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Virtual-reality Simulation of Aircraft Accidents Challenges ARFF Incident Commanders

Wider adoption of this technology hinges on funding and further study of this method of developing aircraft rescue and fire fighting skills.

FSF Editorial Staff

In a 1998 study for the U.K. Civil Aviation Authority (CAA), researchers identified a need to improve training for airport fire officers in the skills of command and control, and to enhance the training facilities in which they develop these skills and practice incident command.[1] The effectiveness of virtual-reality simulators was evaluated as a method of enhancing the command-and-control elements in training incident commanders of aircraft rescue and fire fighting (ARFF) services at airports. From 1998 to 2002, advances in microprocessors and proprietary artificial-intelligence software have enabled manufacturers to increase the realism of virtual-reality simulators in civilian applications such as ARFF training.

The current generation of virtual-reality simulators is being used by U.K. training institutions at a time when authorities are beginning to implement unified standards of training for ARFF incident commanders and firefighters and assessing periodically their competence.[2] Several large U.S. fire departments also have adopted or are considering the technology, said several manufacturers and ARFF training specialists in the United Kingdom and the United States. Nevertheless, wider implementation has been slow because of other priorities for airport/ARFF funds and reluctance to supplement traditional training methods, they said.

The International Civil Aviation Organization (ICAO) *Airport Services Manual,* Part 1, "Rescue and Fire Fighting," Chapter 10, "Personnel," paragraph 10.2.1, says, "Personnel recruited for rescue and fire fighting services should be resolute, possess initiative, [be] competent to form an intelligent assessment of a fire situation and, above all, must be well trained and fully qualified. Ideally, every individual should be capable of sizing up changing circumstances at an aircraft accident and taking the necessary action without detailed supervision. Where the available staff displays limited capacity to use initiative, the deficiency must be made good by the provision of additional supervisory staff of a superior grade who will be responsible for exercising control of their crews. The officer responsible for the organization and training of the rescue and fire fighting service should be an experienced, qualified and competent leader. The capabilities of this officer should have been proved wherever practical by training at a recognized rescue and fire fighting service training establishment, and measures should be taken to ensure the officer's continuing proficiency."

U.K. Civil Aviation Publication (CAP) 699, "Standards for the Competence of Rescue and Firefighting Service (RFFS) Personnel Employed at United Kingdom Licensed Aerodromes," defines simulation as "any structured assessment exercise involving the organization and achievement of a specific task, which seeks to reproduce a real-life situation. Simulations are used where assessment is difficult to carry out (e.g., for safety reasons)."[3]

Fiona Harvey, market manager for VectorCommand, a U.K. manufacturer of virtual-reality simulators for training ARFF incident commanders, said that the company emphasizes the following points about using virtual-reality simulation for training and assessing fire service officers in strategic command and tactical command:[4]

- The initial conditions of an emergency and the resources available can be repeated precisely, enabling incident commanders to learn from the results of trying alternative actions to handle the same scenario;

- For purposes of assessing the application of knowledge and decision-making skills by several candidates for a promotion, assessments can be conducted on a level playing field with event/action logging and replay capabilities;

- The scenarios that can be generated are large in number and varied in content;

- Resources are only those available to the incident commander at his/her airport;

- Assessment parameters can be made to conform to standard operating procedures and training standards;

- Assessment results can be compared to required command skills so that additional training can be provided to incident commanders on specific skills; and,

- More firefighters may be able to pursue training as incident commanders, despite round-the-clock shifts, because access to simulators can be provided at any time, day or night.

"Our simulators are mainly used in a classroom environment to train teams of airport fire officers, sometimes from several agencies," Harvey said. "Simulation cannot replace live exercises and should be used as the theory part of theory-and-practice training. The simulation is projected onto a screen and can be paused as various tactics and techniques are discussed before decisions are made. All scenarios are role-mapped to the relevant U.K. standards. The simulator also can be used in a one-to-one setting for promotion assessment, where an assessor sits with the student to assess his/her skills."

Michael Philip Griffin, technical director of VectorCommand, said that key issues for ARFF personnel for effective rescue in a survivable aircraft accident are the type of training received, the effectiveness of equipment and the speed at which personnel and equipment can be put into use.[5]

"Most learning occurs when you make a mistake," Griffin said. "Recognizing this helps to build greater understanding of how to avoid such mistakes in the future. I would feel more comfortable about being rescued by firefighters who have made mistakes in a simulator that increased their depth of understanding than by firefighters who have no experience. Nevertheless, some ARFF professionals remain very suspicious of simulation and argue that this is just a computer game that cannot teach incident commanders how to fight real fires. I agree that the virtual-reality simulator cannot cover everything that an incident commander needs to know and that other training is required."

