
2018

Learning from Asiana 214—Minimizing Strike/Rollover for Aircraft Rescue and Firefighting

Mary K. Gorman

gormanm@erau.edu, gormanm@erau.edu

Elizabeth Hendel

Embry-Riddle Aeronautical University, hendele@erau.edu

Douglas Mikutel

Embry-Riddle Aeronautical University - Worldwide, mikutd72@erau.edu

Rita I. Herron

drreherron@yahoo.com

Duane Kann

dkann@rosenbaueramerica.com

Follow this and additional works at: <https://commons.erau.edu/ijaaa>



Part of the [Other Social and Behavioral Sciences Commons](#)

Scholarly Commons Citation

Gorman, M. K., Hendel, E., Mikutel, D., Herron, R. I., & Kann, D. (2018). Learning from Asiana 214—Minimizing Strike/Rollover for Aircraft Rescue and Firefighting. *International Journal of Aviation, Aeronautics, and Aerospace*, 5(5). DOI: <https://doi.org/10.58940/2374-6793.1275>

This Article is brought to you for free and open access by the Journals at Scholarly Commons. It has been accepted for inclusion in *International Journal of Aviation, Aeronautics, and Aerospace* by an authorized administrator of Scholarly Commons. For more information, please contact commons@erau.edu.

Learning from Asiana 214--Minimizing Strike/Rollover for Aircraft Rescue and Firefighting

Cover Page Footnote

The authors wish to acknowledge the expert contributions of the ARFFWG A-14-59 Task Group members whose names are listed in Table 1 of this paper; they continue to dedicate themselves to the ARFF profession by sharing their knowledge, serving others, and leading research endeavors such as this.

Introduction

This paper explores the second of four recommendations directed to the Aircraft Rescue Fire Fighting Working Group (ARFFWG) as part of the National Transportation Safety Board's (NTSB) letter, dated July 16, 2014. The letter contained specific recommendations from the accident involving a Boeing 777-200ER, Korean registration HL7742, operating as Asiana Airlines flight 214, that occurred on July 6, 2013, at San Francisco International Airport, San Francisco, California.

In response to the NTSB's recommendations, the ARFFWG created a committee that conducted an applied research project in order to examine theories, knowledge, methods, and techniques to develop new recommended best practices to avoid striking or rolling over seriously injured or deceased persons with ARFF vehicles in a mass casualty situation. The membership of the committee was comprised of ARFF subject matter experts, which included members from the U.S. military, National Fire Protection Association (NFPA), ARFF Technical Committees, academia, and other professional and private sector organizations; it was jointly chaired by members of the Federal Aviation Administration (FAA) and the ARFFWG.

The applied research project was completed between April 2015 and January 2016 with a membership of 20 individuals, including the chair. The committee studied and considered various issues within the topic area of best practices to avoid striking or rolling over seriously injured or deceased persons with ARFF vehicles in a mass casualty situation.

Background and Problem Definition

On July 6, 2013, about 1128 Pacific daylight time, a Boeing 777-200ER, Korean registration HL7742, operating as Asiana Airlines flight 214, was on approach to runway 28L when it struck a seawall at San Francisco International Airport (SFO), San Francisco, California. Three of the 291 passengers were fatally injured, of those fatalities, one passenger was struck by an ARFF vehicle due to her close proximity to the burning airplane.

Existing guidance concerning careful operation of ARFF vehicles and the need for caution while watching for potential survivors in the vicinity of aircraft crashes has been published by both NFPA and the International Civil Aviation Organization (ICAO) - this is widely used by ARFF professionals in the field. This guidance is as follows:

NFPA 402, 7.3.4 (2013) states:

When nearing the accident scene, vehicle operators should be alert to avoid all persons in the area, especially those who might be injured, unconscious, or wandering about in a dazed condition. In darkness, periods of low visibility, or when operating in areas of tall vegetation, extra caution and effective use of lighting equipment, audible warnings, FLIR systems, or a combination of these might be needed. (p. 16)

