runway and pilot stated they would land 30L. Ground Control advised Engine 20B to exit without delay, aircraft landing behind them. The vehicles exited the runway as N99Q approached the displaced threshold, approximately 500 feet horizontal.

12/6/06 VPD Honolulu Intl, HI (HNL) Yankee 2 (crash/fire command vehicle) advises ATCT they will be returning to their respective stations. ATCT instructs Yankee 2 to remain clear of all runways due to a departure. Yankee 2 advises ATCT they will stay in position. ATCT clears UPS 2968, B767, for takeoff Runway 22L full length. Within a minute UPS 2968 reports there are 2 vehicles crossing the runway and ATCT cancels the B767’s takeoff clearance.
ICAO has been studying the same problem. In 2007, ICAO released the "Manual for Prevention of Runway Incursions". The Foreword from that manual printed below summarizes the issue and the actions planned by ICAO to address the problem. As you scan through the Foreword, please note the bold italicized references. We have come full circle for the need to develop a Safety Management System (SMS) at our airports. ARFF can be part of the solution rather than part of the problem.

"FOREWORD"

In 2001, the ICAO Air Navigation Commission took action to address the problem of runway incursions. Several critical areas were identified that needed to be investigated and which had a relation to overall runway safety, including radiotelephony phraseology, language proficiency, equipment, aerodrome lighting and markings, aerodrome charts, operational aspects, situational awareness and Human Factors.

To improve the situation with respect to runway incursions and to encourage the implementation of relevant provisions, ICAO embarked on an education and awareness campaign which began with a comprehensive search for the best available educational material for inclusion in an interactive runway safety toolkit. Information on this toolkit is provided in Appendix J to this manual.

To address aerodromes, air traffic management and flight operations, among other subjects, ICAO also conducted a series of runway safety seminars in the ICAO regions, with the aim of disseminating information on the prevention of runway incursions. Between 2002 and 2005, runway safety seminars were held in the following regions as part of the ICAO education and awareness campaign: Africa-Indian Ocean, Asia and Pacific, Caribbean and South American, European, and Middle East.

Recommendations were made at the runway safety seminars held in the Asia and Pacific and Middle East Regions for ICAO to produce a manual containing runway incursion prevention guidelines. Therefore, the objective of this manual is to help States, international organizations, aerodrome operators, air traffic service (ATS) providers and aircraft operators to implement runway safety programmes taking into account best practices already implemented by some States, international organizations, aerodrome operators, ATS providers and airlines.

All of the above efforts were undertaken to address a specific problem, that of runway incursions. This focus on the so-called “tip of the arrow” was necessary; however, the inherent need to address safety in a proactive and systemic manner cannot be overstressed.

An evolution in safety thinking has led to a change in focus: from that of the individual to that of the organization as a whole. It is now acknowledged that senior management decisions are
influential in shaping the operational contexts within which operational personnel perform their duties and discharge their responsibilities. It is also accepted that, regardless of the extent to which operational personnel excel in their job performance, they can never ultimately compensate for systemic deficiencies and flaws in the system that binds them. This new way of thinking is reflected in the following recent Standards and Recommended Practices (SARPs) on safety management which, for the first time, explicitly address the contribution and responsibility of senior management regarding safety.

Annex 6 — Operation of Aircraft requires operators to establish and maintain an accident prevention and flight safety programme.

Annex 11 — Air Traffic Services requires States to implement safety programmes and ATS providers, to implement safety management systems (SMS).

Annex 14 — Aerodromes requires aerodrome operators to implement SMS, as a part of the certification process of an aerodrome, and recommends the same for already certified aerodromes.

Such evolution in safety thinking notwithstanding, it is a fact that properly selected, trained and motivated operational personnel remain the true custodians of safety. When a system breaks down due to unanticipated deficiencies in design, training, technology, procedures or regulations, human performance is the last line of defence against latent conditions that can penetrate the aviation system defences and potentially result in compromised safety. Operational personnel are the true "gatekeepers" of the aviation safety system.

From this broad perspective, it is imperative to avoid the pitfall of focussing safety efforts on organizational issues exclusively, to the detriment of the human contribution to the success and failure of the aviation system. Active failures by operational personnel are sometimes a consequence of flaws in the system, sometimes a result of well-known and documented human limitations, but usually are a combination of the two. A true systemic approach to safety must consider latent conditions in the system as well as active failures on the front lines of operations. Such a systemic approach underlies this manual."

ICAO and the FAA now share the same definition for an Incursion:

"Any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle or person on the protected area of a surface designated for the landing and take take-off of aircraft."

The fact that these two regulatory Authorities have harmonized a definition emphasizes the seriousness of this issue globally.

3.4 EFFECTS ON AIRFIELD RESPONSE AND TRAINING

The effect of all of this attention on runway incursions, particularly incursions involving vehicles, and even more specifically ARFF vehicles in many locations, has added a complexity to airfield response.

Airports and ARFF Departments need to reduce incursions. A simple methodology for reducing incursions is to reduce risks. A reduction in the number of vehicles, and the amount of time those vehicles are authorized to operate on the runway system should reduce the risk formula. Many airports, in fact, have done that. Air Traffic Control (ATC) in many locations discourages ARFF vehicle access to the airfield for other than emergency responses. Individual ARFF drivers given the option often choose to “drive around”, rather than calling for clearance. The product of these actions, in fact, probably has reduced the risk of incursions, but it has caused a far greater liability.

Familiarity on the airfield and smooth concise communications are skills that are developed through repeated practice. A response on the airfield for an aircraft emergency requires strict compliance with procedures and
heightened awareness regarding the response, weather, surface conditions, traffic, and the nature of the emergency. Our actions need to be routine, rehearsed and automatic. If we are second guessing ourselves regarding our position or route, or if our confidence is dulled in any of the skill sets required, we are subject to delays and errors. In effect, our efforts to reduce risk of runway incursions by ARFF vehicles may put us and our mission at greater risk. ARFF Departments need to strike a balance which reduces risk of incursions yet maintains a high level of skill and familiarity. This can be accomplished with off peak runway familiarization and through a number of tabletop drills and exercises.

3.4.1 EXAMPLES OF LOW RISK AIRFIELD TRAINING

We all learned to label an airfield layout plan, learn the phonetic alphabet and then draw the airfield. We rode around in vehicles while others drove and handled communications. After a while, we handled the radio and finally, we drove and communicated. We were told that we were ready, and then we did our first solo run with the instructor listening on the radio, as nervous as we were. All of these methods work, but a few ideas below might create new training methods for your department, or may fill in for some of the opportunities that you are no longer afforded due to increased restrictions for accessing the airfield.

- **“Street Drills”**: A common practice in structural fire stations. Members sit around the table while an Officer will shout out scenarios. An example follows.

  Officer, “OK, it is 4PM Friday, reported smoke in the building, 1754 Hancock Street on the 3rd floor. Engine 1 driver, what route are you taking? Where will you set up? What are the considerations?”

  The Engine 1 driver might report, “It’s 4PM on Friday, I’m avoiding the center of town, much faster to take School Street to Washington, hook into Hancock around the Church. I know it’s a high rise building, Engine 4 will beat us there. They will take the front door, I’ve got the standpipes which are right opposite the hydrant”. The officer could then get similar feedback from the Ladder truck or the Rescue, then move on to a different address.

  This training makes everybody think. If you didn’t know the answer, you get to hear it. If you have something to add, everybody benefits.

  We can conduct the same type of drills for airfields. If we can picture our route in our minds, we can describe what we are doing. If we cannot describe it, we are probably depending on airfield signs or perhaps the other person in the cab. Once everybody can handle response to hold off positions or crash locations, try a runway change drill. Most ARFF Crews feel a little additional tension when they are enroute to or at a standby position for the reported landing runway, and the tower calls to say the aircraft has changed landing runways. This is a more challenging drill.

- **Airfield Communications Exercise**. Developing proficiency in airfield communications is critical to safe operations. Clear concise messages, in a standard tone is a skill that will serve us all well on the airfield, as well as on the fire ground. How many times have we listened to the audio tapes of a pilot communicating with the Tower moments before a crash, and commented on “how cool that Captain is”. We all want to be regarded that way, and practice and experience are the only way to achieve it.

  The best method for this training to be effective is to partner with the Air Traffic Control (ATC) personnel from your Tower. If they have a training coordinator, that would be perfect. Now your trainer for airfield communications could be the same trainer that trains the Controllers. If this is not available, the Training Officer or simply “The best Radio Person” can fill the position of ATC.

  Put your ATC person in a separate room with a radio set to a frequency on which this exercise will not interfere with operations. The members getting the training are in a different room with a radio on the same frequency. The firefighter in training is given a location to which to respond. He/she signs on the air and calls ground, identifying his call sign, location and request. The ATC trainer grants the permission, asks questions or denies routes, requiring a conversation between the two. Members in listening mode are
asked to critique the event, and make suggestions. They will also be critiqued when it is their turn to call for clearances.

3.4.2 **AIRFIELD RESPONSE**

As part of this study, an informal survey was conducted to determine what methods of airfield response are being followed currently. The response to the survey came from a variety of airports. From the United States, there were respondents from Index A through E airports. From outside the United States, I received responses from airports in Categories 7, 8 and 9. All of these airports (with some minor deviations) reported following what is deemed in this report “The Traditional Response Model”.