The time available to save lives can be very brief; if the incident commander were to watch the simulation run and do nothing, within five minutes there would be only a pile of ashes left, Griffin said. As minutes pass in a simulated scenario, the cabin floor can collapse, fire can spread anywhere, flashover can occur in the cabin, the aqueous film-forming foam (AFFF) blanket sprayed on the ground can decay, allowing fuel on the tarmac to burn, and fire can break into the fuselage, he said.

"Typically, the number of firefighters is so few in these situations that they cannot rescue all the virtual people right away; first, they must create an environment in which people can rescue themselves," he said. "Then, getting inside the aircraft is critical to generate a survivable atmosphere for any passengers and crew who were unable to evacuate. A scenario could involve 300 virtual people to 400 virtual people in a tight space evacuating out of eight exits with one incident commander managing 12 virtual firefighters to 15 virtual firefighters, equipment, extinguishing media and other resources.

"If incident commanders intervene correctly, they can suppress the simulated fires very quickly; if they intervene incorrectly, they are punished by the consequences as mercilessly as in real life. We have modeled one scenario to be similar to the Boeing 737 accident at Manchester Airport, but we are not recreating real air disasters.[6] In that accident, fire penetrated the fuselage within 90 seconds. Another of our scenarios is a straightforward cargo-hold fire in which the objective is to locate the fire, open the hold and extinguish the fire without increasing risk to passengers. This scenario might run for three minutes or four minutes. A scenario of mid-range length might last seven minutes, while a catastrophic scenario — such as a cartwheeled Boeing 747 — would run at least 25 minutes to extinguish the fire and could play out for several hours, if desired. Generally, we model the scenario only until the emergency is concluded in terms of fire fighting."

The company's scenarios are based on real airports, however, in part to set the length of time required to roll the trucks to the scene.

"Tactics practiced typically include the approach of equipment to the scene, lighting the scene, positioning of equipment relative to wind and escape slides, running hoses, isolating and cooling the fuselage and securing the scene against reignition," Griffin said. "Incident commanders will see casualties during evacuation and see some unsuccessful attempts to evacuate. In one scenario, there are 200 casualties wandering around, and the incident commander might be interrupted by a pilot or flight attendant, or accosted by an upset passenger. The simulator models some injuries occurring at the bottom of evacuation slides and injured people being moved to a triage point. This modeling of reality is based on factual data about comparable accidents, with the number of injuries and fatalities modified slightly."

The virtual-reality simulator uses artificial-intelligence software to model not only the look of airport surroundings but also the physical characteristics, behaviors and interdependencies of objects and processes such as crew tasks, types of media, rates of agent discharge and effects of media (extinguishing agent), including depletion of media (in which case, the incident commander might send a truck to another location to be restocked with water).

The incident commander watches and listens to all cues from the environment, including radio messages, and gives verbal instructions by radio to a facilitator outside his or her field of vision. In simulating radio communication, virtual firefighters might report what they have found, how far they have progressed, if they were able to place a ladder successfully, or what casualties they have found. One facilitator handles all aspects of the computer interface, and artificial intelligence provides feedback to each of the incident commander's instructions, Griffin said.[7]

Because of this use of a trained facilitator, the incident commander does not need to master a computer interface — which would not be present in a real incident.

"Incident commanders pretty much do what they would do in a real situation — make decisions and give instructions based on what they see and hear," he said. "When the incident commander receives the alarm call, vehicles typically begin to drive to the appropriate grid reference point on the airport. While vehicles are rolling toward the aircraft, however, the incident commander might give instructions such as, 'Crash Two, deploy full foam to the port nose; Crash Four to starboard nose to make entry; Crash Three to port tail and make entry or deploy hand lines."

An incident-command student being trained or assessed can select virtual-reality views, such as the view from the window of a large crash truck or from the windshield of a command car. The incident commander typically stands and visually simulates walking in any direction around the airplane while hearing simulated voices and radio calls.

