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Fax: 813•974•5168
Email: *jpt@cutr.usf.edu*
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Our troubled planet can no longer afford the luxury of pursuits
confined to an ivory tower. Scholarship has to prove its worth,
not on its own terms, but by service to the nation and the world.
—Oscar Handlin

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PREFACE

This Special Edition of the *Journal of Public Transportation* is provided as part of a grant from the USDOT to the University Consortium for Intermodal Transportation, Safety and Security (UCITSS). We are grateful for the opportunity to present this special issue on this important and timely subject.

As with all issues of the Journal, the contents of this document reflect the views of the authors, who are responsible for the facts and accuracy of the information provided. The USDOT and UCITSS assume no liability for the contents or use thereof.

Gary L. Brosch, Editor
Journal of Public Transportation

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From Policy and Response to System Design and Operations: Inter-Governmental Transit Security Planning in the U.S.

Camille N.Y. Fink, Brian D. Taylor, and Anastasia Loukaitou-Sideris
UCLA Institute of Transportation Studies

Abstract

The events of September 11th, 2001, brought the issue of transportation security and terrorism to the forefront of civil society. Transit security is especially challenging because of the nature of transit systems as open and accessible public places and the need to keep these systems running quickly and efficiently; transit officials cannot employ many of the security strategies used in aviation security. This paper examines the recent developments in transit security planning in the U.S. using two sources of data: 1) interviews with officials from federal agencies, a national transit industry organization, and local transit agencies, and 2) a nationwide survey of transit operators. The findings show that transit security remains a major concern for operators who must work to balance security needs with operations and management goals. Interagency coordination has become a crucial element of security planning. In addition, environmental design and public outreach and education—two strategies that received much less attention pre-September 11th—have emerged as much more important in transit security planning.

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> (CNN) – U.S. mass transit systems were put on higher alert after Thursday's bombings in London, with officials in major cities urging Americans to go about their business but be on the lookout for anything suspicious.... New York Police Commissioner Ray Kelly told CNN his officers were "doing everything that's prudent, everything that we reasonably can do to protect the city." But he said it was impossible to put a police officer "on every train all the time, or one on every station all the time." [*http://www.cnn.com/2005/US/07/07/us.response/*; posted Thursday, July 17, 2005, 11:41 pm EDT (03:41 GMT)]

Overview

The events of September 11th, 2001, brought the issue of transportation security and terrorism to the forefront of civil society. Subsequent attacks—on subways in Moscow and Madrid and, more recently, on the Underground and bus networks of London—have further highlighted terrorism as a global threat with public transit systems as primary targets. While transportation security officials have long been aware of the possible threat of terrorist attacks on transportation networks, these tragic events revealed both vulnerabilities in security systems and the unimaginable consequences of such breaches. Public surface transportation systems are, in general, easy and effective targets for terrorists; this fact is reflected in the relatively significant proportion of attacks occurring on these systems. In 1991, transportation systems were the target of 20 percent of all violent attacks. This rose to almost 40 percent in 1998 (Boyd and Sullivan 2000). In addition, an examination of the public system targets and tactics used worldwide by terrorists from 1920 to 2000 shows that the largest percentage (46%) of terrorist attacks against public surface transportation systems was carried out on subways and trains, subway and train stations, and rail (Jenkins 2001).

The vulnerability of public transit systems lies in the fact that they are very open and accessible, with fixed, predictable routes and access points. Their openness and anonymity make it easy for potential terrorists to hide in crowds without arousing suspicion. Securing such open and public systems presents transit and security officials with daunting challenges. The volume of passengers makes it impossible for transit operators to employ the types of security tactics used in commercial aviation. Closed system security measures, such as the screening of passengers and luggage with X-ray machines and metal detectors, hand searches, passenger profiling, dog sniffers, armed guards, and the like, would lead to intoler-

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able delays and costs (Balog, Devost, and Sullivan 2002; Jenkins 1997; Boyd and Sullivan 1997).

Attractive, convenient public transit systems help to mitigate many of the problems of widespread auto use and provide mobility for those who do not have regular access to automobiles, including youth, the elderly, the disabled, and poor people. Security measures that cause inconvenience, delay, or added cost to travel by public transit are likely to shift travelers and cities toward greater dependence on private vehicles. Given that many transit systems around the U.S. struggle to control costs, maintain a market share of metropolitan trips, and secure and maintain stable sources of public subsidy, security measures that diminish the accessibility, convenience, and/or affordability of transit service conceivably could threaten the viability of public transit in many places. On the other hand, security measures that serve to increase the general safety, attractiveness, and reliability of transit systems without seriously compromising their accessibility are likely to enhance the attractiveness of public transit to potential riders (United States General Accounting Office 2002). Thus, while policing, surveillance, and emergency response will likely remain central to transit security planning, weaving security planning into transit system design and operations in ways that increase the safety and attractiveness of transit service offers potentially significant benefits to transit systems and their customers.

This Study

While most decisions about transit services (routing, headways, fares, etc.) are entirely local, security planning requires transit agencies to work closely with local law enforcement as well as federal transportation and security officials. Such ongoing inter-governmental collaboration, particularly with federal security officials, is new territory for many transit managers. This paper examines the fruits of this collaboration since September 11th, with a particular focus on how security considerations are being incorporated into the planning, design, and operations of U.S. transit systems.

