Improving airport screener training and evaluation through the use of simulation

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Abstract
The tragic events of September 11, 2002, have brought the security of our nation’s airports to the forefront of current research. The purpose of our research was to integrate the field of modeling and simulation with that of psychology to explore the ways in which airport security training and evaluation could be improved. We chose to focus our research on airport baggage screener training and evaluation. The purpose of our paper is fourfold. First, we discuss the necessary elements of a successful training program. Next, we describe the key human system characteristics (i.e., vigilance, pattern recognition, and decision making) that should be addressed when training and evaluating airport baggage screeners. Third, we examine five types of simulation (i.e., live, embedded, virtual, constructive, and discrete event) and suggest how each type can be utilized to train and evaluate performance of airport baggage screeners. Finally, we discuss the areas of airport security in need of future research.

Introduction
The tragic events that occurred on September 11, 2001, have brought many security issues of our nation’s airports to the forefront of research—specifically, the role that airport passenger and baggage screeners play. It is known that airports are complex, dynamic environments that are filled with ambiguity and uncertainty. These conditions, therefore, place great demands on airport screeners. For this reason, it is imperative that screeners remain vigilant and flexible best be prepared for a multitude of situations.

The development of the Transportation Security Administration (TSA) has led to new laws and procedures to better manage security issues (e.g., passenger and baggage screening) at our nation’s airports. The current focus of TSA is to federalize airport passenger and baggage screeners at commercially serviced airports, considered one of the largest and most complex security issues that will be faced (TSA, 2002b). TSA oversees 429 airports at which 30000 screeners are to be trained and deployed by November 19, 2002 (TSA, 2002a; 2002b).

In a study conducted in 1987 (GAO, 2000), and more recently in 2002 (Morrison, 2002), the results indicated that approximately 80% of hidden weapons are detected by airport baggage screeners—great news! However, the results could be better. While the misidentification of weapons have been blamed on a lack of motivation, inattentiveness, and inappropriate employment histories (Harris, 2002), the newly developed TSA hopes to minimize these concerns through improved training, benefits, and more stringent background checks. For example, training of airport passenger and baggage screeners will increase from 12 hours of classroom training to 40 hours, as well as 60 hours of on-the-job training (TSA, 2002a).

Therefore, we sought to integrate the research conducted in the fields of simulation and psychology to propose ways to improve the training and evaluation of airport baggage screeners. The purpose of our paper is threefold. First, we discuss the necessary elements of a successful training program. Next, we discuss how simulation is used for training and evaluation. Finally, we examine five types of simulation (i.e., live, embedded, virtual, constructive, and discrete event) and suggest how each type can be utilized to train and evaluate performance of airport baggage screeners.

Training Overview
We will briefly describe four main steps in designing and developing a training program: training needs analysis, instructional design development, training implementation, and training evaluation.

Training needs analysis
The first of four steps in developing a successful training program is to analyze the training needs. The purpose of a
Training needs analysis is to determine where training is needed within the organization, what needs to be trained, and who needs to be trained. To determine this, three separate analyses should be conducted—(a) organizational analysis, (b) job/task analysis, and (c) person analysis. The purpose of an organizational analysis is to determine those components of the organization that may impact the implementation of a training program (e.g., resources, organizational support) (Tannenbaum and Yukl, 1992). In addition, this analysis will determine if the organization is prepared for the training (Salas and Cannon-Bowers, 2000b). A second analysis that should be conducted is a job/task analysis. This analysis examines specific functions of the job/task to be trained, conditions for performing the job/task, and the competencies required to perform the job/task (Salas and Cannon-Bowers, 2001). A cognitive task analysis is included in this analysis, which seeks to determine the underlying cognitive processes involved in performing the job/task. Finally, a person analysis should be conducted to identify which individuals in the organization need to be trained and the training that they need (Tannenbaum and Yukl). For additional information, see Salas and Cannon-Bowers (2000b; 2001) and Tannenbaum and Yukl (1992).