3.4.3 **TRADITIONAL RESPONSE MODEL**

The overwhelming majority of ARFF responses for aircraft occur as a result of advance notification of in inbound aircraft with a reported anomaly. Upon notification, the ARFF Commander or authorized authority will typically declare the level of Alert or response. The ARFF apparatus will then respond to predetermined standby positions on the airfield to monitor the landing of the aircraft. The action of the ARFF vehicles after touchdown may vary based upon the specific anomaly reported and the threat to safety that exists following touch down. In some cases, the ARFF vehicles may return to the ramp by the same route by which they entered the airfield. In other situations, the ARFF vehicles may follow the aircraft down the landing runway and “set up” on the aircraft after it comes to a stop. Those airports with parallel taxiways follow the parallel taxiway and do not enter the landing runway unless the aircraft comes to a stop on that runway.

3.4.4 **TRADITIONAL RESPONSE MODEL LOGIC**

This response model has been the standard for at least 30 years. It was developed to satisfy a number of needs of ARFF response to best handle the aircraft emergency. Although this logic does not appear in any published reports until now, it is derived from the recollection of senior members of the ARFF Community. The goals of the Traditional Response Model include the following:

- Reduce delays in response to the landing runway, by pre-positioning response assets.
- Provide a forward position in an optimum viewing location to observe the approach and landing.
- Provide a position of immediate access to the runway for pursuit of the aircraft, as soon as it passed the ARFF vehicles standby position.
- Separate response assets out along the landing runway to provide nearly immediate access by one of the ARFF vehicles at any point at which the aircraft comes to a stop.
- Provide distance between ARFF vehicles so that, in the event an aircraft leaves the runway during landing, the number of ARFF vehicles in harm’s way would be minimized.

Our basic training and knowledge that we have attained over the years identify a number of issues which make this response model less than ideal.

1. The first and most flagrant violation of our basic training occurs if, in fact, we follow the aircraft down the landing runway. Aircraft land into the wind. If we follow or approach the aircraft from the same direction from which it landed, we are approaching from downwind. Our first firefighting class, or the first time we tended to a backyard barbeque, we learned that we want to be upwind from a fire.
2. Approaching an aircraft accident from behind, traveling on the landing runway would require us to pass through any debris field created by the aircraft accident. This debris field, at best, will slow our response, and could damage our vehicles, reducing our capabilities. The debris field could include bodies or injured passengers thrown out of the wreckage. No ARFF firefighter wants to find out after the smoke cleared that he or she ran over a passenger.
3. Approaching a large aircraft on the runway from the rear requires some ARFF vehicles to drive around the aircraft to set up on the forward portion. There are a number of complications that can occur as a result of this maneuver.

- The execution of a J-Turn is the event which is most likely to cause the rollover of an ARFF vehicle.
- An aircraft in the process of evacuation will have escape slides deployed and perhaps passengers on the runway and grass areas. Driving past or through this evacuation is an additional risk and delay.
- The position of the aircraft or pieces of aircraft might cause ARFF vehicles to leave the pavement to drive around the fuselage or wreckage. Although ARFF vehicles are designed for off-road use, certain weather and soil conditions can make this a risky maneuver.

3.4.5 NEW RESPONSE MODEL DISCUSSION POINTS

The unique configuration of each airfield, the number of response assets, the need to modify response based on the aircraft anomaly reported, as well as local requirements, make it impossible to have a single response model. We can, however, identify the goals of response and the risks which we want to avoid or minimize. From this list, we can make intelligent choices to suit our unique environment and needs, and develop a “Best Practice”, based on the conclusions drawn from our research.

The goals of response to reported aircraft anomalies have not changed, but our level of sophistication in satisfying those goals has changed. We are also aware of conditions that currently cause a delay in response. The goals of our new response models should be to reduce delays and risks, and better accommodate response, size up, set up and implementation of our Incident Action Plans (IAP).

Typical causes of delays in ARFF response on the airfield:

- ATC Communications. During busy periods, contacting the Tower for clearance to gain access to the airfield can be difficult. If ARFF is using the same frequency as aircraft requesting ground movement, breaking in with your request may be difficult. Delays in response are often encountered as a result of delays in approval for access. The use of a Discrete Emergency Frequency (DEF) may reduce or eliminate that delay. The goal of a DEF is to provide a dedicated frequency to be shared by ATC, ARFF and the Aircraft. A dedicated frequency and a dedicated Air Traffic Controller can reduce delays and increase safety and coordination during aircraft response.

- Aircraft Ground Traffic. Primary taxiways favored by ARFF for response to runway standby positions near the approach end of the runway are also likely to be favored by the Tower to taxi aircraft into position and hold position. These taxiways are likely to have aircraft lined up waiting for their turn during peak periods. These taxiways should be avoided in the development of ARFF response routes. Although the most direct, these routes may take longer than less direct routes. The same situation may be common at your airport for aircraft that have landed and are taxiing off the airfield to the ramp. This is particularly true when aircraft taxing inbound after landing have to cross another active runway to reach the ramp. This usually causes the aircraft to back up while they are cleared one at a time between landings. These taxiways should be avoided in the development of ARFF response routes.

3.4.6 HIGHEST RISK AIRFIELD LOCATIONS

When assessing the level of risk for ARFF vehicles, we must evaluate data from a number of models. Airports keep track of areas that have a high occurrence or high risk of occurrence of incursions. These locations are designated as “Hot Spots” by the airport, and are identified in incursion prevention education for airport users. In terms of risk analysis, it seems clear that avoiding these areas during ARFF response, particularly designated standby positions, would be a wise choice in reducing opportunities for incursions.

Many airports can identify locations on their airfield that are prone to episodes of radio interference or poor reception. Airfields are the source of a tremendous amount of frequency traffic, and often the result is a dead spot or an area that has frequencies washing over one another. This may be in the area of a Remote Transmitter / Receiver
site (RTR) or other localized communications point. Safe airfield transit depends upon clear, concise audible communications by experienced operators. Areas of known communication difficulties should be avoided when possible, particularly for planned response routes and ARFF standby positions. Failures in communications add to the risk of incursions involving ARFF Vehicles.

Another risk that must be factored into ARFF response on the airfield is specific to the known or suspected problem reported by the aircraft for which you are standing by. An aircraft landing with no flaps is likely to use a lot of runway. Positioning apparatus at the end of the runway is putting them in harm’s way. An aircraft landing with an unsafe gear indication for its left main gear leaves us with the question as to whether the left main is down and locked. If it is not, and the gear fails upon touch down, it will create a control problem. It is likely that if the aircraft fails to stay on the runway, it will exit on the left side. In this scenario, it may be wise to avoid any runway standby positions on the left side of the landing runway.

We also need to take a look at aircraft accidents on airport, in general, to see where crashes tend to occur. The National Academies’ Airport Cooperative Research Board (ACRP) in 2008 released a report titled, “Analysis of Aircraft Overruns and Undershoots for Runway Safety Areas”. “Overruns and undershoots are factors in the design or improvement of runway safety areas (RSAs). The objective of this project was to develop an aircraft overrun and undershoot risk assessment approach, supported by scientific evidence and statistical theory, which provides step-by-step procedures and instructions for analysis of runway safety areas (RSA). The major achievement of this research is to provide an innovative, rational and comprehensive probabilistic approach to evaluate the level of risk for specific airport conditions that will allow the evaluation of alternatives when FAA recommended RSA configuration for an existing airport cannot be met. In addition, based on the existing level of risk, this approach will allow prioritizing financial resources to improve safety areas, achieving target levels of safety (TLS) and helping with safety management actions when high risk conditions arise.”

We can use this data to identify areas of the airfield most likely to become the actual site of an aircraft accident. This data can be used to preplan for response to crashes occurring without advanced notification to ARFF; it can also be factored into our risk assessment for positioning our ARFF vehicles while standing by for inbound aircraft with reported problems or declared emergencies.

According to the ACRP study, “from 1995 to 2004, 71 percent of the world’s jet aircraft accidents occurred during landing and takeoff and accounted for 41 percent of all onboard and third party fatalities. Landing overruns, landing undershoots, takeoff overruns, and crashes after takeoff are the major types of accidents that occur during these phases of flight.”

The report provides modeling data and formulas that can be specifically applied to any runway or any point on a runway to understand the risk of that area being the site of an accident or area where wreckage from an accident will be distributed. For our purposes, though, we are looking for a more general understanding of where accidents occur. The table below was developed by the Airline Pilots Association in a similar report written in 1997. The numbers change; some simply because of the specific occurrences in the time frames studied, but the overall pattern is consistent. There is clearly a higher incidence of crashes on the approach and departure ends of the runway, or in runway safety areas. For the purposes of our analysis in identifying low risk hold off positions, runway approaches and departures should be considered higher risk areas of the pavement to occupy.
3.4.7 CONCLUSIONS

Typical existing airfield response routes, procedures and standby positions for ARFF were established by selecting intersections of taxiways and runways, spreading out ARFF assets evenly to ensure complete coverage of the runway and minimal response time to any point on that surface. This model was adequate at the time of its general acceptance and implementation, but needs to be re-evaluated and potentially modified, based on specific airfield characteristics and risk analysis. The plan should be designed to interface with the specific capabilities of the ARFF assets and should be harmonized with department tactical plans.