Furthermore, International Civil Aviation Organization (ICAO, 2014) Doc 9137 Part I, 4th Revision (14.6.4) states:

When nearing the scene of the accident a careful watch must be maintained for occupants who may be dashing away from the aircraft or who may have been flung clear and are lying injured in the approaches. This applies particularly at night and calls for competent use of spot or search lights. (p. 42)

Other than these two official documents, there is one other private training publication concerning scene safety and triage, which is widely recognized by ARFF professionals. First issued in 1971 by the American Academy of Orthopedic Surgeons (AAOS), *Emergency Care and Transportation of the Sick and Injured* (Pollack, 2011) is commonly recognized as the backbone of Emergency Medical Services education and training. It has similar training modules on driver training for emergency response vehicles. Further:

Scene Size-Up is the first priority when approaching an emergency scene to ensure scene safety, not only safety to the first responders but also to victims. Triage of patients should be performed according to a universal, recognized system of priorities designed to maximize the number of survivors. (p. 23)

While the aforementioned is the prevailing guidance in ARFF, it is not sufficiently detailed to ensure minimizing the risk of future persons being struck or rolled over by ARFF vehicles during emergency response operations nor will it assist in task prioritization for first responders. As a result, this task group conducted an extensive literature review within the fire service with specific emphasis on ARFF. The industry was surveyed for best practices, and medico legal professionals were consulted to formulate a recommendation to the NTSB in the aftermath of Asiana 214.

Methodology

The qualitative inquiry used participatory research and evaluation with expert involvement from medico-legal professionals and the committee comprised of 20 aircraft rescue and firefighting key informants. Of the 20 members on the task force, 14 were Chief Officers in the American Fire Service with a minimum of 12 years ARFF experience, with most having more than 25 years of service. The group also consisted of one airport consultant, one airport communications expert, two university professors (one with a cognate in Public Safety Management), and two Fire Captains with at least 25 years of service and ARFF experience. Key informants (committee members) were selected from many regions of the country in order to obtain varying perspectives and knowledge of differing protocols, nationwide. Selection criteria also included: knowledge and command experience in every aspect of ARFF and fire suppression operations; incident management systems; ARFF strategies and tactics; aircraft systems and design; FAA regulations and ACs; airport operations, policies, and procedures; all key informants had a minimum of 12 years in their particular area of expertise within the aviation industry. Each also held a minimum of an AA degree from a reputable institution of higher learning, was currently working in the industry, was a member in good standing in the ARFF Working Group, provided a resume for review by the committee Chairperson and the ARFF Working Group Chairman and was required to participate regularly on the task force. These committee members were purposely selected for their diversity of experience and expertise which would prove essential to understanding an incident such as Asiana 214.

As defined by Patton (2002), “participatory evaluation” is a method of qualitative inquiry where all participants are equally involved as “co-investigators” in a process of reaching consensus on a particular research problem (pp. 183-184). Research participants feel “ownership” of both the process and the ultimate findings, thus, any status differentials are minimized, group cohesion is facilitated, and inquiry is authenticated (pp. 184-185). Further, Patton explained, “The inquiry process involves participants in learning inquiry logic and skills, for example, the nature of evidence, establishing priorities, focusing questions, interpreting data, data-based decision making, and connecting processes to outcomes” (p. 185).

In previous studies from other academic disciplines that relied upon the participatory evaluation methodology, such as Simmons et al. (2015) and Stringer, Fleskens, Reed, de Vente, and Zengin (2014), findings pointed to the importance of considering the perceptions held by stakeholders and scientific evidence uncovered through empirical studies in the development, implementation and sustainability of policies, procedures, and other standards. Simmons et al. (2015) demonstrated that participatory evaluation provided concrete evidence regarding

perceived benefits to stakeholders who operate in partnership and ultimately demonstrated the value of ongoing activities. Stringer et al. (2014) demonstrated support of the consideration and evaluation of outcomes that require the input of a range of experts that are ultimately used to develop management practices. Although these authors wrote respectively about health administration and sustainable land management, the lessons learned are applicable to the burgeoning literature in the emergency management field, particularly as it applied to aircraft rescue and firefighting discussed here.