Instructional design and development

Once the training needs analysis phase is completed, emphasis should be placed on designing and developing the training instruction. This phase has been described as the design and development of “instructional content, objectives, materials, and curricula and preparing all the resources needed for delivering training” (Salas and Cannon-Bowers, 2000b, p. 48). These researchers argue that in order for training to be effective, trainees must learn the competencies being trained (i.e., knowledges, skills, and abilities; KSAs) and transfer them to the actual job environment. To accomplish this, training must do four things: (a) present information to the trainees, (b) present both positive and negative examples of performance, (c) allow trainees to practice the trained competencies, and (d) provide feedback on their performance (Salas and Cannon-Bowers). Additionally, reliance on the theory behind training can help to make training more effective.

A final step in this phase is to select an appropriate instructional strategy for the training program. There are many different methods for delivering training (e.g., simulation, lecture, video). As the focus of this paper is on simulation, we will discuss this method only. For additional information on different methods, see Salas and Cannon-Bowers (2000a; 2000b; 2001). Simulation-based training methods have been used in a variety of domains (e.g., military, aviation, education) (Jacobs and Dempsey, 1993). Research suggests that the use of simulations as a part of training increases the likelihood that skills taught will transfer to the actual environment (e.g., Jentsch and Bowers, 1998) as simulations provide a realistic way to present material to trainees. In addition, simulations provide trainees with an opportunity to practice the competencies taught during training in a relatively safe environment, where errors are encouraged to promote learning, and feedback is provided on one’s performance.

Competencies to consider. There are many long-standing problems with maintaining good performance of airport baggage screeners due to the monotony of the task and distractions within the environment. Therefore, we will briefly discuss three competencies that should be considered when training airport baggage screeners—vigilance, pattern recognition, and decision-making.

Vigilance. Vigilance tasks can be defined as those requiring an individual to monitor and detect signals that are unpredictable, intermittent, and infrequent for extended periods of time (Wickens, 1992). This type of task characterizes the tasks required of airport baggage screeners. As far back as World War II, research has shown that performance decrements (i.e., vigilance decrements) occur within 30 minutes of starting a vigilance task (e.g., Mackworth, 1948; Parasuraman, 1986). Therefore, screeners should be trained to recognize when they are experiencing vigilance decrements, what actions to take when vigilance decrements occur, as well as techniques for monitoring one another’s performance to determine vigilance decrements.

Pattern recognition. The tasks conducted by airport screeners require that they recognize cues in a rapid manner (Fiore, Jentsch, Oser, and Cannon-Bowers, 2000). In addition, the screeners must then interpret the meaning of the cues, as well as determine the importance of these cues. These pattern recognition tasks require both perceptual (i.e., that which facilitates cue recognition) and conceptual (i.e., that which facilitates integration of recognized cues) knowledge of the screener. Both types of knowledge are gained through exposure to the cues (i.e., experience). Training and practice can help to build this experience. Research examining pattern recognition suggests that as experience is gained, individuals store perceptual templates of various situations (e.g., various weapons) (see Richman, Staszewski, and Simon, 1995). These templates are relied upon to make decisions in a quick manner (see Klein, 1997).

Decision making. Finally, as cues are recognized and interpreted in an environment, decisions must be made about them. In the airport security domain, screeners must determine whether a detected cue (or signal) is a threat. It has been argued in the past that vigilant decision making is ideal in that all alternatives are weighed before a final decision is made (Janis, 1982). However, based on
First, training evaluation should be conducted to determine if the training met its objectives—did trainees learn what they were expected to learn? 

Second, training evaluation allows decision makers to make informed decisions about key organizational changes before implementation (Arsham).

The final issue to consider during the training evaluation phase is which method to use. It has been argued that training evaluation should be conducted at multiple levels (see Alliger and Januck, 1989; Kirkpatrick, 1976; and Kraiger, Ford, and Salas, 1993). There are four levels at which the cited researchers argue that training should be evaluated at: (a) reactions, (b) learning, (c) behaviors, and (d) results. Without examining a training program at multiple levels, its true effectiveness cannot be determined. Unfortunately, many programs are evaluated only at the lower levels of evaluation (e.g., reactions) as reactions are very easy to measure using a questionnaire. However, determining trainees’ reactions to the training program (whether or not they liked the training) in and of itself does not determine a training program’s effectiveness. To truly determine the program’s effectiveness (in addition to their reactions), evaluators must determine whether the trainees learned the trained competencies (i.e., learning), whether the trainees exhibit the trained behaviors in practice or on the job (i.e., behaviors), and the impact that the training had on the organization itself (i.e., results).