- Response routes might not always be the shortest distance, but should be the fastest, based on angles and turns and avoiding delays based on queued aircraft.
- Response route and standby positions should be evaluated in a risk analysis that includes passing through or pausing in “Hot Spots” or areas with communications disruptions.
- Response routes should be modeled to avoid, when possible, following the aircraft down the runway. This action heads ARFF crews into possible debris fields and offers an approach from down wind.
4.0  **ADVANCED TECHNOLOGY INTEGRATION AND ARFF**

Advanced technology has been trickling into Aircraft Rescue & Fire Fighting over the past 20 years. Purveyors of this technology have done their best to educate the industry as to the value of the technology which they represent.

The culture of the fire service, in general, is one of long standing tradition with traditional values. With those traditions, we tend to be slow to completely trust technology. We want to witness its successes, build confidence and allow it to earn our trust.

Our biggest asset and resource is the apparatus that upon which we depend to carry our teams, our tools, and our agent to the scene of an emergency. Our overall capabilities during the initial stages of an incident are limited to the number of ARFF vehicles that we have on hand, the capabilities of those vehicles, and the level of staffing that we have on hand to deploy those assets. The evolution of ARFF Vehicles is significantly slower than that of our structural counterparts. There are a number of legitimate reasons for this situation, but the end result is that it takes longer for advanced technology to reach all of us in ARFF than it takes for the structural fire service.

From the standpoint of the manufacturer, the evolution of the product is driven by a few factors.

- Industry Standards
- Competition
- Customer Needs

The sale of ARFF vehicles is competitive. Most purchases are made after a competitive bid process, based on customer specification. To include advanced technology on a vehicle when it is not specifically required may enhance the safety and capabilities of the vehicle, but if the competition is not including it as well, the cost of that technology is likely to prevent the sale. For this reason, ARFF manufacturers develop standard vehicle platforms that comply with the industry requirements or regulations for the market within which they are working. Those standards may include NFPA 414, FAA AC 150/5220-10D, ICAO, and others. ARFF vehicle manufacturers are not likely to add the cost of advanced technology to that “standard platform” in order to remain competitively priced. Customers drive the needs of any industry. In this case, the customers are the Airports or the Airport Fire Service. We have the ability to move the market forward in a number of ways. In any project that we fund, we can upgrade to advanced technology using airport dollars, in order to get the greatest advantage of the available technology. Through participation in the working groups and committees, we can cause appropriate advanced technology to be included in new versions of the Industry Consensus Standards and Regulations that govern the minimum standards for the vehicles upon which we depend.

4.1 **ADVANCED SUSPENSION SYSTEMS**

In a March 2002 report, the U.S. Federal Aviation Administration (FAA) said that from 1977 to 2002, a total of 48 ARFF-vehicle rollover accidents had been documented in Argentina, Bermuda, Cambodia, Canada, Egypt, Iceland, Jamaica, Malaysia, Mexico, Portugal, South Africa and the United States. Twenty-seven of the accidents occurred between 1995 and 2002. Various vehicle models produced by U.S. manufacturers and Canadian manufacturers were involved.

As a result of this disturbing trend, the industry was driven toward solutions that would create chassis suspension systems that would increase vehicle stability and safety. Consequently, it also led to a change in the industry standards.

While working toward change in industry standards that would drive the development of new vehicle designs with a chassis less likely to roll over, it was recognized that there are thousands of vehicles in service worldwide designed to older standards. These vehicles would be in service for years to come and the industry needed options to modify those vehicles to increase stability.

The FAA released a study in 2002 from the FAA Technical Center DOT/FAA/AR-02/14, Titled: “Evaluation of Retrofit ARFF Vehicle Suspension Enhancement to Reduce Vehicle Rollovers”. There is a great deal of information
in the report which helps us to understand vehicle dynamics, and how we, as an industry, have developed the current standards.

In 2002, typical ARFF vehicle designs placed the large capacity water tank on top of the vehicle chassis frame. This situation results in ARFF vehicles with centers of gravity (c g ’s) between 5 and 6 feet off the ground. C.g. between 5 – 6 feet is considered a high c.g.. Vehicles with high c.g.’s do not exhibit good dynamic stability. As the vehicle commences a turn, a large shift of the water content can occur. This weight shift moves toward the outside of the turning radius. This design creates a fairly stable platform when operating on stable level surfaces, traveling straight ahead. The level of safety would diminish to varying degrees based on grade, speed, surface conditions and turning angles.

A typical ARFF vehicle response includes acceleration, high-speed driving, heavy braking, and the need to perform several 90-degree or greater turns. ARFF services respond under emergency situations at airports, thus requiring that the rescue vehicles have rapid acceleration. They must be able to brake under high-weight loads (up to 80,000 Lbs.) with transferring inertia conditions. ARFF vehicles must be responsive to large center of gravity shifts under the high-speed turning radius at intersections of taxiways and runways. Performance testing of all rescue vehicles should include those tests, which mirror response requirements.

At the time of this report, the vast majority of ARFF vehicles in service were solid axles with springs. A great deal of new apparatus currently being introduced includes independent suspension system vehicles, but it will take a number of years to replace the existing world fleet.

In order to mandate change in the overall stability, a standard had to be developed and accepted that could be equally applied by manufacturers and testing agencies. A number of methods were used to develop a measurable level of stability testing that could be applied to any chassis. Initial methods were dynamic tests which provided an excellent real time representation of vehicle reaction to various turns at various speeds. The problem with using dynamic test methods is the difficulty in recreating the specific conditions of the tests, as well as duplication-specific driver reaction times and responses.

The FAA study included the dynamic tests, as described below, that were performed as part of this study.

The Slalom Course was performed on level ground, the vehicle was driven through a course of six traffic cones which were placed in a straight line, 62.5 feet between each cone. Starting in a straight line on the right side of the cones at constant speed, the vehicle was turned left after the first cone, turned right around the second cone, etc. This sequence required three left-hand turns alternated with two right-hand turns.

The NATO Lane Change test was conducted in accordance with NATO AVTP 03-160W. On level ground, the vehicle was driven through a course of traffic cones that outlined a 50-foot straight approach, followed by a 75-foot transition area in which the vehicle's path shifted 12 feet to the side. The vehicle then travels on a 100-foot straight path parallel to the approach path, followed by another 75-foot transition back to the original line of travel, and a 50-foot straight departure lane. All straight sections of the course were 12 feet wide.

As a witness to some of these tests, I walked away with some data that is difficult to document in a technical report. It is the instinct and lessons learned from the standpoint of a user of ARFF vehicles for half of a lifetime. I’ll attempt to illustrate this finding by comparing impressions from the two vantage points I had.
As a passenger in the vehicle traveling through these tests, I was aware of the speed of the vehicle. I could feel the shift of the weight during the sudden turns. My perspective allowed me a view of the course through the windshield, which prepared me for the next movement. Although I felt the exhilaration of the event, I felt safe and did not think that we had exceeded the safe operating envelope of the vehicle.

My second position was that of a spectator. Standing in the middle of a runway, I was able to watch the same vehicle travel through the course in which I had just ridden. As the truck made its way through the lane changes, the dramatic lean of the body was apparent, but not nearly as frightening as the daylight visible between the wheels and the pavement as the weight of the truck lifted them off the surface while negotiating the turns.

In review of my instincts as a passenger in the vehicle, I was not incorrect. Although the maneuvers were pushing the envelope of safety and our wheels left the ground, we did not reach the point that the vehicle could have rolled over. The wheels of the outriggers on this test vehicle were never called upon to keep us from rolling. I felt that the accuracy of my instincts in real life applications were largely due to my familiarity with harsh ride of the solid suspension chassis. With the delivery of my first Independent Suspension vehicle, I became concerned that this improved ride quality might cause operators to push the safety envelope further yet. If it felt safe and comfortable to make the turn at 30 MPH, why not push it to 35 MPH? Fortunately, the statistics regarding rollovers with Independent Suspension vehicles have not validated my fears.

The test vehicle was equipped with outriggers to ensure safety during the testing, as pictured below.

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**FIGURE 5 from DOT/FAA/AR-02/14 NATO LANE CHANGE AND SLALOM COURSE TEST TRACKS**

NATO LANE CHANGE

SLALOM
After all the data was collected from the dynamic testing, it was determined that certain dynamic stability suspension systems reduce vehicle roll rates and body and chassis deflection. These are suitable retrofits to increase the safety and stability, as well as ride quality in ARFF Vehicles.

The method determined to be an accurate, repeatable test for evaluation of vehicle stability is the Tilt Table. SAE J2 180 test procedures are used as guidance for this test evolution. The tilt table is a device that rolls the surface of the table supporting a vehicle about a longitudinal axis. The device can be one table or multiple tables. The tables must maintain angles of tilt within 0.1° under the wheels of the axle. This static test is designed to simulate a nonvibratory steady turn. At the time of this FAA study, 28 degrees was the established minimum angle that the vehicle must withstand on the tilt table. Subsequent to the study, the standards have been revised and ARFF vehicles are tested to 30 degrees.
There are a few tools that we currently use to keep our apparatus safely with all wheels in contact with the ground. Some employ technology, others do not. Certainly the engineering of modern ARFF vehicles have increased stability and ride quality. They have lowered the center of gravity and provide us with lateral G indicators to alert us when we are pushing that safety envelope.

Our most effective tool is training. Lateral G indicators are not designed to keep the truck from rolling over. This technology is simply an aid to develop good driving habits. If we routinely turn too hard or too fast, an audible and visual indicator will alert the occupants of the vehicle to that fact.