Between April 2015 and January 2016, committee members of the participant group worked together in small focus groups, conducted interviews with other key informants and stakeholders, shared oral histories and stories, reviewed and contributed to numerous drafts of the recommended best practices documents, and collaborated as a committee to develop the final version of the recommendations that have been submitted to the FAA/NTSB. In this manner, the committee was able to fully gather information, critically analyze the inputs, and attain consensus through the participatory evaluation process (Zukoski & Luluquisen, 2002).

The critical value of the participatory method for this project was not only in the diversity and depth of subject matter experts' experiences, but in the process of sharing these experiences. Thus, negotiation to validate key findings and developing consensus to finalizing the committee's recommendations were critical aspects of the participatory process which helped to ensure validity of the overall qualitative research process. Combined with an extensive documentary analysis, this approach ensures data credibility through iterative questioning, peer scrutiny, and reflective commentary; transferability through detailed descriptions and comparisons; dependability by use of overlapping methods; and confirmability through the creating of an audit trail and triangulation of data (Guba, 1981).

As mentioned, participatory research and evaluation was complemented with an extensive documentary analysis, including FAA Advisory Circulars, regulations, standards, medical and aircraft rescue industry publications. This documentary analysis is also considered the formal literature review for this research.

Documentary Analysis-Literature Review

A comprehensive review of the literature was conducted, ranging from ARFF training standards, FAA Advisory Circulars (ACs), ICAO regulations, medical manuals, NFPA, to other relevant publications within the ARFF industry. These particular documents are the backbone of ARFF training programs for airport fire departments in the US and throughout the world. Certain literature provides

guidance and recommendations for emergency response vehicle drivers to minimize the risk of persons being struck or rolled over at accident sites. The majority of written material discusses scene safety, awareness, communications, apparatus placement, and triage protocols.

The literature referenced tended to rely exclusively on emergency management trade materials because, as an academic discipline, literature is fragmented compared to other areas of study. Emergency management articles are often found within similar discipline journals, such as public administration. As an example, Kapucu and Garayev (2013) discussed the development of emergency management networks in the *American Public Administration Review* journal and were cited various times among articles in the realms of public administration, safety science, and management. As the literature of emergency management continues to develop, research tends to rely heavily on trade sources until more scholarly academic journals advance.

The 2015 International Fire Service Training Association (IFSTA) ARFF textbook provides relevant guidance for approaching an emergency scene, including consideration of likely locations/positions of victims and survivors, use of auxiliary lighting and other identification aids for night operations, and general wreckage patterns at crash sites. According to IFSTA: “ARFF personnel must remain alert for survivors who may have self-evacuated from the aircraft.” Also, “Injured survivors should be taken to the safe refuge area” (p. 556). It is also important to note past experiences have shown many passengers escaping an aircraft crash will go towards the emergency vehicles to get help, yet this is also potentially putting them in harm’s way. IFSTA recognizes the challenges of performing triage in reduced visibility and tall grass, and recommends the use of light sticks or flags that fly high enough to be seen indicating the patient triage level are useful tools (p. 251). An informational text box discusses apparatus placement and repositioning, providing, “when repositioning apparatus, a ground guide should be utilized to watch for aircraft debris, luggage and/or aircraft occupants who may have been thrown from the aircraft” (p. 367). This would be an importance reference therein to the subject.

FAA AC 150/5210-7D (2008), *Aircraft Rescue and Firefighting Communications*, Sections 6 and 7, contain important communication models that, if correctly implemented, will contribute to incident safety and identification of escaping passengers and injured/deceased persons on the scene. FAA AC 150/5200-12C (2009a) *First Responders’ Responsibility in Protecting Evidence at the Scene of an Aircraft Accident/Incident*, is relevant to this research as it provides guidance to law enforcement for protecting evidence at the scene of an aircraft accident, noting after extinguishment, “all personnel inside the secured area should

be cautioned to keep their activities around the wreckage to a minimum to prevent unnecessary wreckage disturbance and eradication of valuable evidence, such as ground scars” (p. 3). This includes striking victims as vehicles drive in and around the scene.