"The biggest question for U.K. CAA was, 'What happens if a firefighter passes as competent in the simulator but has no experience in real life — how would we know that the person was competent?'" Griffin said. "My response was, 'Why is that a problem; considering how few firefighters have real experience with aircraft fires — what is real?' It took us about 12 months to convince CAA. My point to them was that the knowledge, structure and processes in using information and communication to respond correctly as an incident commander are more important than what the simulated crew does to the simulated airplane. Whether the incident commander believes that he is seeing the fire spread or the fire spread seems totally faked is not that important — the key is that the processes are not faked. We need to be realistic with images and sounds where it matters. Even dealing with an unreal situation forces the incident commander to think about the fundamentals of what to do and why — which can be superior to the past fire-brigade practice of teaching everything by rote memorization."

The quality of imagery in the current generation of virtual-reality simulators does matter to a degree, however, he said.

"Every incident commander must pick up on some subtle cues — cues that they would get in a real situation," he said. "For example, subtle discoloration of the paint is a cue to a cargo-hold problem. We are not out to set a trap for the incident commanders. We do not allow triggering of an unexpected/unrealistic event by the facilitator in this type of training; what occurs is driven only by artificial intelligence. As in real life, the incident commander has to make choices quickly and either will do well or will fail based on those choices. The types of errors that might require more practice after running a scenario include not using the correct radio frequency, failing to check the status of resources (such as injured firefighters or depleted media) and loss of situational awareness so that critical problems are not detected in a timely manner."

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Shabbir Merchant, president of the Simulation Division of Environmental Tectonics Corp. (ETC), a manufacturer with 11 years of experience developing virtual-reality simulators for ARFF incident-command training, said that his company has focused on a few of the world's ARFF services that have decided to be early users of this technology.[8]

"The United Kingdom was the first to recognize that ARFF incident commanders have been faced with challenges that they were not totally prepared to deal with," Merchant said. "We are seeing results elsewhere in the adoption of virtual-reality simulation by the ARFF community, but the results are slow. The biggest barrier is lack of public funding. I do not see airports resisting this technology at all.

"Simulation already is embedded in the military and in the airlines, but for ARFF first responders, infrastructure is not in place and logistics are not in place to adapt a simulator expeditiously into typical U.S. training programs. Adoption will take a lot longer, however, if the technology is not mandated. How to measure the return on investment in training also is a bit elusive. I contend that the ARFF community will be able to use simulation increasingly to identify and deal with previously unforeseen problems."

In the current generation of virtual-reality simulation, realism plays an important role in providing an effective training experience, he said. The company's virtual-reality simulator was added to the Serco International Fire Training Centre, Teesside Airport, England, in 2002 for training of ARFF incident commanders from more than 80 countries, he said.

"Realism psychologically immerses individuals in the simulation through visual cues and the total experience," Merchant said. "We have learned that we cannot provide a generic runway or a generic piece of ARFF equipment in a simulation — these must be representative of what the incident commander will use. Timing also has to be precise; for example, fire and smoke have to be representative of what is burning — fuel, a magnesium part on the undercarriage, or interior materials.

"To simulate hundreds of variables in real time, the challenges far exceed those of computer games. Artificial-intelligence simulation algorithms are essential in recreating anything that has to represent reality. The key challenge for us was creating an infrastructure in software that can represent interactions of objects. For example, if the wind direction changes, everything in the simulation is affected. If an explosion occurs, there is an adverse effect on the virtual environment. If people on the perimeter are injured, you want to see that in real time. The challenge is to do this without pre-programming those events; instead you must let the virtual reality scenario take its course — not programming events but programming complex interactions among model objects so that you can run the scenario a dozen times and get a dozen different outcomes."

The current generation of ETC technology has 80 or more aircraft and an air traffic control module, providing the capability for ARFF incident commanders to talk to virtual air traffic controllers and observe the effects of an emergency on air traffic as well as ground traffic.

"Among hundreds of real-time, independently controlled models and the infrastructure, we can handle as many as 100 different objects, such as aircraft being pushed back from gates, being taxied, and in the takeoff phase and landing phase — all interacting with an emergency occurring on one aircraft," he said. "The next step will be to replicate the inside of the terminal building — such as a cluster of five gates or 10 gates — so that 1,000 passengers can be evacuated onto the ramp during the emergency. Software development that used to require two years now requires one year, and by 2004, the cycle for exponential software advances may be six months. Nevertheless, everyone in this field has to go through a learning curve on graphics, microprocessors, networking, alpha channels and anti-aliasing [smoothing] of detailed graphics. Three factors have been crucial in this acceleration: the performance of the Intel Pentium 4 microprocessor, a more mature software-development tool set and maturity of our platform design."