Driver training programs should exist in every ARFF department. These programs should not be devised to merely show that a driver can pull out of the station, drive around the ramp and back into the station. Drivers of ARFF vehicles have a tremendous responsibility. In addition to the obvious hazards associated with maneuvering an 80,000 lb vehicle through a busy airport, they are also responsible for delivering a large percentage (if not all) of the firefighting agent available for the mission. Safe arrival of the assets, agent and personnel are absolutely necessary.

NFPA 1002, Standard for Fire Department Vehicle Driver/Operator Professional, provides guidelines for the training of fire apparatus operators. This is an excellent starting point for the development of a lesson plan for ARFF Vehicle drivers. The Department of Defense has developed a lesson plan for ARFF Vehicle Operators that is based on the NFPA 1002 model.

In the development of a lesson plan, the following should be considered:

- Typical ARFF response with multiple vehicles responding to a single location often leaves vehicles following one another to the incident site. If one vehicle makes a turn or transition at an inappropriate speed
or turning angle and rolls over, there is an excellent chance that the vehicle behind it will not be able to safely negotiate a turn away from the overturned vehicle.

- Records of quantities of agent discharged at aircraft fires typically exceed the minimum quantities required by Regulations and Consensus Standards. Timely safe arrival and efficient use of available agent increases the overall survivability of the incident. Developing proficiency in the operation of turret controls will ensure efficient use of available agent.
- Drivers should never take their eyes off the road while the vehicle is in motion. Training should develop proficiency in the operation of all vehicle controls, as well as firefighting controls, without having to look at them or read labels.

Areas of concentration for ARFF Operations:

- Pump & Roll
- Pump and Roll reverse
- Turret Range exercises
- Aiming exercises
- HRET
- FLIR
- Blind operation

4.2 **Drivers Enhanced Vision Systems (DEVS)**

In the mid 1990's, the FAA approved the use of navigation equipment on certain aircraft and airports which would allow flight operations in very low visibility. Although aircraft were able to land “by wire”, the low / no visibility conditions on the ground required special accommodations to be able to conduct safe ground movements. The Surface Movement Guidance Control Systems (SMGCS) program implemented at these airports provided systems to safely move aircraft across the surfaces. The systems included taxiway centerline lighting, follow me vehicles, new signage, and designated traffic patterns.

The ARFF crews would be facing a unique challenge. Prior to SMGCS, during low Runway Visual Range (RVR) conditions, the airfield was shut down. If there were no flight operations on the field, there was little chance of an ARFF response on the airfield. Under this new system, aircraft could be landing in conditions as low as 600 feet RVR. It became clear that ARFF needed similar technology as the aircraft to operate safely in these conditions. Prior to the introduction of DEVS, three major aviation accidents occurred in low visibility. During these events, ARFF response was affected by the lack of visibility.

The introduction to the FAA Advisory Circular 150/5210-19 DEVS, provided below, is an excellent overview of the problem and the technology being offered to assist us. The DEVS AC is currently being updated by the FAA.

**“Driver’s Enhanced Vision System (DEVS), AC No: 150/5210-19**

1. **Background.** Between January 1990 and February 1991, three major accidents involving fatalities occurred on active runways at night. ARFF response was impeded to two of these accidents by poor visibility conditions. Due to fog, the accident site was difficult to locate, and ARFF operators were forced to drive slower to avoid becoming lost or colliding with obstacles.

For certification purposes, ARFF vehicles must demonstrate an emergency response time of 3 minutes to a simulated accident on an airport runway, with the goal to get to the accident site in as little time as possible. During periods of poor visibility, ARFF response times tend to increase. The Driver’s Enhanced Vision System (DEVS) program, in an effort to reduce response times, is aimed at the three difficult aspects of poor visibility response: locating the accident, navigating to the accident site, and avoiding obstacles and locating people on the way to the accident site. Evaluations conducted at the FAA Technical Center and airports around the country have
demonstrated that DEVS technology can improve a driver’s ability in these areas. Where DEVS is installed, drivers would be required to receive training on DEVS operation.

2. DEVS SUBSYSTEMS.
   a. Subsystem Components.

   (1) Night Vision. The night vision subsystem shall use a Forward Looking InfraRed (FLIR) device or other comparable state-of-the-art night vision technology. Night vision capability will improve visual awareness in smoky, foggy, or dark environments by sensing thermal radiation instead of visible light.

   (2) Navigation. The navigation subsystem shall make the ARFF vehicle driver aware of the vehicle’s location and serve as an aid in locating the accident site. A Differential Global Positioning System (DGPS) will meet the specifications of this AC. Future alternatives must meet or exceed the capabilities of DGPS.

   (3) Tracking. The tracking subsystem can be tightly integrated with the navigation subsystem through data link. Tracking capability will reduce driver communications work load and improve the situational awareness of the driver and command or dispatch personnel.

   b. Subsystem Integration. DEVS is an integrated system consisting of all three subsystems: Night Vision, Navigation, and Tracking. Depending upon specific circumstances, individual airports may be able to show safety benefits at a lower cost by utilizing a subset of the complete DEVS.

Modern DEVS Systems employ state of the art technology, touch screen displays and utilize the onboard computer for additional capabilities.
The cab mounted touch screen provides operators with the ability to enter a route on the moving map display and navigate in low / no visibility through the use of GPS and the visual references. The on / off course indicator, along with a voice prompt, warns drivers if they are off course. This display, used in combination with a Forward Looking Infra Red (FLIR) Camera, which will show heat signatures of obstacles in your path, provide us with the tools that we need to navigate safely to the scene of an accident in poor visibility.

The on board computer and display provide us with an opportunity to store and access critical information from the cab of the vehicle. Any file that can be saved electronically can be indexed in the computer and brought up on the touch screen display for quick reference.
Crash charts are the most obvious example of files that can be saved and accessed, when needed. Pre-fire plans, SOP’s, Hydrant Maps, ERG’s, and Checklists are just a few examples. This method provides a clearly illuminated copy of the reference that we need that is easily viewed even in a dark cab.

4.3 **HIGH REACH EXTENDABLE TURRETS (HRET)**

High Reach Extendable Turrets provide ARFF Firefighters with a number of tactical advantages useful in Aircraft Rescue and Firefighting.

![HPRV with HRET in down in front, or low attack, configuration.](image)

Testing conducted by the FAA compared a P-19 roof turret with an HRET in a pooled fuel fire. The HRET in its optimum attack mode, the down-in-front configuration, was compared to the P-19 roof-mounted turret agent delivery system. Both vehicles were tested in the same conditions as the HPRV attack mode comparison tests. The HRET in the down-in-front attack mode extinguished the burn area an average of 53% faster than the P-19 roof-mounted turret. Both vehicles used a frontal attack method on the large-scale burn area. The HRET in the down-in-front position was able to extinguish the burn area by oscillating the HRET from right to left without repositioning the HPRV. The P-19, however, had to make slight vehicle adjustments to the...
right and left of the burn area in order for its roof-mounted turret to reach the sides of the large-scale aircraft mockup.

The HRET and skin-penetrating nozzle evaluated at the fire test facility outperformed the standard roof-mounted turret and hand line. In all aspects of the evaluation, the data gathered from simulated real fire aircraft crashes involving the HRET with skin-penetrating nozzle demonstrated the ability to extinguish fire faster, increase the accuracy of firefighting agent application by positioning the HRET close to the source of the fires, and use less firefighting agent on several fires. Other fire extinguishment performance advantages included the extendable reach of the HRETs nozzle, increase in firefighting agent throw range because of its extendibility, and ability to reposition the HRET in all directions without moving the airport firefighting vehicle.

The HRET with skin-penetrating nozzle, when used on the full-scale fire field test using a training aircraft, showed the ability to control and contain the fire from spreading beyond the tail section. It reduced high cabin temperatures from over 1500° to approximately 250°, provided rapid smoke ventilation and the ability to extinguish fire. The injection of fine mist water spray showed immediate results providing a fire-block and lowering cabin temperatures. The ability to ventilate using the skin-penetrating nozzle is a less manpower-intensive and time-consuming process compared to using traditional ventilation fans. The cabin conditions, after discharging the fine mist water spray, allowed fire fighters to enter the aircraft.

All of the benefits of an HRET that have been verified through extensive testing and during actual events can only be realized when in the hands of skilled, qualified operators.

4.3.1 PIERCING TRAINING

Developing and maintaining proficiency in the use of HRETs and piercing devices is a very challenging initiative. In preparation for this paper, a number of airports were contacted relative to the inclusion of HRETs and hand held penetrators in their arsenal of equipment, as well as the training methods employed. Like most areas of ARFF, there is no standard. In many cases, the equipment has been purchased, initial training conducted and proficiency remains the responsibility of the operators. Other departments have full initial and recurrent training, while still others have declined purchasing HRETs because they have too many operators to maintain proficiency. The latter prefer not to utilize the technology without sufficient confidence in their team skills to operate this technology safely and efficiently.

My opinion is that this technology has demonstrated sufficient merit to earn its way into our fleets. The training required to make efficient and safe use of this technology, although extensive, is worth the effort.

ARFF Departments should have an internal training program that is used to initially qualify an operator, as well as ongoing training to re-qualify. A predetermined method of demonstrating proficiency in annual qualification training should be in place for each vehicle in the ARFF Fleet. It may be necessary to train operators from two different positions.

If an airport’s staffing only provides one person per ARFF Vehicle, it is reasonable to assume that members will never have to operate the turret or HRET controls from the right hand seat, but only from the driver’s seat.