FAA AC 150/5210-19A (2009c), *Driver’s Enhanced Vision Systems*, and AC 150/5220-10E (2011), *Guide Specification for ARFF Vehicles*, addresses the Forward Looking Infrared (FLIR) and Driver Enhanced Vision Systems (DEVS) systems available for ARFF Apparatus. FAA AC 150/5210-19A (p. 1) states, “The DEVS program, in an effort to reduce response times, is aimed at the four difficult aspects of poor visibility response: 1. locating the incident, 2. navigating to the accidents site, 3. avoiding obstacles, 4. locating people on the way to the accident site.” The document provides human detection distance requirements for various conditions, with 500 ft. being the maximum distance in clear conditions and 300 ft. being the minimum distance in rain/snow. FAA AC 150/5220-10E (p. 30) item 3.4.6 lists the FLIR system as part of the equipment considered standard for ARFF apparatus being supported with Federal funding. Although excellent tools for use in identification of hot spots, people and debris, these tools may not be available on all ARFF apparatus, as a result, these may not be the most current technology to provide the best results, and cannot be relied upon exclusively.

Emergency Care and Transportation of the Sick and Injured (Pollak, 2011) has similar modules on driver training for emergency response vehicles. Scene size-up is the first item when approaching an emergency scene to ensure scene safety, not only for first responders but also victims. Triage, the rapid sorting of patients according to a system of priorities designed to maximize the number of survivors, is addressed as well. Incident command should be established first, followed by triage, treatment, and transportation of all patients. In particular, this book focuses on the importance of utilizing the Incident Command System (ICS) and control zones (hot/warm/cold) when dealing with a hazardous materials incident. Most aircraft accidents will fall into this category due to high volumes of fuel and composite materials.

National Fire Protection Association (NFPA) standards give guidance to various safety factors pursuant to approaching the scene, scene safety and triage. NFPA 402 (2013), *Guide for Aircraft Rescue and Fire-Fighting Operations*, section 7.3.4, provides guidance:

When nearing the accident scene, vehicle operators should be alert to avoid all persons in the area, especially those who might be injured, unconscious, or wandering about in a dazed condition. In darkness, periods of low visibility, or when operating in areas of tall

vegetation, extra caution and effective use of lighting equipment, audible warnings, FLIR systems, or a combination of these might be needed. (p. 16)

NFPA 424 (2018), *Guide for Airport/Community Emergency Planning* is important to the study because it describes scene approach and scene safety. Section 13.6.3 states:

Triage should begin immediately. Qualified medical personnel should be assigned to this task. Victims are moved from the triage area to the appropriate treatment area before definitive treatment is rendered. Casualties should be stabilized at the treatment areas and then transported to appropriate facilities. The use of colored tarps or other means to identify treatment areas should be used. (p. 22)

In addition, ICAO (2014) Doc 9137 Part I, 4th Revision (section 14.6.4) describes the approach:

When nearing the scene of the accident a careful watch must be maintained for occupants who may be dashing away from the aircraft or who may have been flung clear and are lying injured in the approaches. This applies particularly at night and calls for competent use of spot or search lights. (p. 45)

After discussing this matter with medical directors and paralegals from fire department emergency medical services, it was brought to our attention that adherence to national and local protocols are of the utmost importance. The existing literature explored on these topics, although not fully addressing ARFF vehicles and avoidance of striking persons, provided a solid foundation for the committee to offer recommendations to the NTSB concerning: scene approach, scene safety, use of technology, triage and treatment, and communications.