Our data for this analysis are drawn from two sources. The first is interviews conducted either face-to-face or by telephone with officials from a number of federal and transit agencies and a transit industry organization; each interview lasted approximately one hour and involved an open-ended question format. At the federal level, we spoke with officials from the Department of Homeland Security

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(DHS), the Transportation Security Administration (TSA), the Federal Transit Administration (FTA), and the Federal Railroad Administration (FRA). We also conducted interviews with representatives from the American Public Transportation Association (APTA) and senior staff with several major transit operators, including the New York Metropolitan Transportation Authority (MTA), Amtrak, and two other transit agencies that asked to remain anonymous. The geographic focus of these interviews was the northeastern U.S. We selected this region for three reasons. First, the cities of the northeastern U.S., and in particular the New York metropolitan area, are home to, by far, the largest and most heavily patronized networks of public transit systems in the country; metropolitan New York alone accounted for 39 percent of all transit trips taken in the entire U.S. in 2002 (American Public Transportation Association 2004). Second, while the venue of the September 11th attacks was the air transport system, their effect on New York's, and, to a lesser extent, Washington's, public transit systems was dramatic and long-lasting and profoundly tested the ability of transit staff in these two cities to respond to a major crisis. Finally, as the seat of the national government, most federal transit and transportation security officials are in the Washington, D.C. area.

Where appropriate, the findings from these interviews are supplemented with the results of a 2004 nationwide survey of all 259 U.S. transit agencies that (according to the National Transit Database maintained by the Federal Transit Administration) operate at least 50 vehicles in peak period service. The letter to each general manager asked her/him to designate the appropriate person or persons to complete an on-line survey. All told, respondents from 113 transit agencies completed survey questions, for a 44 percent response rate.[1] This survey follows two earlier surveys of transit operators: 1) a survey of 42 transit managers that took place several years before September 11th (Boyd and Sullivan 1997) and 2) a United States General Accounting Office (GAO) study conducted soon after September 11th that included a survey in 2002 of officials at 155 U.S. transit agencies (2002). This latter survey-based report considered the roles the federal government should play in helping public transit operators reduce both the likelihood and impacts of terrorist attacks on U.S. transit systems.

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Findings

Despite nearly four years of relative quiet, most transit agency security staff remain extremely concerned about the possibility of transit terrorism on their systems.

Chief John O'Connor of the Amtrak Police Department at Penn Station believes that the threat of terrorism on transit systems is "very real and that it is a question of when rather than if." For O'Connor, September 11th was a galvanizing force, but it had started to fade somewhat in the mind's eye of the public. The events in Madrid in March 2004, however, brought the issue of transportation security back to the forefront and, according to O'Connor, "now for most transit agencies it's one of their top priorities, if not the top." Officials are especially concerned about the negative publicity transit has received as a high-profile terrorist target after the recent attacks in Moscow, Madrid, and London. Attention is increasingly focused on rail systems and major stations, such as Penn Station and Grand Central Station. These large multimodal facilities and landmarks are considered potential targets of particular concern.

Indeed, respondents to our nationwide survey believed heavy (80%), commuter (63%), and light rail (60%) to be "very vulnerable" to future attack, while less that half believed bus service (45%), paratransit service (26%), and ferry service (22%) to be very vulnerable. With respect to transit system components, tracks and lines (66%) and stations (63%) were most likely to be identified as "very vulnerable."

Greg Hull is Director of Operations, Safety, and Security Programs for the American Public Transportation Association (APTA), a transit industry organization with a membership of over 1,500 transit agencies and business representatives from across the U.S. In terms of understanding the transit terrorism threat at the local level, he acknowledges that perspectives on the level of risk and threat vary widely. However, he argues that the threat is pervasive regardless of whether the transit system is located in a large metropolitan area or a small one:

> *Some of us might argue that it doesn't matter where you are. I mean, look at Oklahoma City. This isn't just Al Queda we're dealing with. There are domestic terrorists, there are people who have political missions, there are people who are wackos, there are people who are copycats, and so it doesn't matter, from my perspective, it doesn't matter where you are located, whether in Pocatello, Idaho, or Washington, D.C.... It doesn't matter what city you live in or what town you live in, there is a need to address these issues.*

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Hull also asserts that agencies need to address requirements in all modes–from subways to buses–contending that transit terrorism is not confined to the largest population centers. However, he acknowledges that, practically and realistically, when making decisions about security using a risk management approach, local agencies do consider large numbers of people to pose the greatest vulnerabilities.

Increased intra-agency coordination is important in transit security planning and interagency coordination at the national and international levels is crucial.

Several interviewees noted the importance of having management, planning, and operations personnel work hand-in-hand with police and security staff to both minimize security-related service disruptions and to avoid having such disruptions become safety hazards in their own right. Said one interviewee,

> *As the security people come up with ideas that may not fit, if you have operating people sitting there, that's better. We have to reach some sort of a balance, some sort of a medium. How do we stop trains, how do we do inspections, but weave it into the regular fabric of our operations so our customers hardly notice? If we have a suspicious package, what is the procedure to deal with it? We try to minimize the delay to the train while still answering the concern, because when you start delaying trains, you create another safety problem as more trains get backed up. Now you're creating a service disruption. In Penn Station or Grand Central, many of the subway stations where they have such volumes, just delaying a train or two, you can lose a station. We end up having to shut down things. And then you get thousands and thousands of people in a panic situation wondering, "What's going on? Why am I being evacuated?" Once you can't run trains, you can't let people into the station because you have a crush load.*

FTA's assistance to local transit agencies is aimed at trying to standardize practices and provide support such that the agencies are prepared and can share information among themselves. The goal is to identify best practices and their dissemination to other agencies in similar circumstances. A high level of interagency cooperation already has been established in some places; transit security officials in New York describe a significant amount of coordination not just in the New York area, but in the Northeast corridor more generally. O'Connor of Amtrak says that his agency deals with the Massachusetts Bay Transportation Authority (MBTA) in Boston, the Connecticut Department of Transportation, the Long Island Railroad, New Jersey Transit, the Southeastern Pennsylvania Transportation Agency

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(SEPTA), and the Maryland Rail Commuter (MARC). Some of these agencies have their own police departments, while others do not; some agencies provide security services for other transit systems. In a place such as Penn Station, there is a multi-jurisdictional structure where the station is owned by Amtrak, which patrols the majority of the facility. Long Island Railroad leases a portion of the station and the New York MTA police patrol the lower level. Finally, the street level and subway entrances are policed by the New York Police Department (NYPD). Coordination among these policing and transit agencies becomes imperative.

