
**DESIGN, DEVELOPMENT, AND INNOVATION OF AN
INTERACTIVE MULTIMEDIA TRAINING SIMULATOR
FOR RESPONDING TO AIR TRANSPORTATION
BOMB THREATS**

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ABSTRACT

This paper describes an interactive multimedia simulator for air transportation bomb threat training. The objective of this project is to improve the air transportation sector's capability to respond to bomb threats received by commercial airports and aircraft. The simulator provides realistic training on receiving and responding to a variety of bomb threats that might not otherwise be possible due to time, cost, or operational constraints. Validation analysis indicates that the use of the simulator resulted in statistically significant increases in individual ability to respond to these types of bomb threats.

INTRODUCTION

The vulnerability of air transportation facilities and aircraft in flight has recently been underscored by the September 11, 2001, terrorist attacks. While the impact of this tragedy focused attention on hijacking type of attacks, there are actually a number of categories of aviation terrorism. These include hijackings; bomb threats, attempted bombings and bombings; shooting at aircraft in flight; and attacks on airports. This paper describes a research

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effort to improve the nation's ability to respond to bomb threats directed towards airports and aircraft in flight.

When a bomb threat is directed towards an air transportation facility or an aircraft in flight, even organizations with bomb threat response training may fail to respond effectively due to a lack of familiarity or practice. One reason for this is that proper bomb threat response exercises must include notification and coordination procedures, a bomb search, and evacuation and reentry of the area (BATF, 1987; Brodie, 1979; McCarthy & Quigley, 1992; Reilly, 1989). When conducted in an actual environment, these activities can constitute significant losses of operational time for the airline or airport involved in the exercise. As a result, it is simply unrealistic to expect many air transportation organizations to practice bomb threat response exercises enough to become sufficiently proficient. On the other hand, any air transportation organization which does not have comprehensive bomb threat response training nor conducts regular exercises is subject to more severe casualties, property damage, and loss of operational time in an actual bombing. Thus, the problem is how to develop a bomb threat response capability that reduces the severity of casualties, property damage, and loss of organizational productivity in the event of an actual bombing without at the same time losing additional operational time due to bomb threat response training.

RELEVANT LITERATURE

A literature search was conducted to identify efforts with direct relevance to this effort. The search yielded three major categories of relevant past efforts. The first category includes a large number of efforts involving the simulation analysis of airport operations. Representative efforts include terminal operations, departure gate assignment, ticketing counters, and passenger loading (Chung & Gopalakrishnan, 2003; Chung & Sodeinde, 2000; Gu & Chung, 1999; Setti & Hutchinson, 1994; Van Landeghem & Beuselinck, 2002). While all of these types of research efforts utilize simulation technology, they do not directly address any aspects of responding to bomb threats directed at either air transportation facilities or in flight commercial aircraft.

The second category includes a variety of simulation related research efforts directed at improving emergency response efforts. These include CriSys management training software system (Sullivan, 1992), an emergency evacuation simulation model (Weinroth, 1989) and a group of virtual reality simulators involving military ordnance, nuclear weapons, and improvised explosive devices (Kiernan, 1994; Regan, 1995; O'Brien, personnel communication, June 11, 1997; Ryan-Jones, 1995; 1997). The CriSys software focuses on post-incident simulator management training of

crisis teams on chemical plant explosions and other disasters. The evacuation simulation model involves the simulation analysis of emergency evacuation routes in large buildings. The virtual reality simulators consist of simulator training programs for rendering safe ordnance by bomb disposal technicians. While these research efforts all involve the use of simulator training for emergency response, none focus directly on improving bomb threat response.

The third category of relevant research efforts includes a series of interactive training simulators directed at improving an organization's ability to respond to bomb threats. These include bomb threat training simulators for offices (Chung & Huda, 1999), medical clinics (Chung, 2000) and land transportation facilities (Chung & Panjra, 2001). The literature search yielded a number of interactive training simulators associated with emergency response procedures. However, none of these simulators addressed the special issues associated with air transportation facilities or aircraft in flight.