Results

Taken as a whole, the committee determined that the documentary analysis was inadequate and not definitive enough to glean sufficient “best practices” to avoid striking or rolling over seriously injured or deceased persons moving forward from the Asiana crash. However, based on existing published works combined with the participatory research and evaluation process, the committee was able to develop recommended changes to existing procedures in the following areas: scene safety and situational awareness; rapid triage, treatment, and transportation with proper marking for deceased persons; communications and training, utilizing the latest technology; and incident command with risk assessment. The committee was

confident that targeted and specific improvements in these areas *will ultimately result in overall best practices* for ARFF professionals that will minimize the risk of future persons being stuck or rolled over by ARFF vehicles during emergency response operations, which is one objective of this research, based on safety recommendation #1 from the NTSB. The second goal of the research was task prioritization at aircraft crash sites, based on safety recommendation #2, and a best practice for ARFF professionals was offered for NTSB consideration.

Safety Recommendation #1

While life safety is the ultimate mission of emergency responders, life safety makes no distinction between responders and passenger/victim(s). Scene safety management and task prioritization efforts should therefore reflect total scene safety extending to all aspects of the response (e.g., passenger evacuation, search & rescue, vehicle maneuvering, airport ingress/egress routes, staging discipline, etc.). Especially at the outset, the transit, approach, and maneuvering of vehicles in and around the incident scene itself is critically important in this regard. Apparatus driver/operators must always maintain situational awareness.

To formalize situational awareness and ensure scene safety, this committee recommended that the Incident Command System (ICS) must be utilized and control zones established, similar to managing a hazardous materials incident. Hot, warm, and cold zones should be established and identified to all on scene. By establishing these hazard control zones, and clearly demarcating them, all first responders will be operating within a universally-understood working environment. For ARFF emergency vehicle operation, the hot zone is an area where both ambulatory and non-ambulatory victims and evacuees will be expected—as a result, extreme caution should be exercised to minimize strike and rollover. The warm zone is designated as the triage area, and different safety measures would need to be taken as both first responders and crash victims will be maneuvering within that designated area. Within the cold zone, various operational elements will be performed in accordance with implementation of the incident command system.

Rapid triage, treatment and transportation with marking for deceased persons. *Emergency Care And Transportation of the Sick and Injured* (Pollak, 2011) has similar training modules on driver training for emergency response vehicles. Scene Size-Up is the first priority when approaching an emergency scene to ensure scene safety, not only safety to the first responders but also to victims. Triage of patients according to a universal, recognized system of priorities (the START system) is designed to maximize the number of survivors. Thus, this committee recommended that all ARFF personnel should be trained appropriately to establish and employ that universal system of triage, treatment and transportation of all patients. Proper application of the hazard control zones, in addition to this

accepted triage system, should minimize/eliminate the possibility of persons being struck or rolled over by ARFF vehicles during emergency response operations. See Figure 1 in Appendix.

Communications and leadership training. In addition, the committee recommended that all ARFF departments should implement an ARFF driver/operator training and certification program in accordance with FAA AC 150/5210-23 (2010), *ARFF Vehicle and High Reach Extendable Turret (HRET) Operations, Training, and Qualifications*. The course must require the passing of both a written examination and a hands-on driving competency course. Such courses focus on safe driving techniques, avoiding hazards, situational awareness, placement of emergency vehicles, and emergency lighting which are all concerns of the committee.

Another minimum competency this committee recommended is that all individuals subject to incident command on airports should be required to complete the National Incident Management System (“National Incident,” n.d.) core curriculum:

IS 700: NIMS Introduction

ICS 100: Introduction to the Incident Command System

ICS 200: ICS for Single Resources and Initial Action Incidents

ICS 300: Intermediate ICS

ICS 400: Advanced ICS

ICS 701: NIMS Multiagency Coordination System

ICS 702: NIMS Public Information System

Technology. In June 2009, the Federal Aviation Administration issued a recommendation on the standards for the Driver’s Enhanced Vision System program. These recommendations were contained in FAA AC 150/5210-19A (2009c) *Driver’s Enhanced Vision Systems* and incorporate three specific components: low visibility vision enhancement, navigation, and tracking. One of the specific requirements for these systems is for the ability to detect humans at distances of 300-500 feet depending on atmospheric conditions and the speed of the vehicle utilizing Forward Looking Infrared (FLIR) technology. This ability, if properly utilized, could prove extremely valuable in preventing victim strikes. One of the key concerns as it relates to this specific technology will likely be cost/availability.