If your Department has or may have a firefighter or Officer assigned to the Right Hand seat, it is reasonable to think that the turrets and HRET may be operated from either seat.
If your department routinely staffs two or more personnel on an ARFF Vehicle, the second member should be seated in the right hand seat, and should be the primary turret and HRET Operator. A trained individual who is not simultaneously operating the vehicle will be more efficient than one who is multi-tasking. In this case, the driver may become the back up operator of the turret or HRET. The second member is likely to be leaving the cab to conduct operations on the ground and the driver would be left to provide protection of the scene with the turrets and HRET.

The point of this discussion is that turret and HRET Operators may need to be trained using their right hand for operation of the controls if they are seated in the driver’s seat, and again using their left hand in case they are seated in the right hand seat. We all have one hand which is dominant, and completing the same functions with the opposite hand may require extra practice.

There are a number of training methods that have proven effective. Some of these methods are “high tech” and others make use of very basic tools that are available at no or low cost.

Each ARFF Department should have an established standard for the qualifications of a Training Officer. The person conducting the training must be qualified to instruct, and possess the knowledge and experience to gain the trust of his or her students. The Training Officer must have established proficiency in the subject matter or skills sets being taught. Students need to have confidence in the instructor’s ability to provide the training necessary for them to develop required proficiencies.

There are some “high tech” training tools available that allow virtual training using HRET’s. Full size cab mock-ups with airport specific driver training models can be customized whereby a student can virtually drive the new vehicle around their airport, respond to an aircraft accident, fight a fire and even penetrate the aircraft using the HRET and piercing nozzle.
Other technology available makes use of virtual training from a desktop PC via joysticks and controls identical to those in your ARFF vehicle to develop good technique before attempting a penetration on a fuselage or trainer.

There are other methods of training that do a great job of building skills, have little or no cost, and can be accomplished without supervision. These types of tools are extremely valuable in maintaining skills in trained operators. They can be used during daily check out / run up. Proficiency with turret operations is only developed through training and experience. Each joystick has a slightly different touch, with which the operator needs to become familiar. Turret operators need to develop a good sense of range and aim, and develop the ability to be as accurate as possible from stationary positions, as well as during pump and roll.

Turret training aids are generally nothing more than an area marked off by cones and delineators. Operators set out to cover a designated area within the cones without knocking them over. These training evolutions can be designed as competitions; driving members improving their skills while beating fellow members or another team.

T-Ball is a turret training competition that requires a number of skills. In T-Ball, a soccer ball or volleyball is set on top of a tall cone. The vehicle is sent to a hold area, requiring the operator to drive to the training area, set up on the target, determine proper range, go into pump and roll, discharge the turret and knock the ball off the cone. The event is timed and the goals are to perform the evolution in best time with minimal agent.

This training can be conducted with bumper turrets, high volume bumper turrets, roof turrets or extendable turrets. Proficiency in turret operations is a critical skill that can conserve agent and save lives.

Perhaps the greatest hazard to an elevated boom is the possibility of contact with energized power lines. Never take chances with power lines. Most fire department Standard Operating Procedures require operators or man-rated and non man-rated aerials to maintain at least a 10-foot separation.

The most critical skill required for operators of an ARFF vehicle with a High Reach Extendable Turret is piercing of an aircraft fuselage. Practice is the only way to become proficient. Manipulation and aiming of the controls can be practiced every day during apparatus check out and run up. Raising, rotating and positioning of the boom helps to develop skills, as well as checking for mechanical issues.

A very simple, no cost-mock up can be used to practice approach distances and aiming. All that is needed is a section of tall chain link fence and some colored ribbon. Select a section of chain link fence that is accessible most of the time for training. Select some links on the fence at different heights to simulate a low attack, mid range and high attack position. Wrap colored ribbon or colored tape around the links. Practice approaching, setting up and stopping the vehicle at an appropriate distance from the fence. Use the controls to raise the boom and pierce the fence link in one of the identified areas.

Having an aircraft fuselage available for piercing training is the best case scenario. This provides the most realistic training, and allows evaluation and discussion of penetration depths, difficult areas to access, and realization of the amount of spray through the piercing nozzle and the area that is actually covered inside the fuselage. Because aircraft fuselages are not available for training at all airports, we find other ways to simulate piercing. Cargo containers, and automobiles are used by many airports as piercing mock-ups.

FAA CERTALERT Number 0807, issued on July 18, 2008, encourages hands on training to obtain and maintain proficiency in the use of HRETs with skin penetrating nozzles. When airports purchase an HRET with AIP funds, they are also authorized to purchase training aids, as described below, to enhance and maintain proficiency in the operation of the HRET.

1. Advisory Circular 150/5220-10D authorizes 8 days of training from the manufacturer when an ARFF vehicle with an HRET is purchased. The training is divided between driving, operational use of the HRET and vehicle maintenance.
2. Advisory Circular 150/5220-10D also authorizes an “Aircraft Skin Penetrating Training Device”. The Penetration Aircraft Skin Trainer allows the operator to actually pierce the same type of metal on the same curvature of an actual aircraft.

3. Advisory Circular 150/5220-10D also authorizes a Computer Based Training (CBT) program which allows the operator the ability to develop the skills necessary in preparation for actual hands on operation of the HRET.

CBT training units may be used in any office space suitable for PC computer use, and includes a real-time graphical representation of the truck, boom, and nozzle. It also includes interactive audio instruction through speakers, or, to eliminate office distractions, earphones. This “live proctor” guides the user through all basic instructions.

These operations are designed for the user to observe the relationship between joystick manipulations and nozzle motions.

*Screen shot from CBT.*

Training with an aircraft skin penetration device can dramatically increase the skills sets needed to effectively use the piercing tool on a High Reach Extendable turret during fire fighting evolutions.
All ARFF personnel should become familiar with the interior configuration of each of the different types of aircraft that normally operate at your airport. Understanding the interior layout is important when selecting a piercing point. Piercing of fuel lines, oxygen lines, hydraulic lines may increase the hazard to occupants and emergency services personnel.

The overall goal of piercing training is that, when required, there is a high degree of confidence that your ARFF crew will be able to penetrate the fuselage rapidly and accurately with total confidence and no hesitation.
5.0 HISTORICAL AVIATION ACCIDENT REVIEW & LESSONS LEARNED

Fortunately, aviation is, in general, very safe. Considering the number of flight operations conducted every year, the number of incidents is extremely low. In light of the number of actual accidents or fires, we see an even better representation of the safety of commercial aviation.

For ARFF Firefighters, this means that we will never develop proficiency in our trade from the actual events in which we participate. Our skill sets will be honed through training, and our tactical “experience” developed through those incidents in which we are involved and by studying the accidents and fire that occur elsewhere.

Reviews and commentary in this report are not meant to be critical in any fashion. In fact, any lessons learned and shared through a review of this incident are gleaned as a result of the honest report, as well as hindsight testimonials as to what worked well and what might have worked better. This report is simply a continuation of that information exchange to perhaps contribute to tactics that may prove effective at a future incident. Text highlighted in bold font warrant further consideration. Editorial is provided after each section, offering perspective.

The following aircraft fire will be critiqued as an example, simply to allow us to consider any changes in outcome, had any of the methods suggested in this study been employed. This particular incident is an excellent case study for the following reasons:

- There was no loss of life.
- The incident has been used by the aviation industry to highlight the need for ARFF Training on cargo aircraft.
- The Philadelphia Fire Department has taken the lead in effecting change. The PHL Chief has lectured extensively at ARFF venues to raise awareness to the lessons learned. PHL has developed a unique database to serve as a tactical tool for Incident Commanders, providing data they needed, but could not obtain on the day of the incident.

5.1 ACCIDENT REVIEW: UPS AIRLINES FLT. 1307, PHL, PHILADELPHIA, PA

The following information was taken from the “NTSB Survival Factors/Airport And Emergency Response Group Chairman’s Factual Report, Docket NO. SA-228 EXHIBIT NO. 16A”

Summary

On February 7, 2006, at 2359 (EST), a Douglas DC-8-71F, N748UP, operated by United Parcel Service Company (UPS) as flight 1307, landed at Philadelphia International Airport (PHL), Philadelphia, Pennsylvania, after the crew reported a cargo smoke indication. The three flight crewmembers were able to evacuate the airplane using the L1 slide. Fire subsequently caused substantial damage to the airplane and numerous cargo containers on board. The three crewmembers received minor injuries.

Notification

The Air Traffic Control Tower notified ARFF of an Alert 1 (a reported aircraft emergency or problem) via the “crash phone” at 23:57:15 EST. The Tower reported that UPS was 5 miles southeast of the airport with a smoke warning light in a cargo hold.

Fire Control Time

According to the City of Philadelphia Fire Department FCC dispatch logs, ARFF arrived at the accident site at 2359 local time. A period of 4 hours and 8 minutes elapsed from the initial arrival on scene to the time the incident commander radioed to dispatch for fire control (e.g., fire under control) (at 0407 local time).

(Editorial Comment) A control period of 4 hours is the first printed indication that the selected tactics were not effective.

Fire Conditions On-Scene

When ARFF vehicle arrived on-scene, no fire was visible, but smoke could be seen coming from the open L1 door and the outflow vent in the tail. The first indication of visible flame came when firefighters opened the
**right over wing emergency hatch.** Flames were observed rolling on the fuselage ceiling over the tops of the cargo containers. Smoke began emanating from all open exits. All fire was located aft of the over wing exits toward the aft bulkhead. Burn through of the fuselage roof occurred at several locations between the trailing edge of the wing, aft toward the tail.