PROBLEM STATEMENT

Bomb threats and bombs on aircraft in flight represent a significant issue to the safe and effective operation of commercial air transportation operations. Despite the high consequences of failure in responding to these types of situations; training costs and scheduling, as well as operational limitations remain a significant challenge. To help improve the commercial air transportation sector's ability to respond to bomb threats and bombs on aircraft in flight, this research effort designed, developed, and validated an interactive multimedia Air Transportation Bomb Threat Training Simulator. This simulator provides commercial air carriers with the opportunity to obtain realistic training on receiving and responding to a variety of bomb threats that might not otherwise be possible due to time, cost, or operational constraints.

METHOD

This section addresses the methodology used in the design, development, and validation of the Air Transportation Bomb Threat Training Simulator. The Participants section describes the different categories of individuals that participated in different phases of the research effort. The Materials section describes the design and development of the training simulator. The Procedure section describes the methodology used to assess the training validity of the simulator.

Participants

Two distinct types of participants were utilized in the research effort. The first type was used to assess the face validity of the training simulator. This population consisted of several U.S. government-trained bomb disposal officers. By virtue of their training and professional experience, these individuals were considered to be knowledgeable on the subject of bomb threats. Their involvement consisted of ensuring that the training simulator appeared to represent reality sufficiently for training purposes. The second type of participant was the test population. These participants were used to determine the training validity of the simulator. These individuals consisted of a group of engineering graduate students at the University of Houston. This population was presumed to be not knowledgeable on the subject of responding to bomb threats in airports and aircraft.

Materials

The materials section describes the design and development of the training simulator. This section specifically includes the System Description and the Scenario Operation. The System Description section includes a general description of the major components of the simulator. The Scenario Operation section describes the sequence of events that a user would experience during a training session.

System description

The Air Transportation Bomb Threat Training Simulator is an interactive multimedia application developed in Macromedia's Authorware 7.0. Authorware is a powerful software design program which facilitates the development of mission critical applications (Macromedia, 2003). Authorware is particularly effective in incorporating multimedia features such as wave sound files, animation, and interactive objects. Figure 1 illustrates the opening screen of the simulator.

Figure 1. Opening screen of the interactive multimedia training simulator for responding to air transportation bomb threats



The simulator consists of instructional, training, and testing components. The instructional component provides static non-interactive screen by screen instruction on receiving and responding to bomb threats. The module is based on both the Bureau of Alcohol, Tobacco, and Firearms (BATF) bomb threat and physical security planning pamphlet and the Federal Aviation Administration (FAA) operational procedures.

The training component provides the user with interactive training on receiving and responding to bomb threats from the perspective of the person receiving the threat. When the module is run, it allows the user to select the type and location of the bomb threat on which the user would like to receive training. There are scenarios involving bomb threats directed at commercial airport passenger gate areas, commercial aircraft at the loading gate, and commercial aircraft in flight. Once the user has selected the category of scenario, the program will generate scenario parameters such as background information, whether or not the threat is real, where the suspect devices is, and when the device will function. There are ten base scenarios in each category. The individual scenarios are based on data collected from actual bomb threat incidents. The parameters in each scenario are randomized. This means that each time the simulator is run, the user is presented with a different situation that requires a unique solution. On completion of the

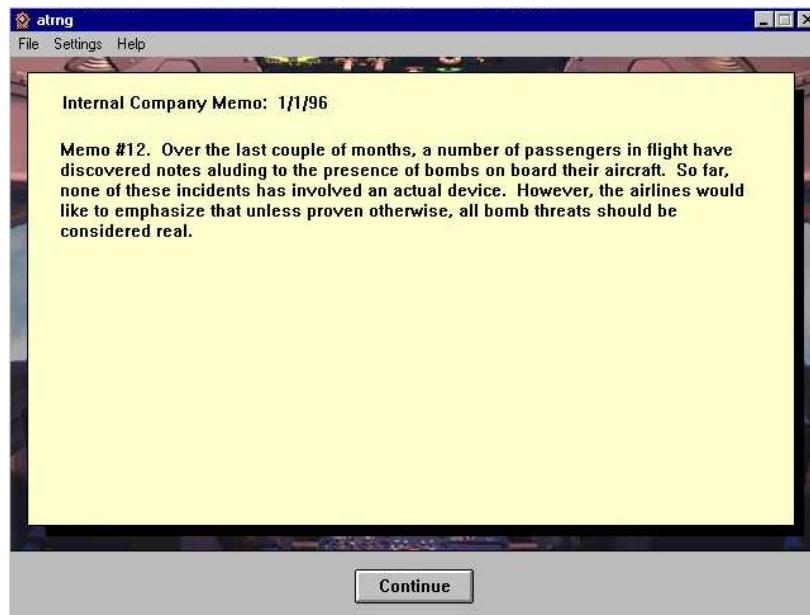
scenario generation, the user is positioned in a first person environment and the interactive scenario begins.