Lt. Thomas Wagner, ARFF training officer at the Chicago (Illinois, U.S.) Fire Department, said that in spring 2003, the department is scheduled to begin using a virtual-reality simulator customized for the department's advanced incident-command training — including simulations to develop and practice skills of ARFF incident commanders — at Chicago O'Hare International Airport. The department spent several years determining its requirements, preparing bid specifications and working with the manufacturer after contracting for purchase of an Advanced Disaster Management Simulator–Virtual Reality (ADMS–VR) from ETC.[9]

"The idea of virtual-reality simulation is that the incident commanders will face the virtual accident in front of them under the stress and time pressure of unfolding events … .

"We have 42 firefighters on duty each shift, so we are very much the oddity, compared with more typical airports running with two or three ARFF trucks and four or five firefighters per shift," Wagner said. "I have been running a live-fire training facility providing hands-on experience with various vehicles and extinguishing agents. But only a few pieces of ARFF apparatus can be used at a time to extinguish propane fires using our airplane mockup at the live-fire training facility. It may be difficult, at first, for some people to see the practicality of using a virtual-reality simulator system, costing US$3 million to $4 million, to train firefighters on how to run an exercise. But with the 11 pieces of apparatus that we have, and many firefighters to command, there are many limitations and cost constraints in what we have been able to practice. By comparison, soon we will be able to practice limitless scenarios that show much more realistically — compared to the live-fire training facility — what firefighters will encounter on the airport."

The system has been designed to allow an ARFF incident commander to interact with large rear-projection screens and speakers that generate realistic sensations of operations at O'Hare by modeling, in real time, the sights and sounds of people, vehicles and aircraft moving in an environment of buildings, runways, taxiways, aprons, signs, markings, light conditions, radio communications and weather.

"Incident commanders using the virtual-reality simulator will pull up on the scene and experience the realism of being at O'Hare," Wagner said. "The idea of virtual-reality simulation is that the incident commanders will face the virtual accident in front of them under the stress and time pressure of unfolding events and will be able to tap all resources and put to work all equipment that we have at the airport to control this emergency.

"Many things that we want to practice cannot be duplicated at the live-fire training facility at the airport. With the live-fire simulator, we ignite a fire and then practice commands to delegate a specific number of companies to respond. We cannot put to work all our pieces of ARFF apparatus at the same time, however. In the virtual-reality simulator, we will be able to put as many as all of these vehicles into operation as required and see how our incident commanders and firefighters handle the accident and how effectively the selected agents extinguish the fire. The system also is built so that we can see if the incident commander can put to work effectively all of the required resources, based on the circumstances, location, terrain and weather. We can throw a difficult challenge at the incident commander under many combinations of conditions — including day, night, clear, cloudy, snow and fog — that affect the correct positioning of fire fighting apparatus. The incident commander then can move from any location to any other location within our airport boundaries."

Virtual-reality simulation also has the advantage of being extendable in various ways in the future, Wagner said. For example, rather than one incident commander using the system at a time, an extended system with many desktop screens could enable multiple participants to display on personal computer screens contemporaneous individual views of the environment — as if each person were looking through the windshield of a real piece of ARFF apparatus during an emergency.

Incident command has become a discipline applicable to ARFF regardless of the size of the incident.

"The incident commander will be able to direct all companies and participants, and each officer or driver will have to know how to drive to the scene, and position and use the apparatus," he said. "In such scenarios, the incident commander could be killed or incapacitated — requiring someone else to become the incident commander while the emergency continues to unfold at the simulated airport."

Ken Gilliam, senior fire fighting specialist at the U.S. Federal Aviation Administration (FAA), said that several companies are producing virtual-reality tools that could be useful for the command-and-control training of ARFF incident commanders in the United States. Gilliam also is FAA representative to ICAO on ARFF issues and a member of the ARFF technical committee of the National Fire Protection Association (NFPA).[10]

Incident command in the United States originated during the 1970s during wild land fires in California as a form of resource management, Gilliam said. Variations of incident-command systems have evolved in different parts of the country, and the subject is now taught throughout the world. Incident command has become a discipline applicable to ARFF regardless of the size of the incident, he said.