*(Editorial Comment)* Hindsight is nearly always 20/20. We have the ability to see the outcome of the selected tactics, pass judgement, and then consider alternative methods. In this case, we have an apparently intact fuselage with no signs of significant fire. There is no blistering of paint, no visible deformity to the skin, and based on the smoke report, a containable volume of fire. The first action was to open an overwing hatch which introduced oxygen. Let us consider the effects of the opposite action. A similar level of effort may have been able to secure the open L-1 door, cutting off the source of oxygen. Our smart approach to tactics takes us back one of the first lessons in firefighting. Our parents told us that if a pan caught on fire on the stove, we should put a lid on it, cutting off oxygen. In this case, we know that we may not be completely sealing off all air, but we are contributing to a reduction of flame rather than feeding it with the air it needs.

**Firefighting Strategy**
The ARFF units surrounded the airplane and a water attack was ordered. Access to the main cargo area was obtained via the right over wing doors, and an exterior hand line attack was initiated from this location. Turret streams were applied into the R4 doorway while a Snozzle piercing operation was conducted on the left side. The piercing operation began behind the left aft overwing exit, in line with the windows, and continued aft toward the tail. The entire operation switched to a foam attack. Eventually hand lines were advanced to the interior of the airplane through the R4 and left side over wing doors until total extinguishment was completed.

-report of 4 hour control time. If we instead directed some water to the top of the fuselage, of which we had already secured the doors, we could keep the metal cool. Cool metal does not melt. The reaction to the water as it flows over the metal is an excellent method of evaluating the temperatures inside the aircraft. If the water immediately turns to steam, in an area of the fuselage roof, that is the area directly over the fire. As time goes on and the fire uses the available oxygen, the amount of heat on the fuselage roof should diminish and the size of the heated area of the fuselage may diminish (a good indicator of effectiveness).

As outside resources arrive, an aerial platform could be positioned to monitor this activity and report conditions to the Command Post. A Thermal Imaging Camera (TIC) would be an excellent tool to be used in this monitoring position.

*If the method is effective, we have saved a great deal of effort, reduced our risks and minimized damage. If it is not effective, it will certainly buy us enough time to gather resources and expertise together and develop an Incident Action Plan (IAP), based on the combined knowledge of the stakeholders.*

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**Hazmat Information Exchange**
The following excerpts are taken from the Hazmat Information Exchange section of the PHL report. Actual names of individuals have been changed as the names have no relevance to the points being made.

When Captain (Smith) arrived on scene, he asked the airplane’s captain if there was hazmat on board. The captain notified him that hazmat was on board, however, he did not have the manifest with him. The Captain requested that airport operations obtain the information. According to the Airport Operations Duty Officer, he arrived on the UPS ramp at 0006 and requested the hazmat documents from UPS personnel.

A UPS representative, brought a “faxed copy” of hazmat documentation to an Airport Operations Agent, who was staged on the UPS ramp. The airport operations agent immediately brought the UPS representative to the scene, and handed the hazmat documentation to the Airport Duty Officer at 0107.

The UPS representative stated that a UPS Ramp Supervisor gave him the “prediction” of what was onboard the airplane. At approximately 0014, airport operations met him at Taxiway Uniform and drove him out to the airplane. When he arrived on scene, a firefighter with a white helmet asked him what hazmat was onboard. He told the firefighter that the hazmat was located in position 14 and 3. He told the firefighter that he could only provide positions of the hazmat, because only the Notice to Captain (NOTOC) discloses the onboard hazmat. The UPS representative also saw a firefighter throw the NOTOC out of the airplane along with some other items. He said he personally picked up the NOTOC and opened it to find four pouch placards, two for hazmat and two for dry ice. He explained what the hazmat onboard was to the firefighter, handed him the two pouch placards for the hazmat, and kept the NOTOC and two pouch placard for dry ice. Later, he handed the rest of the paperwork to Lieutenant (Jones) when he asked for it.

Notification to Captain (NOTOC) Chain of Custody
According to the UPS Flight Operation Manual, the NOTOC information is obtained by the Captain from the UPS load supervisor prior to departure and placed in a Dangerous Goods “pouch,” which, in this case, was located on the outside of the lavatory door of the accident airplane. According to interviews of the flight crew (refer to the Operations Group Chairman’s Factual Report), the NOTOC was on floor of the flightdeck during the flight and the Flight Engineer picked it up and “wedged it in the crash axe sheath.”

According to the ARFF crew, when ARFF arrived on scene, the Captain instructed Lieutenant Blue to attempt to enter the cockpit to find the “manifest.” Lieutenant Blue entered the cockpit to do a quick search for the manifest and crewmembers, but was not able to find the manifest.

According to a statement from Firefighter White, at a later point, he entered the flightdeck to search for the NOTOC again, and found it. He handed it to Battalion Chief Green and he was instructed by Deputy Chief Yellow to handle Hazmat operations. According to Battalion Chief Green, he relayed the information on the NOTOC to Lieutenant Black from the Hazmat Unit for research. According to Lieutenant Black, he handed the NOTOC to a firefighter on his crew and requested information on the particular chemicals from the Materials Safety Data Sheet.
(MSDS). After receiving information on the chemicals, Lieutenant Black radioed the information to Battalion Chief Green. There was no further handling of the NOTOC until Lieutenant Jones from the Hazmat Unit requested to see any information regarding the chemicals on board. At this time, he gave the NOTOC to Lieutenant Jones.

The Survival Factors Group received the NOTOC envelope on-scene from Lieutenant Jones on February 10, 2006.

(EDITORIAL COMMENT) In this particular event, Hazmat onboard was not a significant hazard to responders or the airport community. There was a greater danger created by the burning of aircraft components than by what might have been onboard. The report would seem to indicate that a significant level of effort and time was committed to tracking down the NOTOC. The conflicting reports would seem to suggest that all information was not being routed through the Command Post.

Early in this study we talked about development of a safety culture and Community Resource Management (CRM) at our airports, and the positive effect it has on emergency management. The miscommunications regarding the NOTOC during this incident had no obvious effect on the outcome of the event. It does, however, stand as an excellent lesson learned. ARFF Departments that immerse themselves in relationships with the airport community will reap the benefits at the Incident Command Post. The community will have learned about emergency management, chain of command, incident site discipline and, more importantly, better understand how important their role is to help achieve the best possible outcome.

Interviews (Airport Operations)
The Incident Commander contacted Airport 10 and requested that he contact UPS to track down a manifest for the hazmat on board the airplane. Airport 10 tried to radio an Operations Agent to go to the UPS hangar, but was not able to get a hold of anyone. He heard an Airport Operations Agent confirm, over the radio, that he was at Gate 11. Airport 10 then proceeded to UPS via Echo, Sierra and Uniform to stay clear of the airplane.

Airport 10 arrived on the UPS apron at 0006 and flagged down people on the ramp and told them they had a DC-8 incident. He said they needed “managers” and the cargo hazmat manifest. He also asked for a mechanic that knew cargo doors, doors of airplane and other general information about the airplane. He advised the airplane appeared to be on fire and stressed the importance of getting the necessary people in a hurry. While sitting on the ramp, he upgraded the emergency to Alert 27 (at 0014) as directed by his supervisor. At 0020 Airport 10 left the UPS ramp with a “chief pilot” and a mechanic. He noted that he was “unable to get a hold of anybody.” The benefits of ARFF involvement in Airport SMS planning and Community Resource Management (CRM) teambuilding would have been beneficial, as is evidenced in these comments. The optimal time to learn how to contact the key people needed for an emergency is not during emergency operations. “Flagging down people on the ramp” can be replaced by the execution of an updated call list and notification system. Through emergency planning and CRM, the people on those contact lists would already know exactly where and to whom to report, what is expected of them upon arrival, what to bring, and would already have corporate authorization to represent the airline in the capacity outlined in the emergency plan.

(EDITORIAL COMMENT) These interviews provide additional examples of the lack of relationships with the community and how that impacts emergency management. We all need to use this example to remind us that our contact lists need to be inclusive of all operations and be kept up to date.

Another important consideration here is the disparity in ARFF Requirements between Cargo Aircraft and Air Carrier Aircraft at Certificated Airports in the United States and its territories. 14 CFR Part 139 is the Federal Regulation that mandates the MINIMUM standards of ARFF protection for Air Carrier operations. It does not include Cargo Aircraft in that MINIMUM standard in regards to agent, chassis or training. Therefore, many ARFF departments have little or no training on Cargo Aircraft, and perhaps less interaction with Cargo Airlines. We’ll not debate the double standard in the Federal Regulation here, but instead remind ourselves that these MINIMUM standards should not limit our planning, training and preparation for accidents and incidents at our airports.

At 0110, the Incident Commander asked Airport 10 to identify closest fire hydrant in the area. Airport 10 contacted airport maintenance that confirmed hydrant locations at gates D10, D15, and D8. This information was
relayed to the Incident Commander. The Police Supervisor (77A) dispatched an officer to check Hog Island Road for a hydrant location as a back up. Fire engines were dispatched to both gates D10 and D15 to run a hose line to support the operation on the runway. Airport 10 requested vehicles on each side of hose line to stop vehicles from running over the hose line.