The testing component consists of randomized automated multiple choice pretests and posttests. Under normal conditions, the user takes the pretest prior to using the training simulator. After using the simulator, the user can take the posttest. Each time the user takes the pretest or the posttest, the program randomizes the questions. This is designed to minimize the possibility of memorizing answers to the questions. On completion of the posttest, the program will automatically score both the pretest and the posttest. The program will also determine the increase or decrease between the two tests. Both training supervisors and individual users can use the testing component as a guide for assessing the level of user proficiency.

Scenario operation

In the case of an aircraft in flight scenario, the user is placed in the cockpit of a commercial jetliner. The program provides a background scenario briefing. The purpose of the briefing is to provide a frame of reference for recent bomb threats directed at the airline. Figure 2 illustrates this screen.

Figure 2. Example of scenario briefing screen of the Interactive Multimedia Training Simulator for Responding to Air Transportation Bomb Threats



When this screen is cleared, the program issues the bomb threat to the user. With the aircraft in flight scenario, the flight crew is contacted by radio

with details of the bomb threat. This effect is achieved by playing a wave file. Once the user is given the details of the threat, the user then has the opportunity to try to obtain additional information from the control tower. This includes attempting to ask the following questions:

1. Who is the caller?
2. What does the bomb look like?
3. Where is the bomb?
4. When is it going to explode?
5. Why was the bomb placed?
6. How will the bomb go off?

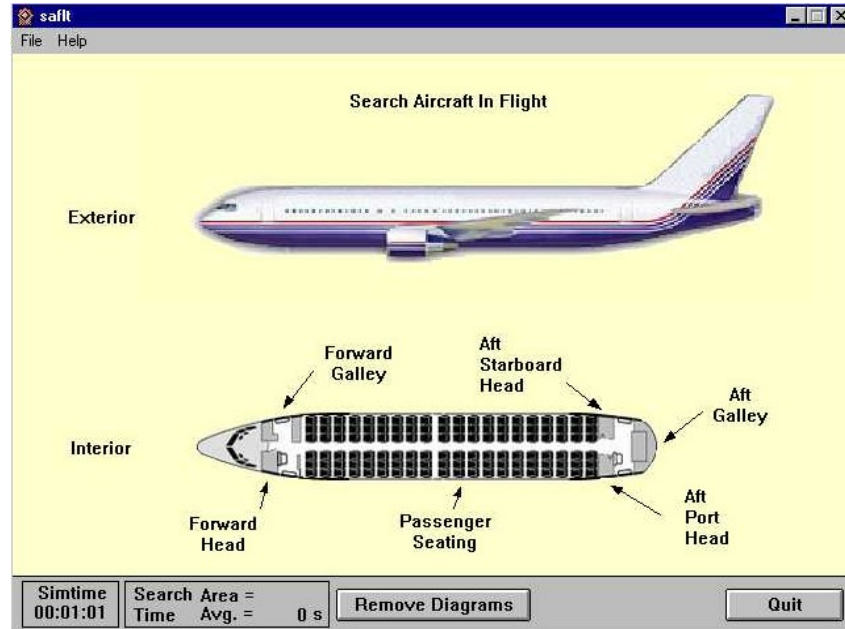
If this information is available, the simulator will respond to these questions by playing additional wave sound files. When the call is terminated, three buttons pop up on the bottom of the desk screen. These buttons allow the user to make an initial decision to ignore or search the aircraft. This screen is illustrated in Figure 3. If the user either ignores the threat or runs out of time, the program immediately evaluates the user's performance on gathering information and responding to the threat. In the event that the threat was real, the user fails the scenario.

Figure 3. Example of a cockpit screen of the Interactive Multimedia Training Simulator for Responding to Air Transportation Bomb Threats



If the user decides to search the aircraft, he or she is presented with a diagram of the aircraft. Users may search different areas of the aircraft by clicking on the corresponding part of the diagram. This screen is illustrated in Figure 4.