"Critically important to overall mitigation is to have a strong, well-equipped ARFF incident commander, because these individuals can make or break the scene in the early minutes of any aircraft accident or fire by actions that they take or fail to take," Gilliam said. "Certain steps that the incident commander looks at are concern for life, exposure, confinement and extinguishment. Proper size-up also will affect the application of the fire-extinguishing agent and the conservation of agent."

Protecting exposure refers to preventing a worse situation overall. The incident commander may choose to forego fighting the primary fire when there is risk of explosion or rapid fire spread.

"For example, if firefighters from a small fire department — knowing that mutual aid is five minutes to 25 minutes away — arrive at the scene of a massive aircraft fire and dump all their agent within one minute or two minutes when there are other exposures, they are out of business — game over," he said. "In this example, a properly trained incident commander would size up the situation, deal with imminent life-saving issues, allow evacuation of survivors and use the limited resources to protect exposures until mutual aid arrives. Another time, the incident commander might roll in and find no life endangered or exposure from fire."

Confinement refers to the ability of a well-disciplined fire crew to control a fire and/or extinguish a fire with very little water or other extinguishing agent by using both offensive strategies and defensive strategies, which can include commands to "hold off" further application of agent until more agent can brought to the scene.

"You should stop the fire where you find it and work it until the fire is extinguished," he said. "The inappropriate action would be to roll in and start shooting agent, for example, without considering what will occur if you do not have enough agent to finish the job."

Containment also is an important element in achieving the overall objective, he said. For example, an airport fire, involving a massive spill of 40,000 gallons (151,400 liters) of jet fuel and strong wind, probably could not be controlled with the type of agent — or extinguished with the quantity of agent — from the first ARFF apparatus to arrive at the scene, he said. The fire truck might be able to produce 1,500 gallons (5,678 liters) of AFFF when 6,000 gallons (22,700 liters) of AFFF are required to extinguish the fire. Nevertheless, with appropriate containment measures, the truck could be used first to clear a path to an aircraft door or structure door and to assist in rescuing people.

"No ARFF incident commander will pull up and do nothing, but there are many strategies in fighting airport fires," Gilliam said. "One school of thought says not to waste agent until the entire amount of agent required has arrived; another offers a different solution." If the opportunity to conduct rescue operations has ended, and the incident commander knows that he or she can contain the fire, then focus will shift to extinguishment, he said.

"Because of these steps, there has to be one person in charge; if you roll in multiple trucks and no one is in charge, personnel will not have the needed direction," he said. "They will not know where the greatest emphasis should be minute by minute."

FAA currently does not have requirements for training ARFF incident commanders or for use of this technology in U.S. Federal Aviation Regulations Part 139, "Certification and Operations: Land Airports Serving Certain Air Carriers."

Chief William Stewart, division chief of training, BWI Airport Fire Rescue Department, Baltimore/Washington International Airport, Maryland, U.S., and chairman of the ARFF Working Group, a U.S.-based association of the world's ARFF professionals, said that several issues seem to be slowing the adoption of virtual-reality simulators to train ARFF incident commanders in the United States.[11]

"I want our firefighters to have the opportunity to drive up to a real aircraft and flow agent … yet we never have the opportunity to shoot agent at a real airplane."

"To me, useful virtual-reality simulation technology is now available but is not affordable, given cuts in ARFF training budgets since Sept. 11, 2001 [when four aircraft were used in terrorist attacks in the United States and government funds subsequently were redirected to enhance security]," Stewart said. "Finding time for additional training is another practical problem, and introducing new training methods is difficult from the standpoint of working through normal personnel issues."

Stewart said that virtual-reality simulation primarily can help incident commanders to "think outside the box" in unusual situations and can bridge "a large gap" that he perceives between expectations and reality in the capabilities of incident commanders, firefighters, ARFF apparatus, extinguishing agents and related techniques.

"In historical terms, we have not been doing this very long, compared with hundreds of years of knowledge about structural fire fighting," he said. "Structural firefighters go on far more calls than ARFF officers and learn something new every time they go out on an emergency call. By comparison, ARFF officers assume that they have a maximum of 90 seconds to get to an aircraft on fire — the rule-of-thumb for time required for an exterior aircraft fire to penetrate an intact fuselage. So ARFF crews responding to many emergencies probably never have handled that type of emergency: They have one opportunity to do the job right for the people on the aircraft."