Hull also emphasized that agency coordination and the dissemination of information are crucial. Very few people in the transit industry, even among the police forces, have security clearances. According to Hull, after September 11th, APTA realized that the transit industry and federal transportation agencies needed to access security intelligence information. Transit agencies in major cities had good working relationships with the Federal Bureau of Investigation (FBI) through established joint terrorism task forces. However, this was not the case across the board. The U.S. Department of Transportation (USDOT) designated APTA a sector coordinator for the establishment of a Public Transit Information Sharing Analysis Center (PT-ISAC), part of the larger umbrella Surface Transportation ISAC. In this role, APTA has served as the primary contact for organizing public transportation agencies around security issues. APTA worked on this PT-ISAC project through an FTA grant. Hull says that APTA used the grant to contract with a company based in Virginia:

> *They have on staff those people who have backgrounds, past careers with the FBI and Department of Defense. They have top-level security clearances. And they are able to glean through sources of information and package it in a manner that's meaningful to the transit industry. We are now in the process of connecting all transit agencies within this ISAC to be able to access this information.*

Hull related that the flow of information is from the ISAC out to transit agencies, but there is also a push to have agencies input their own information into the intelligence system: "If an agency experiences a certain degree of trespassing, they might see that as kids getting into the train yards or something. But maybe it's part of something that's more of a trend in the industry and that becomes good information that needs to be analyzed and disseminated out to the industry."

Hull says the direct exchange of information among agencies is also a priority for APTA and something it helps facilitate:

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> *We get the permission of the transit agencies to share whatever the best practice might be. It might be something like preventive maintenance, it might be a design concept in a facility, it might be the way that staff are utilized for safety and security. Our industry has historically and continues to be very supportive of one another. One of the things that has occurred is that where prior to 9/11 we saw more agencies more willing to share their security plans, now that's a little more closely guarded. They may share those plans with one another, but it would be eye-to-eye and hand-to-hand as opposed to what we may have seen in prior years. But there's a very, very open sharing of information within the system.*

In addition, APTA has actively engaged individuals in various federal agencies working on security issues, particularly DHS and TSA, in order to educate them about public transit. According to Hull, APTA has used a *Transit 101* presentation with the message that the organization—not the federal government—has the real expertise in transit. APTA involves the transit industry in all important stages of planning:

> *They [the federal government] may have the expertise in terms of security development for certain perspectives and certainly they have the funds and the legislative mandate. But the bottom line is that if there are any directions or mandates to the transit industry.... the only way that those things can be successful is by engaging us at a very early stage so that the industry can have proper buy-in and actually have a hand in the development of any such standards that might come forward.*

Hull understands that transit security is happening in an international context. As such, the organization has formal partnerships with other transit industry groups around the world: the Canadian Urban Transit Association, the International Association of Public Transport (UITP, with headquarters in Brussels), the Latin-American Association of Underground Networks and Subways (ALAMYS), and the Cooperation for the Continuing Development of Urban and Suburban Transportation (CODATU), based in Paris and representing transit systems in developing nations. A couple of years ago, APTA invited these associations and some of their primary agency members to meet with them in Washington. The goal was to share information about program development and relationships with government agencies. APTA representatives continue to share information with these other groups and they invite each other to special conferences and workshops on security.

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Balancing the security of their systems with other operations and management objectives is a central dilemma for many transit managers.

Particular security strategies, like inspecting passenger bags or employing explosives detection technologies, pose enormous challengers to transit systems that depend on operating as quickly and reliably as possible. Some officials, like Amtrak's O'Connor, are sanguine that improved security and efficient operations can be effectively integrated to bolster ridership: "If people do not feel safe and secure, they won't use the system. They'll avoid it if possible. If you allow the system to fall into disorder and decay, it will definitely affect your ridership." Thus, operators are aware that weighing the costs and benefits of system security overall, as well as of particular measures, is a complex process and includes variables that can be difficult to quantify. An overwhelming majority (87%) of the respondents to our nationwide survey of transit operators reported that anti-terrorism efforts were either fully (46%) or partially (41%) congruent with anti-crime efforts.

Amtrak's O'Connor believes that all security strategies are important, and the distinction is between short term and longer term strategies:

> *On a day to day basis, your focus is on operations, police deployment, both prevention and response. Long term, you need to set goals and design activities to help achieve those goals. You need to plan long term capital improvement that will help you achieve those goals. And you have to constantly—daily, weekly, quarterly, yearly—measure the effectiveness of your strategies and tactics to see if they are in fact achieving those goals.*

Threat and vulnerability assessments are one important tool to help security officials weigh their different options, and, in fact, 80 percent of our survey respondents reported that they conducted the most recent threat and vulnerability assessment at their agencies to identify effective security technology and procedures. These assessments are also quite common. Eighty-five percent of the 113 agencies surveyed nationwide indicated that they have conducted some level of threat and vulnerability assessment; agencies with rail were much more likely to conduct a comprehensive assessment than other agencies. This is a significant increase over the 54 percent reported by respondents to the 2002 GAO survey (United States General Accounting Office 2002).