(Editors Comment) We will see in the following section that, although PHL Engine 78 is staffed by senior firefighters and fire officers, the majority have very little time at the airport. This may account for the need to send airport operations and police to areas to search for hydrants. This report is being written in 2009 when we have the technology and level of sophistication to develop any number of methods of keeping track of hydrant locations. Earlier in this study, we explored DEVS technology which provides us with multiple aids to increase safety, reduce response time and put technology at our fingertips. DEVS technology can put the hydrant locations on a touch screen display in the cab of every vehicle. Water supply is a critical component in our ability to satisfy our mission. In addition to hydrant locations, we need to be familiar with the water main sizes, capacities and conditions, hydrant flow rates, and airport pumping station capacities. We need to have a water supply plan to ensure that we can provide constant water supply to the rate and capacity of our vehicles on any area of the field, including the fuel farms. This may include the need for mutual aid agreements (MAAs) or Memorandums of Understanding (MOAs) with mutual aid departments. Depending on your local infrastructure, it may include tankers, Large Diameter Hose Wagons, relay pumping, etc.

Interviews, Aircraft Rescue and Firefighting Personnel

PHL Fire Captain (2½ yrs ARFF Experience)
He walked around the airplane with a thermal imaging camera to locate hot spots. Based on what he saw on the camera, he instructed Foxtrot 7 where to pierce. The Captain’s main concern was to keep the fire contained between about 6 feet aft of the wing and the tail. He wanted to keep the fire from moving forward. Once the fire spread was contained, he began operations for extinguishing.

(Editors Comment) This Captain was using his tools and his knowledge, and identified a point where he wanted to make the stop. It is unfortunate that the FLIR Cameras mounted on the ARFF Vehicles were not working, or not working properly. FLIR images are an excellent indicator to identify hot spots, as well as to gauge effectiveness of the smothering or firefighting efforts. In lieu of the vehicle mounted FLIRS, the handheld TIC’s are the next best method of utilizing technology to measure effectiveness.

PHL Chief Officer (2½ yrs ARFF Experience)
This Chief said another group of firefighters were standing on a “pallet truck” working on the cargo door itself. He said that ARFF was “not familiar with cargo,” which was “a problem in hindsight.”

(Editors Comment) PHL has taken this valuable lesson and developed plans and programs using technology and training to correct this problem. We should be studying every event and making the same corrections in our operations before we are forced to do so, based on hindsight.

PHL Captain (Initial IC - Foxtrot 21) (2 Years ARFF Experience)
Foxtrot 21 ordered all ARFF vehicles to take up “standard position” around the airplane. Foxtrot 21 notified the FCC to “strike out Box 6355,” which was a code to send predetermined off-airport responders, consisting of 4 engines, 2 ladders, 2 chiefs, 2 squads and a Deputy Chief, to Gate 11. Foxtrot 21 ordered SCBA’s to be used when he found out hazmat was onboard. (Foxrot 2) placed a ladder at the L1 door, over the emergency slide, in order to enter the cockpit to look for manifest and attempt entry into front cargo area. A dual agent (water/powder) line was placed in service through the L1 door.

(Editors Comment) The fire service has predetermined plans and Standard Operating Procedures which summon additional resources, specialized equipment and manpower to satisfy the needs of the incident. These models create a plan that can increase those resources by striking additional alarms to bring in additional predetermined levels of resources. Modern fire service planning at airports needs to be expanded to automatically draw in non firefighting expertise and assets available within the airport community.

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Foxtrot 21 scanned the fuselage with a handheld Thermal Imager Camera (TIC) and found no hotspots. Foxtrot 2 told him that they were unable to locate the manifest because the smoke in the cockpit was too heavy. He called Airport 10 to get a UPS representative and a copy of the manifest. Foxtrot 21 said he was concerned about hazmat volatility and water reactivity, as well as the exact location of “Section 15.” He also requested the fuel capacity. He was informed the lower cargo hold was clear of smoke and fire, and firefighters told him they could not make entry into the airplane from that area. The crash charts available for ARFF crews were for the passenger version of DC8, not cargo.

(Editorial Comment) Cargo position locations such as Position 15 are standardized among aircraft types and cargo carriers. This information is available through your cargo carriers along with the crash charts for the cargo positions. This information can be carried in paper form or mounted onto Mobile Data Terminals (MDT’s) or on DEVS equipment.

Foxtrot 21 notified the Deputy Chief of his desire to pierce the airplane and informed the UPS representative, who was with Airport 10, of his intentions. The first pierce attempts were on the right side of the airplane, forward of the wing, where he picked up the hot spot. The piercing attempt was made to the top of the airplane. The tip slipped and did not pierce the fuselage. He ordered the truck to reposition to the rear of the wing and attempted another penetration to the top. This attempt was unsuccessful and tip once again slipped and moved the nozzle out of place.

(Editorial Comment) Each piercing tool, whether it be mounted on a High Reach Extendable Turret (HRET) or handheld penetrator, has defined capabilities and limitations. The HRET at PHL is a Snozzle, and the manufacturer cautions users in the Operations Manual that the top and bottom of the fuselage are not preferred angles for penetration, and will likely cause the clutch to slip. As we discussed in the training section of the report, proficiency in the use of HRET’s is a skill acquired through initial and constant recurrent training. It is of equal importance that Command Officers have the same level of knowledge and proficiency with the tools in their arsenal as the actual operators. It is impossible for a commander to effectively order the deployment of assets if he/she is not fully aware of the capabilities and the limitations.

The Officers size up was made on an intelligent needs assessment based on the results of a thermal scan of the hot spots, but the method chosen to penetrate caused additional delays in introducing agent, thereby providing more time for the fire to propagate.

Foxtrot 21 said that there were two onboard recording cameras on the ARFF trucks; one was not turned on and one had technical problems with recording. There was also one Forward-looking infrared (FLIR) camera, which was out-of-service.

Foxtrot 21 indicated that he did not believe that the responding structural companies or the Heavy Rescue Unit participate in training with the ARFF crews, with the exception of the triennial drill. He indicated that he was not familiar with the manual main deck cargo door opening procedures or cargo airplane, but he does train on other commercial passenger aircraft.

(Editorial Comment) These comments in the interview further support the need for CRM. ARFF is a highly specialized area of firefighting. ARFF Departments are not staffed or equipped to the level required to successfully handle a major incident without bringing in outside resources. This incident illustrates the critical need to include responders necessary for the success of the mission in training events.

PHL Firefighter (1 yr ARFF Experience) Operator of Fox 7 w/Snozzle

Fox 7 FF said that someone asked him to make sure the video recording device was working on Foxrot 7. He tried to put a tape into the machine, but he had trouble because the machine kicked the tape back out. He continued pushing the tape back in until he saw a recording light come on. Although there is a FLIR camera installed on the snozzle tip, Fox 7 FF said it is a bad design that does not let you see much.

Fox 7 FF tried to use Foxrot 7’s piercing snozzle to pierce the roof area in front of the wing on the right side, but the way the snozzle is designed, it does not really allow for piercings from that angle. They repositioned the
New technology is often integrated into our resources by regulation, or as a result of an individual’s desires expressed in the specification. We do not get the greatest benefit if this is the method used. Technology needs to earn its way onto a truck or into a tool box. An analysis should be conducted before and after new technology is selected. Input from users, commanders and maintenance personnel may cause decisions to be made that provide better capabilities, increased longevity, and greater tactical advantage. This type of involvement also tends to create “buy in” by users, who are the ones who will ultimately make the decisions as to when and how to deploy the tool, or not.

PHL Firefighter (Fox 5 Driver) 15 yrs ARFF Experience
Fox 5 FF said there are FLIR cameras on Foxtrot 2 and Foxtrot 7, but neither were operational during the incident. He indicated that there were no FLIR cameras on Foxtrot 5 or Foxtrot 6.

(Comment) In addition to technology that we consider tools of our trade, there is additional technology that can be used to monitor and track the availability, status, and scheduled maintenance and repair of apparatus and mounted components. Systems that hold everybody accountable from the user to the fleet maintenance group to the command staff make a great deal of sense. Firefighters are much more likely to go through the effort of checking their apparatus and equipment and documenting problems and issues if they feel that attention if being paid to their needs. Fleet management software systems, i.e., telematics systems, are able to draw information directly from the apparatus, apply manufacturers recommended service intervals for scheduled maintenance and integrate discrepancies noted by drivers to schedule maintenance and repairs. The most advanced fleet management solutions can also predict failures before they occur, based on vehicle or component histories, known failure indicators, such as heat, speed or performance. Custom algorithms can be developed to provide prognostic capabilities to reduce or eliminate downtime and increase overall lifecycle, while reducing life cycle costs. All of this translates into increased reliability, and a spike in user pride and confidence in assets.

PHL Firefighter (Fox 2 Driver) 10 Yrs ARFF Experience
Fox 2 Driver and the Fox 2 Lt. extended the dual-agent bumper line to be used in the front of the plane. He assisted the Lt. with putting on his gear and SCBA, and then he checked the FLIR system to get it on-line and check the recording capability. He reported that there were images but they were not distinct. He noticed the driver of Foxtrot 7 to his right, and asked him to see that his camera was working. Fox 2 Driver climbed into Foxtrot 7 to get the FLIR set up for recording. The FLIR was operational and all lights indicated it was recording. At this point, he stayed in Foxtrot 7 and another firefighter got into Foxtrot 2.