The guidelines provided above are based on many years of research and the development of a science of training (see Salas and Cannon-Bowers, 2001b). Therefore, we recommend that organizations developing a training program, such as TSA for airport screeners, should look to the literature and follow these guidelines as it can make the difference between a successful or unsuccessful program.

Training Implementation

The third phase is training implementation. When implementing training, several things must be considered (see Salas and Cannon-Bowers, 2000b). First, the training environment must be set up to ensure the comfort of the trainees. This can range from appropriate lighting conditions to necessary resources. In addition, preparation should also be provide to trainers so that they can adequately provide training. Second, a learning climate must be established that encourages trainee participation and is supportive of the training. One way to encourage this is through the implementation of technology (e.g., simulators, games). Finally, the organizational environment must be prepared to encourage the transfer of the learned competencies to the job. Research suggests that there are several important factors that encourage the transfer of training including supervisor support and organizational commitment (Rouiller and Goldstein, 1993; Tracy, Tannenbaum, and Kavanagh, 1995).

Training Evaluation

The final phase of any training program development is to evaluate the program to determine its effectiveness. There are two main reasons for conducting training evaluation. First, training evaluation should be conducted to determine if the training met its objectives—did trainees learn what they were expected to learn? Second, training evaluation can determine the impact that the training had on the organization as a whole. Many organizations establish new programs, build new facilities, and approve training methods without measuring statistically the increase or decrease of efficiency or effectiveness. Organizations can save time, physical resources and money by conducting a detailed evaluation of a small sample of the population affected by the proposed change or by conducting various scaled simulations based on accurate input data. When simulation “what if ” scenarios are created and evaluated, organizations can measure the estimated significance of potentially costly changes to programs and processes. The evaluation allows decision makers to make informed decisions about key organizational changes before implementation (Arsham).

Simulation for Training and Evaluation

Instructional Strategy

Simulation-based training is being used extensively in the military and aviation communities. Research suggests that use of simulation in training has led to improved performance (Jentsch and Bowers, 1998), although the data is somewhat incomplete in that only reaction-level evaluation data has been collected (Salas and Cannon-Bowers, 2001). The types of simulations used range in terms of fidelity, cost, and functionality. However, high fidelity, high cost, and high functionality does not necessarily lead to better transfer of training to the actual job. In fact, PC-based simulations are being implemented and results suggest that complex skills can be transferred to the actual job environment using these low fidelity trainers (Gopher, Weil, and Bareket, 1994).
Simulation and Airport Security

Embedded Simulation

Embedded Simulation can be defined as “the ability to train a task using the operational system” (Green, 2002). Prior to 1997, classroom training was the only Federal Aviation Administration (FAA) approved program for checkpoint screeners (Klock and Rubinstein, 2001). In April 1997, the FAA approved three computer-based training (CBT) programs (Klock and Rubinstein). Based on this research, the incorporation of CBT with classroom instruction has proven successful. Therefore, embedded simulation is a technology and a tool that should be used to facilitate training objectives.

There are several reasons for choosing embedded simulation as a tool for training and evaluation. First, and foremost, is that the trainee can train in the same place and with the same equipment upon which the work will be performed. While similar to on-the-job training, embedded simulation can be targeted toward specific training objectives. Second, employees may use downtime for training. Since the equipment is at hand, training may occur at any point during the work schedule. Third, high costs associated with travel and maintaining dedicated training centers are reduced. Travel costs are reduced because the bulk of the training is performed at the work site. Embedded simulation does not obviate the need for the dedicated training center, but it does reduce the need. Fourth, personnel busy performing critical tasks are unable to take time for training. Finally, embedded simulation facilitates training on an as needed basis.

How can embedded simulation help training and evaluation of airport security? Embedded simulation can be a powerful tool in training airport security personnel. Most manufacturers of current baggage screening equipment offer systems for embedded training. For example, it is possible for systems to embed dangerous objects into images that screeners must evaluate and react to. Embedded simulation can be used in two situations. First, embedded simulation can be used during training to help screeners build experience reacting to dangerous objects in passengers’ baggage. Second, embedded simulation can be used as a form of on the job training. Dangerous objects can be overlaid randomly on passengers’ baggage helping screeners to maintain their vigilance during their shift. While the establishment of embedded simulation as a training and evaluation tool in airport systems may be costly at first, the associated benefits of improved job performance, reduced overall training costs, and ultimately enhanced security make the benefits far outweigh the costs.