Survey respondents were asked to describe other ways their agencies have attempted to identify and assess security vulnerabilities in the transit system.

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Methods identified most frequently were constant monitoring of crime statistics, periodic reviews/discussions of security by employees, daily visual checks/observations, employee and customer feedback, and regular contact with local law enforcement agencies. Many agencies reported having an internal security committee that meets on a regular basis to discuss and monitor security. One agency reported an active Transit Watch program, which solicits the participation of customers to point out vulnerabilities.

The perceived relevance of environmental design as a security strategy increased significantly after September 11th.

All of the transit officials interviewed for this research believe that design elements are central to security planning and should be explicitly addressed during the design and construction of facilities. Said one interviewee, "We've now incorporated security in the designs and boilerplates. Whereas at one time if you were going to construct a station, you would have only had to do safety—fire suppression, fire and life safety, ventilation, lighting, fire alarms. But now there's a security piece that gets incorporated." Several of those interviewed suggested that, by including security as an integral part of the design process, transit agencies can avoid costly and sometimes problematic station retrofits and redesigns.

The officials interviewed reported implementing other, less expensive environmental design strategies since September 11th, including removing trash cans, locking down seats in rail cars, taking out recessed telephones, eliminating nooks and crannies at stops and in stations, and installing access controls on all doors. Such strategies—both elaborate and simple—often are grouped under the rubric of "crime prevention through environmental design," or CPTED. Among the 113 respondents to our nationwide survey of large and medium-sized transit operators, 58 percent reported that their agency now makes moderate or extensive use of CPTED strategies. About half (49%) of bus-only agencies reported using CPTED strategies; among transit agencies operating one or more rail modes, which are far more likely to include enclosed stations, the figure was closer to 9 out of 10 (88%).

While extensive design retrofits for existing stations would be costly, certain design schemes means can be utilized to enhance security. Amtrak's O'Connor says that, after September 11th, his agency took several steps to put environmental design features into place. At the major stations, barricades and CCTV systems were installed without making major renovations to any of the stations. O'Connor pointed to the Washington, D.C. Metro system as one of the best in terms of

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security-oriented environmental design, with its clear sight lines and relatively few nooks and crannies. With respect to the future, O'Connor suggests that inter-city transportation agencies will have to consider creating "secure zones," where people are screened and their bags checked before they enter boarding areas. He acknowledges, however, that this type of system is difficult to implement in intra-city transit environments where very large numbers of people make relatively short trips.

Most transit officials believe that passenger outreach and awareness strategies are important.

Many transit systems internationally—such as the Underground subway system in London—have actively sought to enlist the help of patrons in watching for and reporting suspicious activity. William Morange, Executive Director for Security at the New York MTA, believes that rider and employee awareness is *the* most effective transit security strategy. He notes that the Executive Director of New York MTA put an "if you see something, say something" program in place before September 11th, "where if you see something that's not kosher—the way it should look—report it to the conductors, report it to the motormen. . . Now calls are going up, but it's worth it for us."

APTA's Hull says that there are "tools that enhance security and we certainly see more of the transit agencies moving towards introducing a variety of technologies," but he emphasizes two particular security strategies: (1) training and (2) emergency preparedness drills. The former includes the formal training of transit staff, but also outreach to transit customers—"the whole concept of having a broad network of eyes and ears and voices that will look for and let us know when they see something that just doesn't seem right."

When asked about information and outreach strategies to educate transit riders about general emergency and safety issues, three-quarters of those surveyed from rail systems report having such programs in place, and 90 percent of these include specific strategies to educate transit riders about dealing with terrorist attacks. In addition, while fewer than 30 percent of respondents to our national survey of transit operators perceived public education and user outreach as "central" or "significant" to increasing transit security prior to September 11th, this figure jumped to over 60 percent after September 11th.

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Conclusions

In this paper we have examined, through both in-depth interviews and responses to a national survey, efforts of federal agencies and national organizations in the U.S. and transit operators (primarily in the large cities of the northeastern U.S.) to maintain and enhance the security of local rail transit system design and environments. Our findings show that transit security has emerged as a significant concern for transit operators, especially after recent terrorist attacks on systems in Madrid, Moscow, and London. Although policing and security hardware and technology continue to be primary security strategies, the incorporation of environmental design and public education and user outreach programs has increased substantially since September 11th. Agencies continue to struggle with the conundrum central to transit security planning—effectively securing their systems while keeping the system running efficiently. In this regard, transit operators are constantly assessing their security options and understanding the ways in which system security can help or hinder ridership.

One of the important developments in transit security is the amount of cooperation that appears to be occurring among federal, national, and local agencies. Federal interviewees were unanimous in their view that relatively little in the way of "turf battles" was occurring as agencies juggle their evolving and, in some cases, newly acquired roles and responsibilities. The contributions of non-governmental industry organizations, particularly APTA, deserve special mention in this regard. APTA has assisted each of the organizations mentioned in this paper in a variety of ways, including cooperation in the development of the PT-ISAC, which facilitates the sharing of security-related information among transit and government agencies. APTA and transit operators in the U.S. also seem eager to foster these relationships both in the domestic and international contexts. As to the ultimate effectiveness of these many efforts to increase transit system security, only time will tell.

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Appendix—List of Interviews

Hull, Greg. Interview by Camille Fink. American Public Transportation Association, Washington, D.C., 14 January 2004.