Many ARFF techniques taught 20 years ago were not backed by fire science or practical experience. For example, one obsolete edition of an ARFF manual shows that the philosophy was to cut three sides of a triangular opening in a fuselage and fold out the cut section so that people could escape, Stewart said.

"Drawings in the manual showed how to cut this opening, but I have seen videos of firefighters doing this, and even with current tools, we would be lucky to cut such a hole in less than an hour — that solution was not practical," he said. In the future, solutions to problems never experienced in reality might be discovered through scenarios played out using virtual-reality simulators.

"Things happen very rapidly on the scene of an emergency, but ARFF professionals in the United States are fairly slow in adopting new technology for training," he said. "A virtual-reality simulator forces incident commanders to formulate correct decisions under stress in a quicker manner — and their skills can be enhanced as long as incident commanders keep an open mind. They must remember that what they experience in real life may not happen exactly as presented in the simulator — they must be ready to react to the unexpected."

"Simple training tools from the past — such as having a detailed discussion among incident commanders and drivers of what each driver would do while looking at projected diagrams of many different scenarios — also have been effective," he said. "The important concept is that the incident commanders do not necessarily have time to make decisions for ARFF responders — incident commanders could be working off a different sheet of music [protocols], compared with ARFF drivers."

Although BWI does not have a virtual-reality simulator, Stewart said that he envisions increasing realism of current training methods in other ways. One idea to augment exercises at the BWI live-fire training facility involves obtaining the unserviceable fuselage of a medium-frame airplane such as a Boeing 727.

"I want our firefighters to have the opportunity to drive up to a real aircraft and flow agent through the roof turret and bumper turret," he said. "We are expected to do this, yet we never have the opportunity to shoot agent at a real airplane."

Neither live-fire training facilities with mock aircraft nor virtual-reality simulators provide the full-scale perceptions and the preview of practical problems that will be encountered in working around and inside a real aircraft, he said.

"Every time I watch television programs showing deserts in Nevada [U.S.] crammed with unused aircraft — the images make me crazy because I believe that airports should be able to do apparatus set-ups and shoot agent at real airplanes," said Stewart. "Firefighters need to see from how far away the turret is effective — what happens at a distance of 180 feet [55 meters] in wind and bad weather — scenarios that we could be experiencing rather than discussing at a chalk board. Our firefighters could run hose lines and crawl into the fuselage over the wings to practice rapid-ventilation techniques with theatrical smoke, for example. My specialty as an incident commander and trainer is aircraft familiarization for firefighters. In my experience, virtual-reality simulators have a purpose. But until firefighters actually practice some skills in the physical world, they will not see the difference in learning from talking vs. learning from doing."

Virtual-reality simulators complement live-fire training facilities, which increasingly have computer-controlled scenarios and sensors that enable firefighters and incident commanders to practice fire fighting techniques and handling hose lines.

"There is a learning curve between training with propane fires that generate very little smoke in the live-fire training facility vs. training that shows the highly unpredictable characteristics of burning fossil fuels, such as Jet A aircraft fuel, which we use at BWI," Stewart said. "With propane, only because of the facility's sensors do firefighters know that they have used enough water for the fire zones to be extinguished. Compared with simulators, fossil-fuel fires really get the firefighter's blood pumping."

Craig Williams, director, airport safety and security, American Association of Airport Executives (AAAE), said, "I have seen the virtual-reality simulators and find them interesting, but from my conversations with other airport firefighters, I could summarize — and agree with — most of those who call these simulators 'rigid' or 'a fun game.' That is not to say that they are useless, but until the price comes down, I do not foresee any widespread use."[12]

ARFF personnel from airports of varying sizes participate in the AAAE ARFF Certification Program, which uses conventional techniques, such as tabletop exercises to enhance decision-making skills, and covers common ARFF scenarios, as well as rare scenarios, Williams said.

"Typically, ARFF crews are trained primarily to respond to a major aircraft accident when, in reality, the majority of their responses are to anything but a major accident," he said. "Our training classes try to focus on providing the students with a mix of scenarios — for example, an Alert II incident with smoke in the cockpit. The best exercises allow students to share and discuss ideas not only with the moderator but also with the other students in the class. We have utilized tabletop exercises with good results in these classes, and we have been ahead of the curve in putting together realistic scenarios for incidents, including simulation of a terrorist incident involving weapons of mass destruction before this type of scenario became popular among trainers after aircraft-related terrorist attacks in the United States on Sept. 11, 2001. In my opinion, a tabletop exercise is only as good as the person moderating the session, however."