This committee recommends that the use of handheld Thermal Imaging Cameras (TIC) should be investigated for potential benefit. The use of handheld TIC devices has become a widely accepted standard for locating victims during

interior search operations by structural firefighting personnel. These devices could provide a similar capability to detect obscured victims as that provided by the low visibility vision enhancement component of DEVS without the cost of a fixed installation.

Incident command and risk assessment. While the FAA mandates that airports produce, maintain and follow an airport emergency plan (AEP) as part of their certification documentation, this document typically only provides general and superficial guidance for specific types of emergencies that may occur on an airport. The FAA AC 150/5200-31C (2009b), *Airport Emergency Plans*, currently calls for an incident command structure to be illustrated within the plan and to be utilized during all emergencies. This committee recommended that in addition to the existing requirements, supplementing this plan and its component command structure should be an appendix composed of response procedures that prescribe management processes to be employed throughout the incident/accident for each type of event. These procedures should specifically address: priority of certain tasks to be accomplished in a manner consistent with universally accepted standards of care; maintaining awareness of changing circumstances across the entire incident area and peripherals (i.e., situational awareness); and a means for performing the aforementioned items with the staffing available at the outset and as the incident evolves.

In addition, this committee recommended that, in order to achieve the desired result in a rationally defensible fashion, every airport should be required to conduct a prescribed hazard and risk assessment for all types of events, with the results made part of the airports' emergency plan and certification manual. A reasonably comprehensive risk analysis would also serve as a potential metric for any future examination of staffing levels associated with an individual airport. The FAA should issue a CertAlert that recommends the use of ACRP Report 131-*Guidebook for Safety Risk Management at Airports* (Airport Cooperative Research Program, 2015). The FAA should also include this comprehensive reference in the next revision of AC 150/5200-31C - *Airport Emergency Plan*. This information should be used by U.S. certificated airports performing any Safety Risk Assessment (SRA) while implementing a Safety Management System (SMS). An example tool is the "Ready Business" risk assessment model from the U.S. Department of Homeland Security (2013). Although this tool is intended to assist businesses, the general organization and format is easily germane to airport risks and hazards.

Safety Recommendation #2

Clearly there can be no absolute protocol for every situation or every airport. However, among the variety of other commonly occurring tactical activity, the

committee developed a recommended best practice for task prioritization which incorporated common actions to be considered relevant to this discussion (Note: adequate flexibility should be exercised in any tactical procedure to allow for the exigencies of the event). The following task prioritization best practice has been developed from existing FAA (FAR Part 139), NFPA (403 Annex E, Table D. 14), ICAO (10.5.7.6, Table 2), EASA (AMC2 ADR.OR.D.027, Safety Programs), NIMS document annexes and appendices, as well as common tactical practices and input from committee subject matter experts. See Table 1 in Appendix.

Recommendations for Future Research

Based on the committee's findings, the authors propose a pilot study be designed to evaluate the quality and efficiency of the committee's recommendations and best practices herein described. To date, the NTSB has not yet approved the final recommendations from the ARFFWG and they have not been released to the ARFF community-at-large for implementation on a broad scale, although many have been put into practice informally among the ARFFWG membership. However, any deficiencies in process, strategies or tactics at the department, local, regional or state levels have not yet become readily apparent. Working with the ARFFWG, the researchers should be able to obtain a representative sample population and adequate data within 12 months of actual best practice implementation.