Live Simulation

The Department of Defense (DoD) Modeling and Simulation (MandS) Glossary (1998) defines live simulations as “simulations involving real people operating real systems”. These simulations provide trainees with the opportunity to use organizational equipment in realistic environmental conditions (e.g., simulating combat) to train with other people (or against others in the military) without computer interaction. Live simulations provide realistic tasks that require trainees to perform the tasks in a realistic manner.

The military, specifically the Army, is one of the largest advocates of live simulations for training purposes. The Army conducts many large-scale live simulations at several major training centers (e.g., National Training Center) using brigade combat teams where soldiers and equipment can be outfitted with instrumentation devices that track location, time of event, impact, and other important information. These devices record and transmit information that is organized and saved. In addition, training support personnel provide services that facilitate the live simulation experience. Performance is collected and evaluated for interaction and interoperability. The most popular system used in conjunction with military live simulations is the Multiple Integrated Laser Engagement System 2000 (MILES, n.d.).

A similar system has been developed to record performance during live simulations using civilian emergency response teams. The system is called the MIND system and it uses digital photos to capture events during a live simulation (see Morin, Jenvald, and Worm, 1998a; 1998b). In addition, vehicles are equipped with global positioning systems (GPS) that allow their movements and position to be tracked. Actions of trainees are observed and performance is recorded. Observer controllers use time stamps on the photos as references for presentation during the after action review (AAR). Regardless of the system used to collect performance data, it should be packaged and presented to the training audience during an AAR. Live simulations are most effective when they are the culminating event of a training program. A well-executed live simulation coupled with a
properly orchestrated AAR, can serve to validate an organization’s tactics techniques and procedures.

Live simulation is a tool of choice for training. As live simulation has been an invaluable training tool for the military, the airport security domain could benefit from the lessons learned from the military. In fact, airport security has already begun to use live simulations for training at the International Aviation Training Center (IATC). IATC is a one-of-a-kind center in Michigan that provides both aviation and airport security training (Cavalry Security Gear and Systems, 2002). IATC provides training programs for issues from passenger screening to aircraft hijackings. Training can be conducted at IATC or can be conducted at an off-site location (e.g., a specific airport). Finally, IATC is providing training to law enforcement officers at the state and federal levels, airports and airline personnel, and even non-US governments.

How can live simulations help training and evaluation of airport security? The main benefit to using live simulations as a training tool in airport security training and evaluation is its realism. Airport security personnel are able to practice the competencies learned during training in a safe learning environment. Live simulations can be used to simulate a multitude of situations. For example, live simulations can allow airport personnel to react to a threatening situation such as an explosive detected in a passenger’s baggage. Airport evacuation procedures could also be practiced using live simulation as a training tool. In addition to being a useful training tool, performance during live simulations can be evaluated to determine the effectiveness of the training program. Based on the evaluation, areas in need of improvement can be incorporated into future training programs. Finally, the information obtained can then be incorporated into the after action review. Given the proper instrumentation, live simulations provide the best data for use in documented after-action review. The lessons learned during the live simulation and after-action review can lead to improved airport security.

Constructive and Virtual Simulations
In addition to live and embedded simulations, constructive and virtual simulations may also benefit airport security training and evaluation. Constructive simulation defines constructive simulation as involving “simulated people operating simulated systems” (DMSO, 1998). People make inputs to constructive simulations, but they do not actually determine the outcomes—simulated people do. On the other hand, virtual simulation is defined as “real people operating simulated systems” (DMSO). Virtual simulations are a human-in-the-loop system in which humans play a central role. This is done by exercising motor control skills (e.g., operating a tank), decision-making skills (e.g., cue detection), or communication skills (e.g., acting as a member of a team)” (DMSO). While constructive and virtual simulations are categorized as separate, there are no clear boundaries demarking their implementation and often simulations include aspects of both.