Figure 4. Example of a search diagram screen of the Interactive Multimedia Training Simulator for Responding to Air Transportation Bomb Threats



Users can then search for suspect devices by clicking on different objects in the selected part of the aircraft. This module retains a high degree of realism by using both digitized photographs of the aircraft and different interactive objects. For example, clicking on a seat will cause it to be lifted to allow the user to search underneath for suspect devices. Similarly, clicking on a compartment in the aircraft head will cause the door to swing open for inspection. This is illustrated in Figure 5.

Figure 5. Example of aircraft search screen of the Interactive Multimedia Training Simulator for Responding to Air Transportation Bomb Threats



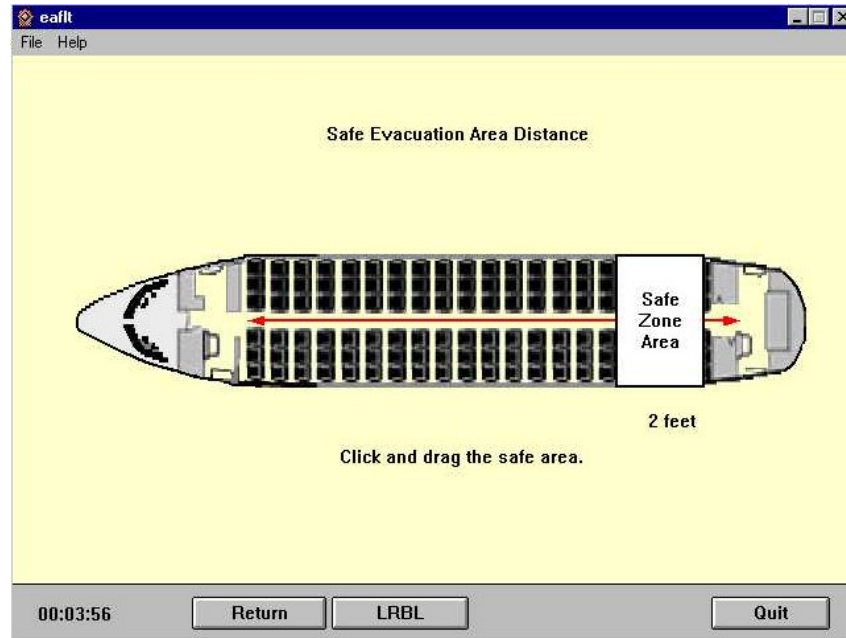
When an object is examined, a sound wave file is played related to the status of the object. A harmless object would provide a sound file of a comment such as, "I know who that belongs to" or "That's ok." Similarly, a suspect device would yield a sound file of a comment such as, "Where did that come from?" or "That doesn't belong here." The program records the number of possible objects examined by the user. This statistic is later used to determine the completeness of the search effort.

In the event that a suspect device is found, the user must move the device to the least risk bomb location. This position is where a suspect device will have the least effect in the event of a detonation. Once the suspect device is positioned, the user must then properly prepare the least risk bomb location to best protect the passengers. This is accomplished by following specific procedures for barricading the device with material on hand.

The evacuation module is typically activated by the user when a search has resulted in the discovery of a suspect device. This module presents a diagram of the aircraft similar to that used during the search process. This time however, the user must decide how to position the passengers on the plan to minimize injuries in the event of a detonation. Normally users will want to evacuate the passengers to a point furthest away from the suspect

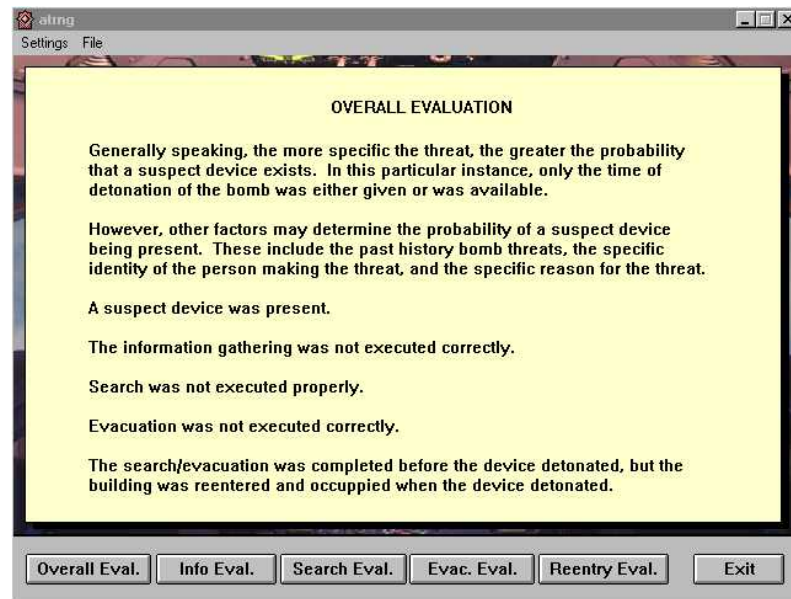
device which is now positioned at least risk bomb location on the aircraft. The evacuation screen is illustrated in Figure 6.