Morange, William. Interview by Ellen Cavanagh. Metropolitan Transportation Authority, New York, NY, 4 June 2004.

O'Connor, John. Interview by Ellen Cavanagh. Amtrak Police Department, Penn Station, New York, NY, 1 June 2004.

The interviews of security officials at two other transit agencies informed the findings reported here, but the identities of the people interviewed, their organizations, and any agency-specific information from these interviews are not reported here to honor their requests for anonymity.

End Notes

[1]Both the interview and survey data are drawn from a larger transit security study entitled "Designing and Operating Safe and Secure Transit Systems: Assessing Current Practices in the U.S. and Abroad" undertaken by the paper's authors and a group of other researchers at UCLA, UC Berkeley, and San Jose State University.

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In addition to the authors, three people contributed importantly to this article. Professor Peter Haas of San Jose State University conducted a number of additional

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interviews with U.S. federal transportation security officials related to the issues presented in this paper. Professor Robin Liggett analyzed the survey data reported on here. Norman Wong of the UCLA Institute of Transportation Studies helped to design and execute the survey and, in addition, assisted with the production of this paper. Thanks also to the other members of the "Designing and Operating Safe and Secure Transit Systems: Assessing Current Practices in the U.S. and Abroad" research team: researchers Ellen Cavanagh (UC Berkeley), Christopher Cherry (UC Berkeley), Rachel Factor (UCLA), Babak Hedjazi (UCLA), Kimiko Shiki (UCLA), and Martin Wachs (UC Berkeley) and project advisory committee members Annabelle Boyd, Frances Edwards, Greg Hull, Brian Jenkins, John Sullivan, and Amy Zegart.

Finally, our heartfelt thanks to all the transit managers, chiefs of security, planners, and architects who took time to share their thoughts and opinions in our interviews and survey.

About the Author

Camille N.Y. Fink (*cnyfink@yahoo.com*) is a Ph.D. student in the UCLA Department of Urban Planning. Her interests include transportation safety and security; transportation equity; qualitative methods in transportation; and race, gender, and the built environment. Before returning to graduate school, she worked in radio broadcasting and for a homeless advocacy coalition in the Bay Area. She has a B.A. in Sociology from UC Davis and an M.A. in Urban Planning from UCLA.

Brian D. Taylor (*btaylor@ucla.edu*) is an Associate Professor and Vice-Chair of Urban Planning and Director of the Institute of Transportation Studies at UCLA. His research centers on both transportation finance and travel demographics. He has examined the politics of transportation finance, including the influence of finance on the development of metropolitan freeway systems and the effect of public transit subsidy programs on both system performance and social equity. His research on the demographics of travel behavior have emphasized access-deprived populations, including women, racial-ethnic minorities, the disabled, and the poor. His work in this area also has explored the relationships between transportation and urban form, with a focus on commuting and employment access for low-wage workers. Professor Taylor teaches courses in transportation policy and planning and research design. Prior to coming to UCLA in 1994, he was an Assistant Professor in the Department of City and Regional Planning at the University of North Carolina

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at Chapel Hill, and before that a Transportation Analyst with the Metropolitan Transportation Commission in Oakland, California.

Anastasia Loukaitou-Sideris (*sideris@ucla.edu*) is Professor and Chair of the Department of Urban Planning at UCLA. She holds a doctoral degree in Urban Planning and master's degrees in Architecture and Urban Planning from the University of Southern California. Her area of specialization is urban design and physical and land use planning. She has published extensively on issues of downtown development, inner-city revitalization, transit-oriented design and transit safety, and parks and open spaces. Recent and ongoing projects have been funded by the California Department of Transportation, the California Policy Research Center, the National Endowment for the Arts, the Poverty and Race Research Action Council, and the John Randolph and Dora Haynes Foundation, and the Mineta Transportation Institute. She has served as a consultant to the Transportation Research Board, the Federal Highway Administration, the Southern California Association of Governments, Los Angeles, the Metropolitan Transportation of Authority, the South Bay Cities Council of Government, the Los Angeles Neighborhood Initiative, the Roger Wood Johnson Foundation, the Greek government, and many municipal governments on issues of urban design, land use and transportation. She is the co-author of the book *Urban Design Downtown: Poetics and Politics of Form*, published by the University of California Press in 1998.

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Ferry Transport: The Realm of Responsibility for Ferry Disasters in Developing Nations

Catherine T. Lawson, The University at Albany
Roberta E. Weisbrod, Partnership for Sustainable Ports

Abstract

Ferries, the safest form of transportation in North America and Europe, can be the agents of catastrophe in some developing nations. Over the past decades there have been numerous incidents in which hundreds have died. The international ferry community, under the leadership of Interferry and the Worldwide Ferry Safety Association, working with IMO support, has embarked on a comprehensive 10-year plan to reduce ferry fatalities by 90 percent. This article describes the first research task needed to achieve the ferry safety goal of devising a framework to determine the responsible parties for ferry safety across the full social fabric, including ferry owners, local and national ferry authorities, national trade associations and international business and regulatory associations. This framework is intended to inform and be used as a guide to mobilize the relevant sectors of society to achieve reduction in ferry fatalities.

Introduction

Ferries, the safest form of transportation in North America and Europe, can be the agents of catastrophe in some developing nations. Over the past decades

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there have been numerous incidents in which hundreds have died. Even in the first few years of the 21st century there have been, on average, over 1,000 fatalities per year. In most of the nations with the poorest safety records (e.g., Bangladesh and Somalia), ferry travel is not discretionary. Travel is not primarily for recreation but is virtually the only way to pursue work and maintain social connections. The economic development of these nations is stymied by the lack of reliable mobility. In addition, the loss of life and the human tragedy disproportionately impacts those in their prime.