(Comment) As we have read each of the NTSB interviews, it was impossible to notice the lack of years involved in ARFF for most of these experienced structural firefighters. This particular interview highlights the value of experience. The firefighter with 10 years ARFF experience went to work in vehicles outside of the one for which he was responsible to troubleshoot and activate equipment in other vehicles. He even took control of another vehicle when there was no mention of any problem with his assigned vehicle. Although not specifically mentioned, it leaves me with the impression that his skills and experience were needed in that particular vehicle.

As we have discussed, ARFF is a highly specialized area of firefighting. Experience is not gained quickly. As a former ARFF Chief Officer, I always hoped to have a blend of years and experience on each of my shifts. You
hope to have seasoned experienced members of all ranks blended with youth and strength, ready to work long and hard, developing the experience for the day when they are the seasoned veteran. It is not always easy to achieve this blend, but it should be a consideration in staffing options.

Foxtrot 7 was redirected from the left side of the airplane to right. The FF scanned for a heat signature and to get access to the plane. He positioned F7 in front of the right wing and tried to pierce the airplane based on direction from the Captain. The first attempt was unsuccessful and he was directed to move Foxtrot 7 farther back towards the tail of the airplane. The FF realized that there was a ladder where he needed to be, and instead, moved closer to the airplane. A Chief directed him to try to pierce the airplane from the top. The FF told the officer that he was outside the limitation for piercing the airplane without the boom being at a 90-degree angle to the airplane, but he tried it anyway. This action was not effective and it broke a part off the housing on the tip. His Lieutenant asked the FF to bring the tip down so that he could reset it. Then the Lieutenant told him to go to the left side of the plane and pierce there. This is where the first penetration was made. The FF began to flow water and foam, mainly water. The Lieutenant was outside directing the placement of where to penetrate, based on what he saw in the TIC.

The FF pierced the airplane two times before he had to go back to Engine 78 to refill with water. Foxtrot 5 was already at the station refilling with water. After refilling, he returned to the same position on the right side of the airplane, and resumed piercing the fuselage. At this point, he was only flowing foam and he had a water relay from another truck. The FF did notice a dramatic difference in the fire when he switched from mainly water to strictly foam application. One of the Captains had taken over the direction of locating hot spots and directing the piercings.

Conclusions:
This study discusses a number of areas of ARFF that we tend to look at individually rather than collectively. We have applied some of the salient points of those discussions and applied them to a single case study, UPS Flt. 1307 at Philadelphia International Airport. Many of the discussions offered provided new ways to think about the tactical challenges the ARFF Crew at PHL faced on Feb 7th and 8th, 2006. We do not make determinations as to right or wrong, but rather what lessons with which we can we walk away to better prepare us for our mission.

5.2 LESSONS LEARNED

5.2.1 EMERGENCY PREPAREDNESS

It is very clear that the planning, management and mitigation of a major aircraft accident or fire requires a huge commitment from multiple agencies, organizations, businesses and individuals from multiple jurisdictions. The need for outreach, planning and practice involving all of the players required to successfully manage these incidents is a mandatory component of our emergency planning model. The ability to operate with this diverse group of stakeholders under the National Incident Management System, (NIMS) will better prepare us all to work together under a universally recognized command structure.

Outreach specifically within our airport community, (Community Resource Management) throughout the year as part of the development of Safety Management Systems (SMS), Ramp Safety and awareness will develop a culture that is familiar with the other stakeholders, accustomed to working together, and able to think outside their own areas of responsibility.

5.2.2 TECHNOLOGY INTEGRATION

Each of our operations is different. We come from different cultures, different organizations and different levels of responsibility. As different as all of these considerations are, we are all the same on a relative scale. From Index A or Category 1 airports to Index E, Category 9-10, we each have the responsibility of the safety of the individual passenger in each seat that flies in and out of our airport. We need to evaluate each available piece of technology that may apply to the needs of our mission Precious few dollars make their way into our budgets, so we must invest those dollars wisely. We need to study the best application of that technology and develop training that is designed not with the
intent to allow us to check off a box on the training form, but instead to develop proficiency by its users. Our internal procedures must be such that each asset assigned to us is checked daily and ensured to be safe and operational.

We must also recognize that most technology is not meant to be “stand alone”. The firehouse kitchen or training room is a great place to brainstorm appropriate utilization of technology and how it can be combined for even greater benefit.

An example of this would be FLIR cameras, TICs, onboard video recorders, DEV systems, HRETs with piercing tips, and hand held penetrating nozzles.

The FLIR Cameras and Thermal Imagers provide us with thermal images of anything with a heat signature different from ambient air temperature within the range of the camera. The ability to monitor temperature range from a distance allows us to identify areas of concern, as well as monitor the effectiveness of our suppression efforts. Recorders are connected to FLIR or color cameras. If these recorders are digital and are self activated, there is a good chance a recording will be created. These recordings are a once in a lifetime training resource. This information can be used to train your entire department, as well as the next generation of firefighters which have not yet been hired. These recordings will also be used by investigators and may save your department a lot of time trying to remember the course of events and timeline. In the case study of the 4 hour suppression event at PHL, a number of inconsistencies in testimony are recorded. This is because of the difficulty in recalling specific events and the order of those events after a long term incident.

As we discuss combining technologies like TIC’s with penetrating nozzles, we need to include additional knowledge. If we were fighting aircraft fires every day, we would have had a natural evolution of procedures, based on experiences and lessons learned. We will never have that level of experience, so we need to develop our tactical advantages in the classroom.

Using the FLIR or TIC is extremely valuable in identifying the hot spot, but it is only a small piece of the puzzle, particularly when we are working to control a fire in a large aircraft. Using the cargo aircraft, as in the case study, adds to our challenges, because we do not train as often on cargo aircraft. This may be the first thing you want to change.

Piercing nozzles and penetration depths required to put agent where needed varies, based on aircraft type, loading, and company specific configurations.
Snuzzle HRETs are designed to add additional length to the piercing tip. With a strap wrench, you can add 12 inch extensions to the existing piercing tip. Understanding the loading, configuration and aircraft type will assist in determination of the best height and depth of piercing. Working with cargo airline representatives, collecting crash charts of cargo aircraft, conducting familiarization visits and holding tabletop training exercises will help ARFF Crews and Command Officers make smart choices during an actual event.

You do not have to have a vehicle mounted HRET to pierce aircraft. There are a variety of hand held piercing nozzles that are very effective methods of introducing agent into an aircraft fuselage. If, in fact, your hot spot is in the center of the fuselage, a very effective attack could be with 2 hand held piercing nozzles. By placing one forward and one aft of the hot spot, you may be effective in suppressing the fire without pushing it in either direction.

5.2.3 TRAINING

It is worth repeating again, Aircraft Rescue and Fire Fighting (ARFF) is a highly specialized area of expertise in the firefighting industry. Excellent structural firefighters are not prepared for the challenges created at an aircraft crash or fire. Initial and recurrent training in a number of mandatory subject areas by the FAA or ICAO is only a baseline for the knowledge required. Individual tactics and strategy training scenarios on aircraft fleet types and specific hazard types at your airport should be routine events. Review of case histories taken from incident reports of NTSB Investigations should be very familiar to ARFF Firefighters. Any department, group or agency that has a role in your Airport Emergency Plan should be invited to participate in ARFF training. In a major event, the outside departments may have more manpower than the ARFF Department. Doesn’t it make sense that those departments should be trained as well?

Never forget your original training! Our recruit firefighter training teaches us the basic skill sets. It is where we learn the basic fire science, fire behavior, basic construction, PPE, water supply, fire stream management, fire hydraulics, etc. We learned that if you have a fire in a confined space and you can maintain the integrity of that confined space, the fire will either run out of oxygen or run out of fuel. This brings us back to putting a lid on a pan burning on the stove. We are not naive enough to think that it will always be this simple. We understand that the integrity of the airplane may not be complete. We know that if the integrity is nearly complete, we will slow the fire significantly and buy a lot of time to gather a great deal of data, assemble teams with considerable expertise, and develop an Incident Action Plan that offers the best possible outcome.
Remember that no matter what is burning or where it is, no matter what technology we deploy or special teams that we launch, we are still extinguishing the fire based on removing one of the required components of combustion.

5.2.4 MAINTAIN “SMART APPROACH” BASED ON ARFF KNOWLEDGE AND TRAINING

Another important lesson is one that we need to impress upon our Command Officers: to stay the course of the “Smart Approach”. The stress of the incident upon others who do not understand our methods can influence us to make decisions that may be different from the decisions our training tells us to make. For example, if we arrive at a fuel fire in a large diked area, we know that we may need to delay the application of foam until sufficient quantities of foam arrive to cover the surface area of the spill and maintain the integrity of the seal created by the foam. In that scenario, we may be evacuating structures, establishing water supply and protecting exposures, but not applying anything to the burning spill area. Upon arrival of the airport manager or media, we start getting pressured to take a different action, even though we know through simple math that we need to wait for the other truck to arrive from the opposite side of the airport. That pressure can cloud our thinking, affect our judgment, and cause actions that are difficult to defend after the fact.

Case in point - the PHL Case Study, wherein there may have been some criticism by officials had the ARFF Crew made a decision to:

- close up the aircraft and cool the fuselage
- monitor the heat inside while developing a plan for a piercing attack to surgically inject agent at the correct location and depth if the fire did not suffocate.
It is clear in this business that we will be under scrutiny and our actions will be second guessed by the media, our peers, and investigators. In order to sustain through these intense periods of scrutiny, we must simply be well prepared, well trained and have a system in which we have confidence. After the cameras are gone and the reports are written, it is our own conscience by which we will forever be held accountable.
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