Figure 6. Example of safe zone evacuation screen of the Interactive Multimedia Training Simulator for Responding to Air Transportation Bomb Threats



On either the completion of the scenario or the detonation of the device, the user is evaluated for their information collection, searching, and evacuation performance. Feedback on the user's performance is provided through both a summary screen and individual detailed screens. This feedback allows users to improve their ability to respond to the bomb threat. Training supervisors can also use this information to target future bomb threat training. The summary evaluation screen is illustrated in Figure 7.

Figure 7. Example of a summary evaluation screen of the Interactive Multimedia Training Simulator for Responding to Air Transportation Bomb Threats



Procedure

In this type of research effort, the methodology procedure consists of establishing the validity of the simulator. With traditional simulation models, the validation process may include both an assessment of face validity and a quantitative comparison of behavior between the real world and the simulation model systems. With training simulators, the face validity assessment can still be performed; however the quantitative comparison between systems must be approached differently. Here, an assessment of training validity must be conducted. This is a quantitative comparison of whether or not the simulator adequately represents reality for the user to exhibit the same or increased user performance in the task that the simulator is designed to simulate. Thus, if the simulator is able to demonstrate equal or improved training effectiveness with users, then it can be considered to have training validity from the standpoint of adequately representing the real system.

Both face validation and training validation assessment were performed on the simulator. The face validation was achieved through a process of continuous review and improvement over a period of several months with the assistance of the Houston Police Department's Bomb Squad. The quantitative methodology was based on the use of pretests and posttests and

examination of the test scores using the paired t-test approach (Remus, 1981). The pretest and the posttest were based on information from the BATF Bomb Threat and Physical Security pamphlet and FAA documentation. The test consisted of twenty multiple choice questions on receiving and responding to bomb threats. The split half reliability of this test was 0.82. The test was face validated by representatives of the FAA.

As identified in the Participants subsection of the Method section, the test population to determine the training validity was a group of engineering graduate students at the University of Houston. This population was presumed to be not knowledgeable on the subject of responding to bomb threats in airports and aircraft. After an orientation session, the pretest was administered to the class. The test group then ran multiple training scenarios with the simulator. After the completion of this phase, test group were given the posttest.

RESULTS

The results for the pretest and the posttest for the test group are presented in Table 1.

Table 1. Pretest and posttest results for test participants of training validation of the Interactive Multimedia Training Simulator for Responding to Air Transportation Bomb Threats

	Pretest	Posttest
Number of test participants	26	26
Mean score of participants	32.88	69.42
Standard deviation of scores	13.86	19.14

The pretest and posttest scores were paired between individuals. The formal hypotheses are:

Null Hypothesis: There is no gain between the pretest and post test scores

Alternative Hypothesis: There is a gain between the pretest and post test scores

The difference in gain between the pretest and the posttest was calculated and a paired t-test was executed at an alpha level of 0.05. The results are presented in Table 2.

Table 2. Difference in gain between pretest and posttest of test participants of training validation of the Interactive Multimedia Training Simulator for Responding to Air Transportation Bomb Threats

	t statistic	t critical (1 tail, $\alpha=0.05$)	t significance
Paired t-test	10.22	1.708	0.000

The qualitative analysis of the training validity of the simulator was based on a paired t-test between the pretests and posttests from the test group. The critical value for a one tailed test at an alpha of 0.05 is 1.708. The paired t-test resulted in a test statistic of 10.22. Since the test statistic was greater than the critical value, the null hypothesis is rejected. This means that there is a statistically significant gain between the pretest and posttest scores at an alpha level of 0.05. Thus, there is evidence that the use of the simulator had an impact on how well the test group learned to respond to bomb threats of this type.