The international ferry community, under the leadership of Interferry, working with International Maritime Organization (IMO) support, has embarked on a comprehensive 10-year plan to reduce ferry fatalities by 90 percent. This article describes the first research task needed to achieve the ferry safety goal of devising a framework to determine the parties responsible for ferry safety across the full social fabric, including ferry owners, local and national ferry authorities, national trade associations, and international business and regulatory associations. This framework is intended to inform and be used as a guide to mobilize the relevant sectors of society to achieve reduction in ferry fatalities.

Background

Over the past several decades, the number and frequency of large-scale fatalities from ferry incidents in emerging nations have been appalling. This trend has continued to the present time, with over 4,000 people reported to have died in ferry accidents between January 2000 and May 2004 alone. (Note that the fatality statistics are based on bodies recovered; very often there are a larger number of persons listed as "missing." In addition, precise documentation is not always possible because the actual number of passengers is frequently unknown. See Table 1).

Context of Ferry Fatalities

Compared to other modes within Bangladesh, the rate of ferry fatalities is comparable to road transport fatalities. Four thousand people die annually in road accidents.[1] Compared to the developed world—for example, the United States—road fatalities in Bangladesh have a high convergence; in the United States there are close to 40,000 fatalities annually—10-fold the number of fatalities in Bangladesh, a nation with about 45 percent of the U.S. population. (The differential reflects the

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Table 1. New Millennia Ferry Fatalities (Documented)

Date	Nation	Number of Fatalities	Cause	Source
5/24/04	Bangladesh	>150	Weather	Lloyd's List (2004)
3/20/04	Somalia	100	Collision	IOL (2004)
3/20/04	Indonesia	>200	Rough seas	ABC News (2004)
3/19/04	Maldives	17	Overcrowding	BBC News (2004b)
3/10/04	Madagascar	100	Cyclone	BBC News (2004a)
2/22/04	Pakistan	6-12	Capsize	BBC News (2004c)
11/03	Congo	163	Collision	Henry (2004); BBC News (2003c)
11/03	Zambia	40	Storm	Henry (2004); BBC News (2003c)
10/03	United States (NYC)	11	Illness	Kennedy and Flynn (2003)
7/03	Bangladesh	400	Whirlpool	Tribune (2003); BBC News (2003a)
4/03	Bangladesh	>280	(4 incidents)	BBC (2003b)
1/03	Tanzania	40	Capsize	BBC News (2003c)
1/03	Somalia	80	Rickety boat	BBC News (2003c)
11/02	Somalia	30	Lost power	BBC News (2003c)
10/02	Senegal	1800	Storm	Henry (2004); BBC News (2003c)
5/02	Bangladesh	370	Storm	World Travel Watch (2002)
N/A	Indonesia	60	N/A	Henry (2004)
12/29/00	Bangladesh	200	Collision	Priyangika (2001)

very low rate of vehicle ownership, counterbalanced by the high rate of incidence of road fatalities and the high rate of fatalities to casualties.[2])

When the number of ferry fatalities is compared to road fatalities in the developed world, the issue of ferry fatalities is stark. In the developed world, the number and incidence of road fatalities are high, whereas ferry fatalities are virtually nil. For example, the U.S. ferry system transports 200 million passengers annually (*http://www.oduport.org/Ferry.htm*); the Bangladesh system transports approximately 40 million (*http://nation.ittefaq.com/artman/exec/view.cgi/18/10609*). In Bangladesh, there were over 1,000 fatalities annually; in the United States, there were virtually no fatalities between 1904 (the General Slocum ferry incident) and 2003 (the Staten Island ferry incident).

Why Study and Seek to Address Ferry Fatalities?

Although for Bangladesh the ferry and road transport accident statistics are roughly comparable, ferry transport is important because, relatively, ferry systems are more environmentally sustainable and require far lower capital investment for

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expansion and improvement and they have multiple values for economic development.

In general, ferry transport is often a critical element of economic development for many nations because of their fundamental reliance on ferries for the transport of people and goods—hence the critical importance of ferries to jobs and trade as a catalyst of economic growth (Weisbrod and Lawson 2003a). In many of the nations where the high fatality incidents occur, ferry transport is essential to the lives of the local populations. Geographic features, both physical and political, precondition the need for ferry transport for nations with island archipelagos, unbridgeable straits, riverine deltas, poor road transport, or a combination of these geographic features. With transportation the basis of economic development and ferry systems the major component of transportation systems, the lack of safety is economically devastating.

Creating a safe and reliable ferry system is also crucial to these nations' sustainable future. Ferries for transport of people and goods, notwithstanding the fact that they produce emissions, have a lower environmental impact than other forms of transportation. In terms of planning for the future, the highly developed and urbanized world has concluded that more waterborne transport of people and freight is sustainable, with both the European Union and the United States actively encouraging its use, particularly for freight.

The problem of ferry safety in the developing world will not go away on its own. The mindless loss of human life must be curbed—and can be. The international maritime and ferry communities stand ready to offer their assistance and capacity-building know-how. Foremost in this endeavor is the international ferry organization, Interferry.