References

- Airport Cooperative Research Program. (2015). *ACRP report 131 - A guidebook for safety risk management at airports*. Retrieved from https://vsgc.odu.edu/ACRPDeisngCompetition/2015/Resources%20for%20Design%20Competition%20Website/acrp_rpt_131_Safety%20Risk%20Management%20for%20Airports.pdf
- Aircraft Rescue Fire Fighting Working Group. (2014). *ARFFWG response to NTSB (A14-58 through -61)*. Retrieved from <http://arffwg.org/wp-content/uploads/2014/11/ARFFWG-Response-to-NTSB-001.pdf>
- Federal Aviation Administration. (2008). *Advisory circular 150/5210-7D: Aircraft rescue and firefighting communications*. Retrieved from https://www.faa.gov/documentLibrary/media/advisory_circular/150-5210-7D/150_5210_7d.pdf
- Federal Aviation Administration. (2009a). *Advisory circular 150/5200-12C: First responders' responsibility for protecting evidence at the scene of an aircraft accident/incident*. Retrieved from http://www.faa.gov/airports/resources/advisory_circulars/index.cfm/go/document.information/documentNumber/150_5200-12C
- Federal Aviation Administration. (2009b). *Advisory circular 150/5200-31C: Airport emergency plan*. Retrieved from https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/74488
- Federal Aviation Administration. (2009c). *Advisory circular 150/5210-19A: Driver's enhanced vision systems (DEVs)*. Retrieved from https://www.faa.gov/documentLibrary/media/advisory_circular/150-5210-19A/150_5210_19a.pdf
- Federal Aviation Administration. (2010). *Advisory circular 150/5210-23: ARFF vehicle and high reach extendable turret (HRET) operation, training and qualifications*. Retrieved from https://www.faa.gov/airports/resources/advisory_circulars/index.cfm/go/document.current/documentNumber/150_5210-23
- Federal Aviation Administration. (2011). *Advisory circular 150/5220-10E: Guide specification for aircraft rescue and firefighting vehicles*. Retrieved from https://www.faa.gov/documentLibrary/media/Advisory_Circular/150_5220_10e.pdf
- Guba, E. G. (1981). ERIC/ECTJ annual review paper: Criteria for assessing the trustworthiness of naturalistic inquiries. *Educational Communication & Technology Journal*, 29(2), 75-91.

- Kapucu, N., & Garayev, V. (2013). Designing, managing, and sustaining functionally collaborative emergency management networks. *The American Review of Public Administration*, 43(3), 312-330.
- International Civil Aviation Organization. (2014). *ICAO Doc 9137 AN/898: Airport services manual part 1* (4th ed.). Montreal, Canada: Author.
- International Fire Service Training Association. (2015). *Aircraft rescue and fire fighting* (6th ed.). Stillwater, OK: Author.
- National Fire Protection Association. (2013). *NFPA 402: Guide for aircraft rescue and fire-fighting operations*. Retrieved from <http://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=402>
- National Fire Protection Association. (2018). *NFPA 424: Guide for airport/community emergency planning*. Retrieved from <http://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=424>
- National incident management system*. (n.d.). Retrieved from <https://www.fema.gov/national-incident-management-system>
- Patton, M. Q. (2002). *Qualitative research & evaluation methods* (3rd ed). Thousand Oaks, CA: SAGE.
- Pollak, A. N. (2011). *Emergency care and transportation of the sick and injured*. Burlington, MA: Jones & Bartlett Learning.
- Simmons, V. N., Klasko, L. B., Fleming, K., Koskan, A. M., Jackson, N. T., Noel-Thomas S., Luque, J. S... Britt, L. (2015). Participatory evaluation of a community-academic partnership to inform capacity-building and sustainability. *Evaluation and Program Planning*, 52, 19-26.
- Stringer, L. C., Fleskens, L., Reed, M. S., de Vente, J. & Zengin, M. (2014). Participatory evaluation of monitoring and modeling of sustainable land management technologies in areas prone to land degradation. *Environmental Management*, 54(5), 1022-1042.
- U.S. Department of Homeland Security (2013). *Emergency preparedness resources for business*. Retrieved from <https://www.fema.gov/media-library/resources-documents/collections/357>

Zukoski, A., & Luluquisen, M. (2002). Participatory evaluation: What is it? Why do it? What are the challenges? *Partnership for the Public's Health*, (5), 1-6. Retrieved from http://depts.washington.edu/ccph/pdf_files/Evaluation.pdf g, IFSTA ARFF 6

Appendix



Figure 1. Suggested universal system of triage, treatment, and transportation for patients. Adapted from “Aircraft Rescue and Fire Fighting” by International Fire Service Training Association, 2015.