CONCLUSIONS AND SUMMARY

Bomb threats directed at airports and aircraft in flight can result in significant losses of operational time. In the event of an actual device there may also be casualties and property damage. By maintaining an effective level of bomb threat response training, air transportation organizations can help minimize the effects of bomb threats regardless of whether the threat involves an actual device or not. Unfortunately, due to time, cost, or operational considerations, many airports and airlines are simply not able to receive and maintain effective levels of bomb threat training.

The Air Transportation Bomb Threat Training Simulator was designed to overcome these limitations. The quantitative and qualitative analysis of the simulator has established its training validity. Thus, the Air Transportation Bomb Threat Training Simulator provides the opportunity for the commercial airlines industry to provide realistic and effective training in receiving and responding to bomb threats that might not otherwise be possible. While the testing at the University of Houston was performed under a controlled environment, it is expected that the same level of training effectiveness and acceptance will be present in the field environment.

REFERENCES

- BATF. (1987). *Bomb threats and physical security planning*. AFT F 7550.2. Washington DC: Department of Treasury, Bureau of Alcohol, Tobacco, and Firearms.
- Brodie, T. G. (1979). *Bombs and bombings: A handbook to detection, disposal, and investigation for police and fire departments*. Springfield, IL: Charles C. Thomas.
- Chung, C. A. (2000). Development of an interactive multimedia training simulator for responding to abortion clinic bomb threats. *IEEE Transactions on Information Technology in Biomedicine*, 4(1), 79-82.
- Chung, C. A. & Gopalakrishnan. (2003). Simulation analysis of carry on baggage on aircraft loading time. Proceedings of the 2003 Industrial Engineering Research Conference, Portland, Oregon.
- Chung, C. A. & Huda, A. (1999). An interactive multimedia training simulator for responding to bomb threats. *Simulation* 72(2), 68-77.
- Chung, C. A. & Panjra, P. S. (2001). A land transportation bomb threat training simulator. *International Journal of Modeling and Simulation*, 20(3), 95-100.
- Gu, Y. & Chung, C. A. (1999). Genetic algorithm approach to the aircraft gate reassignment problem. *ASCE Journal of Transportation Engineering*, 125(5), 384-389.
- Chung, C. A. & Sodeinde, T. (2000). A simultaneous service approach for improving air passenger queue times. *ASCE Journal of Transportation Engineering*, 126(1), 85-88.
- Kiernan, V. (1994). Bomb-breakers play safe in fantasy world. *New Scientist*, 141(1916), 9.
- Macromedia. (2003). *Using Authorware (Documentation Set)*. San Francisco: Macromedia, Inc.
- McCarthy, W. F. & Quigley, R. C. (1992). Don't blow it. *Security Management*, 36(3), 52-53.
- O'Sullivan, D. (1992). Management training software system simulates disaster situations. *Chemical and Engineering News*, 70(38), 21-23.
- Regan, E. C. (1995). Superscape desktop virtual reality system for training the threat assessment stages of improvised explosive device disposal. Salisbury, Wilshire: U.K Defence Research Agency.
- Reilly, J. A. (1989). Bomb threat, what now? *Security Management*, 33(9), 94-96.
- Remus, W. E. (1981). Experimental design for analyzing data on games. *Simulation and Games*, 21(1), 3-14.

- Ryan-Jones, D. A. (1995). Graphical environment for training explosive ordnance disposal. Washington DC: U.S. Navy Bureau of Personnel.
- Ryan-Jones, D. A. (1997). Graphical environment for training explosive ordnance disposal. Washington DC: U.S. Navy Bureau of Personnel. Available at <http://www.nprdc.navy.mil/nprdc/eod.html>
- Setti, J. & Hutchinson, B. (1994). Passenger-terminal simulation model. *ASCE Journal of Transportation Engineering*, 120(4), 517-535.
- Van Landeghem, H. & Beuselinck, A. (2002). Reducing passenger boarding time in airplanes: A simulation based approach. *European Journal of Operation Research*, 142(2), 294-308.
- Weinroth, J. (1989). Model for the management of building evacuation. *Simulation*, 53(3), 111-119.