Interferry is a trade association representing the worldwide ferry industry. Its participation is key to solving the ferry safety catastrophe in developing nations. In existence for almost 30 years, the organization has over 160 member companies from 22 countries and is actively engaged in expansion. Interferry participates with nongovernmental organization (NGO) status in IMO activities and is a member of the Maritime Safety Committee. As such, Interferry can reach out to developing nations on a collegial basis. Trade associations can be an effective vehicle for positive change, for both the industry and for government, as our research on the role of the transportation trade associations in homeland security has demonstrated (Weisbrod and Lawson 2003b).

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Members of Interferry formed a nonprofit organization, the Worldwide Ferry Safety Association (WFSA), a registered 501C3. The organization is led by a board of directors, which includes the CEO of Interferry, Len Roueche, and one of the authors of this paper, Roberta Weisbrod. An advisory board is in formation.

Interferry/WFSA and IMO have initiated a 10-year plan with the goal of reducing fatalities by 90 percent. The first steps are: (1) identification of the nature of the safety problem in ferry transport through root cause analysis; (2) comprehending responsibility for ferry safety, in order to know with whom to work and how to work with them; and (3) creation and analysis of a definitive 25-year database for ferry fatalities, in order to know what major factors are precipitating and contributing to fatalities, so that a practical and effective approach may be devised. A pilot project will be planned by a Bangladesh-based ferry safety working group in late 2005–early 2006.

A Framework for Determining Responsibility

Essential to the success of the endeavor is the development of a framework capable of examining how responsibility is distributed and how it can be leveraged. One of the most famous ferry tragedies was the *General Slocum* (in which over 1,000 people died on a sunny day in sight of land in New York City, in 1904) (O'Donnell 2003). Previous work used the sinking of the *General Slocum* as a platform for understanding the realm of responsibility (Weisbrod et al. 2005). Based on that analysis, questions to be asked include not only what entities control creation of policy, establishment of regulations, application of technology, inspections, enforcement of regulations, training, training standards, search and rescue, and reporting and analysis of incidents, but also what other entities, such as the press, citizens groups and local governments without statutory authority, can raise the standards and how can the governmental and nongovernmental sectors create the feedback loop on continuous improvement? These questions illustrate the complex reality of controlling ferry safety.

The review of the incident in Bangladesh in 2004 is used to develop a model to determine what entities in the public, private and nongovernmental sectors are responsible for which aspects of ferry safety and how they do and do not exercise their responsibility. Other recent and highly documented ferry casualties include the capsizing of the Baltimore water taxi in 2004 (Brumfield 2004); the Staten Island ferry collision of 2003 (Weisbrod and Lawson 2004); the sinking of the vehi-

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cle passenger (Ro-Pax) ferry *Estonia* in 1994 (Langewiesche 2004); and the capsize after debarkation of the Ro-Pax *Herald of Free Enterprise* in 1987 (Crainer 1993).

Bangladesh: Exploring the Realm of Responsibility

Role of Ferries

Bangladesh is a nation of over 130 million people living on a coastal river delta, interspersed with 250 north-south rivers. Ferries, of which there are purported to be 20,000, are a major mode of transport for most of the population (Reuters 2004). The ferry fleet is divided into two distinct types of services and vessel types: (1) ferries used for river crossings that are designed to carry cars and trucks, under the control of the Inland River Authority; these ferries rarely become involved in accidents, and (2) ferries that travel longer distances, leaving from Dhaka to travel to the islands and delta communities, which are more likely to be involved in catastrophic accidents.

Record of Ferry Accidents

In Bangladesh, every year there are many ferry accidents in which hundreds of people die. According to our records, between April 2003 (Lawson 2003) and July 2003 (BBC News 2003a) alone, over 1,200 people died in six separate incidents. Tracking the number of fatalities is difficult because the number of passengers is usually not known and multiple accidents occur at similar times and places. At the time of a recent ferry disaster in May 2004, when over 150 people died (Lloyd's List 2004), officials from the Inland Water Transport Authority said that over 1,000 people die in ferry accidents *each year* and more are counted missing (Reuters 2004). Accident reporting is unreliable at present and makes meaningful analysis difficult.

Disaster Factors

The precipitating factors tend to be weather-related. The storms of May and June are most virulent. The Ministry of Shipping addressed this issue by forbidding ferries from going out during the hours of 3:00 and 8:00 PM during the monsoon, a ban that was subsequently rescinded when ferry operators protested (BBC News 2003b).

One major contributing factor seems to be massive overcrowding. The number of passengers is never known, but the overcrowding is surmised from the number of fatalities and survivors. The Minister of Shipping has stated that "ultimately, it

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was up to passengers to decide not to board ferries that are too crowded" (Lawson 2003). Related to the overcrowding issue is the governmental mandate to cap fares. If ferry operators are unable to raise revenues by increasing fares, they are likely to increase revenues simply by allowing many more passengers on the vessel.

Stowage of cargo on the deck is another factor, creating top-heavy imbalance and contributing to capsizing, especially in rough weather. Substandard vessels are also a significant contributing factor; some have been purchased after long-term use elsewhere. Officials from the Inland Water Transport Authority said that over 20,000 vessels are in service, but only 8,000 are registered and, of those, only about 20 percent were certified as fit to operate (Reuters 2004).

Structure of Responsibility

The portfolio of the Minister of Shipping, one of 24 cabinet ministers, includes design of vessels as well as enforcement of laws and regulations pertaining to shipping. The minister has stated for the record that passengers have a responsibility not to board overcrowded vessels; during April 2003 the ministry ran public service announcements not to travel on overcrowded vessels during the stormy season which begins in April/May (BBC News 2003b).

The Inland Water Transport Authority, established in 1958, develops and regulates the inland water network. With respect to inland development, the agency undertakes planning and dredging projects. Its regulatory role is limited to the commercial aspects—overseeing ferry fares and timetables. Although the Inland Water Transport Authority apparently has no regulatory authority on ferry safety, it does seem to be documenting incidents.