Assessment of the real-world performance and challenges of ARFF incident commanders has been difficult using traditional methods. Some proponents of virtual-reality simulators for training ARFF incident commanders believe that as experience with this technology accumulates, there will be opportunities to conduct research and gain insights about incident command that previously have not been possible.♦

Notes

1. Brown, Bernard; Brunskill, Ray. "Use of Virtual Reality Simulation Techniques for Training Airport Fire Officers." U.K. Civil Aviation Authority (CAA) Paper no. 98006. August 1998. The study was conducted by the CAA's International Training Centre at Teesside, England, and the University of Teesside Virtual Reality Centre.

2. U.K. CAA. "Standards for the Competence of Rescue and Firefighting Service (RFFS) Personnel Employed at United Kingdom Licensed Aerodromes." Civil Aviation Publication (CAP) 699.

3. U.K. CAA. CAP 699.

4. Harvey, Fiona. E-mail communication with Rosenkrans, Wayne. Alexandria, Virginia, U.S. Nov. 18, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

5. Griffin, Michael Philip. Telephone interview by Rosenkrans, Wayne. Alexandria, Virginia, U.S. Nov. 19, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

6. On Aug. 22, 1985, about 0612 local time in Manchester, England, the left engine of a British Airtours Boeing 737 exploded while the airplane was accelerating on the runway, and the takeoff was rejected. The explosive engine failure had caused a rupture in the wing's fuel tank and a fire had erupted when the fuel reached the hot engine. The aircraft was turned off the runway and stopped. Fuel pooled and burned, intensified by a light wind, beneath the rear of the aircraft. Fifty-five of the 137 occupants of the aircraft were killed.

7. Kirkpatrick, Terry; Godley, Stuart; Ivancic, Karolina; Neal, Andrew; Hesketh, Beryl. "An Evaluation of the VectorCommand Simulation." July 2000. The research project involved collaboration by New South Wales Fire Brigades and the Australian Research Council Key

Centre for Human Factors and Applied Cognitive Psychology at the University of Queensland, Australia, and the University of Sydney, Australia. The Australian Fire Authorities Council and the United Firefighters Union formed with six fire fighting authorities throughout Australia the VectorCommand User Reference Group in May 2000. The group conducted a trial evaluation of VectorCommand simulations involving strategy, tactics and tasks for extinguishing fires in residential-fire scenarios, highrise-building-fire scenarios and industrial-fire scenarios by 83 firefighters and fire officers. The participants observed one demonstration session, participated in two simulation sessions and completed questionnaires. The report said, among its results, conclusions and recommendations: "One assumption underpinning the VectorCommand system is that the principles of command are universal and can be applied successfully, irrespective of the type of incident or fire scenario. … [Participants] rated the VectorCommand scenarios as satisfactory in terms of their realism, requiring similar decision-making processes to those used by incident commanders on the fireground. … Correlations indicated that the more fire fighting experience, and the more years of command experience, the higher the rating achieved for incident-command skills. … A further evaluation should be conducted to assess [the] transfer of training from the VectorCommand simulation to tabletop scenarios, drill situations and performance on the fireground. … Given the complexity of the VectorCommand system, an issue that needs to be addressed is whether the simulation always needs a facilitator to run the scenarios to gain the maximum instructional potential. If the system were to be widely used among the fire services, always using a facilitator may be impractical."

8. Merchant, Shabbir. Interview by Rosenkrans, Wayne. Alexandria, Virginia, U.S. Nov. 19, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

9. Wagner, Thomas. Telephone interview by Rosenkrans, Wayne. Alexandria, Virginia, U.S. Nov. 26, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

10. Gilliam, Ken. Telephone interview by Rosenkrans, Wayne. Alexandria, Virginia, U.S. Nov. 21, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

11. Stewart, William. Telephone interview by Rosenkrans, Wayne. Alexandria, Virginia, U.S. Nov. 20, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

12. Williams, Craig. E-mail communication with Rosenkrans, Wayne. Alexandria, Virginia, U.S. Dec. 3, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

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