Virtual and constructive simulation techniques are currently being used to support training and evaluation of cognitive skills, human performance, and team performance, all of which can be generalized to the airport security domain. Investigators have used distributed virtual simulation to reproduce decision-making environments for training and evaluation of aircrews (Mauro and Barhsi, 2000). Additionally, models of human performance are being used as predictors of system performance and to identify performance shortfalls in the human-machine interface (Corker, 1999; Dahn, and Laughery, 1997). Simulation is also used to support the entire life cycle of weapons systems, operational policy, systems training, and mission rehearsal for the military (Hughes, 1990; Macedonia, 2002; Middleton, and O’Keefe, 1993). These systems make it possible to model very complex situations that are dependent on the interactions between individuals, like those encountered in the airport security domain.

How can constructive and virtual simulations be used in airport security training? Constructive simulation applies directly to the training of airport screeners. Mauro and Barhsi (2000) describe a simulation in which aircrews were trained and evaluated using the Internet as a distribution system. Simulations similar to those described by Mauro and Barhsi could be developed in which screeners could be partially trained and evaluated via the Internet. This type of simulation has the advantage over other simulations (e.g., live simulations) in that the environment is not subjected to public influences. Given that embedded simulation also occurs using equipment found on site, the purposes and training facilitated by the embedded simulation training program could also be extended to the Internet, increasing the amount of time screeners could use the training system and the number of screeners that could be trained concurrently. This Internet-based scenario also lends itself well to a centralized curriculum.

Applications of virtual simulations include rehearsal and incident response training (Molineau, Gorzerino, and Papin, 1997). Advantages of virtual simulations are most appealing when situations require different configurations of elements within a training environment. Changing the virtual simulation can be relatively quick and results from unlimited new situations can be tested. Constructive simulation techniques could also be used to increase the realism of these simulations by the provision of computer generated forces to dynamically respond and by decreasing
the predictability of the simulators responses. Although the development costs are higher, these simulators offer the benefit of reduced costs over live simulation in that they are repeatable with no additional costs. Computer-based simulators can be run 24 hours a day and in tandem to more efficiently train a large force, such as the one the TSA is tasked with training.

**Discrete event simulation**

A discrete simulation can be defined as one in which there is a finite number of events and only at discrete points in time do the variables change (Banks and Carson, 1984; Pollatschek, n.d.). This method of simulation is used to model real world systems able to be decomposed into a set of logically separate processes. It has been used to conduct evaluations on hospital emergency room staffing, to confirm the correlation of events in manufacturing processes, and to model CO2 absorption reactions in underwater breathing apparatus (Clarke, 2001; Kumar and Kapur, 1989; Miyamato and Hayashi, 1996). Discrete event simulation is clearly compatible with a diverse list of applications.

**How can discrete event simulations be used in airport security training?**

Discrete event simulation can be used as an evaluation tool capable of measuring the efficiency and effectiveness of airport baggage training. In the case of discrete event simulation, various software packages allow the evaluation of a single alternative or the comparison of two or more alternatives using proven statistical methods. Although it is unlikely that Arena 5 (discrete event simulation software) could be used to train airport security personnel, it does have characteristics which allow it to be used as an evaluation tool for training effectiveness and efficiency for airport security personnel.

**Conclusion**

Based on our review of the literature, use of simulations as tools in airport screener training and evaluation would be invaluable. The most important thing to remember when developing a training program is to utilize the science of training. Extensive research has been conducted to determine guidelines for designing and developing an effective training program. The key is to adapt these guidelines to a particular organization. Once the training program has been developed, we encourage organizations to utilize simulations to help train the competencies learned during training. The events developed for the simulations should be based on the training objectives previously established. As trainees perform in the simulation of choice, performance must be observed and recorded. This information will be an integral part of a debriefing (e.g., AAR) following the training where trainees can receive feedback on their performance as well as tips for improvement. Finally, the training needs to be evaluated. Simulation tools may also be helpful for determining if the learned competencies are being applied in practice in addition to its impact on the organization as a whole. As a last point, we encourage organizations to take advantage of the benefits of the types of simulations discussed in this paper. We believe that the combination of several techniques will further improve the benefits of the simulations, improve trainees’ performance, and improve overall organizational effectiveness.

**References**


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