Table 1

Recommended Best Practice for ARFF Personnel Task Prioritization

Priority	Action	Comment
1	Upon activation of alert, mobilize response apparatus	Require trained ARFF personnel are available to safely and effectively drive and operate the required ARFF vehicle
2	The Airport Emergency Plan shall be activated to alert support and other responders depending on event magnitude as per the plan	To the extent practicable, responses routes to selected, high-risk locations are pre-determined to avoid obstacles and ground traffic in an efficient manner
3	Communications between responding apparatus, personnel and support units shall be instituted immediately and be assigned to the appropriate and discrete tactical or command frequency/talk-group as per the Airport's Emergency Plan	ARFF apparatus shall communicate their intentions for positions upon their arrival on-scene and advise other responding units of other significant hazards/responsibilities
4	Available resources shall be used to guide units to the emergency and within the hazard zones	Driver Enhanced Vision Systems that include both mapping and FLIR technology shall be utilized especially during night and low visibility as well as in events with anticipated large debris fields and evacuating passengers. If practical, spotters should be employed to guide apparatus through debris/victim congested approaches

- 5 An ICS shall be implemented by the first on scene, typically the highest ranking officer shall be assigned or shall assume this function upon arrival

ARFF personnel shall be available to perform incident command functions during an aircraft incident or accident. The Airport's Emergency Plan shall identify the individuals and/or rank structure of those persons assigned to be in Command positions in addition to how the Command System will evolve over time and circumstances. The Command System shall reflect the local capabilities with respect to local authorities including all airport resources and mutual aid partners.

- 6 Immediately establish Hazard Control Zones and simultaneously implement START triage

Utilizing a Hazardous Area inside 75ft (23m) from any surface of the aircraft for Hot/Warm/Cold zones.

- 7 Discharge extinguishing agent/create and maintain survivable corridors for self-evacuating passengers

Upon arrival, ARFF personnel shall assess evacuations in progress and potential evacuation corridors and be capable of discharging appropriate extinguishing agent at the required discharge rate from any vehicles. Once ARFF apparatus are initially positioned, any additional maneuvering of those apparatus may require an externally positioned spotter based on the urgency to reposition the ARFF vehicle.

- 8 Control fires and other hazards external to the aircraft and assist with self-evacuation

While maintaining a hazard watch to ensure a safe operating area, direct self-evacuating passengers to highly visible locations remote from the hazard and

vehicle movement areas surrounding the aircraft (hot zone).

- 9 Personnel shall place clearly unique markers at locations of all fatalities or non-ambulatory victims

A cache of markers of a type that is easily manipulated, readily identifiable and unique in appearance so as not to be confused with any other device shall be maintained on all apparatus. This marker must be conspicuous from a distance of at least forty feet and contrast with typical background conditions anticipated at an aircraft emergency. The type of marker shall be determined by the local authority and clearly described in the Airport's Emergency Plan.
- 10 Initiate access to aircraft cabin

Initiate access to aircraft cabin to facilitate rescue. ARFF personnel shall be capable of initiating access to the aircraft cabin, using forcible entry tools, ground ladders, aerial fire apparatus, Aircraft Interior Access Vehicle (AIAV) or mobile air-stair. ARFF personnel gaining access to the cabin shall be protected by ARFF vehicle turrets and/or hand-lines.
- 11 Begin interior aircraft rescue and firefighting

An interior ARFF team, consisting of not less than two ARFF personnel, shall be capable of entering the aircraft with a charged hand-line. The interior ARFF team shall be equipped with protective clothing and self-contained breathing apparatus. The interior ARFF team shall initiate rescue of trapped occupants

simultaneous with firefighting and ventilation.

- 12 Command will identify passenger treatment areas, ingress/egress routes for vehicles
- Command will establish triage, treatment, and transportation groups and assume accountability for all passengers/patients. Command will ensure a stable location and management of vehicle/personnel/resource staging, including ingress/egress for transport and support vehicles.
-