Public and Private Sector Operators

Of the more than 20,000 ferries in Bangladesh, 3,000 are state-owned and more than 4,000 are privately-owned. Some of this uncertainty in numbers of ferries can be explained by the fact that only 8,000 ferries actually are registered (Reuters 2004).

Labor

The relevant labor federations include the Noujan [river vessels] Workers' Federation, which operates on 4,000 private river ferries. In 2002 the workers went on a strike over safety—but their issue was piracy, not operational safety (Worldwide Socialist News 2002).

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Ferryboat Operators

Ferryboat operators exercised their right of protest in April 2003 to overturn a government-imposed ban on night travel (BBC News 2003b). The Ministry of Shipping had instituted a ban on travel between 3 and 8 PM during monsoon season in early 2003 and rescinded the ban when "ferry owners promised not to operate their vessels in inclement weather and to follow safety regulations" (*Sydney Morning Herald* 2003). Note that the protest and its results were reported in July 2003 in an article headlined "600 feared dead in a night voyage during monsoon season," which the ban was intended to avoid and the ferry owners' promises would have prevented.

Local Government

To date, the local government has not played a role.

International Organizations

The IMO, a United Nations agency, is concerned with safety for international shipping and the prevention of marine pollution. The agency is responsible for adopting rules for international maritime issues, which the 164 member nations implement. Ferries that are in domestic trade only are not considered part of its portfolio. However, the current leadership, as well as the previous one, is committed (as are members) to addressing the issue of ferry safety. As Efthimios Mitropooulos, the secretary-general has said (Maritime News 2004):

> It is essential that we find way of addressing the question of safety standards aboard non-convention ships [i.e., ships that are not subject to IMO regulations]. The tragic ferry accidents in the Philippines and the Maldives this year have highlighted how devastating these incidents can be in terms of loss of life. IMO has already promoted the development, adoption and implementation of safety codes for non-convention vessels in Asia and the Pacific, Africa, the Caribbean and the Mediterranean and will continue to explore initiatives to assist countries in avoiding these tragedies in the future.

Bangladesh is a member of the IMO and also a member of the Maritime Safety Committee (MSC). A Bangladesh citizen, Captain Moin Uddin Ahmed, is the head of the Asia Pacific Section of the Technical Cooperation Division of the IMO (L. Roueche, personal communication 2005).

Table 2 highlights the important aspects of ferry accident prevention, including the role and effectiveness of regulation, vessel design and operations and the initial

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response. Table 3 addresses postevent issues: investigation, documentation of the accident, sanctions, insurance, and victim support.

Table 2. Prevention and Response for Ferry Safety in Developing Countries

Function	*Issues/Area of Inquiry*
Prevention	
Regulatory Approach	Are the regulations adequate to the conditions? How does the rule making take place? How are rules communicated? How are regulations enforced? Is there any oversight in the implementation of the regulations?
Vessel Design	Are vessels designed properly for their purpose? What proportion of the fleet of vessels is certified? Are there penalties/obstacles for certification? Are these noncertified vessels long-after, after-market vessels? Are there penalties for noncertification? Is there a difference with respect to accident rates for long-after, after-market vessels? What and how rigorous is the certification process? What is the relationship between ferry fatalities and vessel certification? Are the vessels inappropriate or inadequately maintained and/or improperly operated?
Operational Standard	What is the accident record differential between certified/noncertified vessels with respect to operating standards? What is the accident record differential between vessels that are publicly or privately owned? Are there differences with respect to routes and type of service between public and private operations? How can registration/certification be encouraged by the industry, local government, or citizens groups?
Response	What type of training and drills are available for private or public crews? Is there a relationship between the record of training and drills and ferry fatalities? Is there a formal system in place for search and rescues? Have "safe havens" been identified in event of major storm and/or vessel damage?

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Table 3. Post-Event Responsibilities for Ferry Safety in Developing Countries

Function	*Issues/Area of Inquiry*
Investigation	What agency investigates ferry accidents? How are involved parties informed of results? Are accident investigation reports disseminated in a timely and well-publicized fashion so that operators and regulators can learn from them?
Documentation of accidents	Where, who, how and what if there isn't any? Is there an active press to track and continually publicize incidents and the role of government and industry in implementing safe conditions on ferries?
Sanctions	What is the record of sanctions to those who violate the safety rules? Consider that the innate sanction of loss of asset for owners is not a feedback mechanism because the vessel is already depreciated. What would be effective?
Insurance	Do vessels need to have insurance to operate legally? Is insurance available? Are liability coverage provisions enforced?
Victim support	Are victims given compensation, through an insurance system, which would have the effect of discouraging reckless behavior?

Effecting Positive Change

One approach to establishing a positive model for ferry safety is to tie international aid for the purposes of vessel purchase to improved operational oversight. The Danish aid organization Danida has had a history of assisting the ferry sector of Bangladesh, working with the national government and coordinating its activities with the World Bank (Underenrigmisteriet undated). Since 1981, Danida has assisted the ferry sector by delivering several ferries, financing local construction of ferries (with main components from Denmark), and helping to construct and rehabilitate docks. Technical assistance and training have been part of the package. In 2002, Danida announced that relations with the Shipping Ministry were such that cooperation was not possible and rescinded its commitment for renovation

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of ferries for the locality of Aricha (a port on the Ganges) and related activities. Danida is assisting the roads and highways department of the Communications Ministry in the construction of ferries and landing pontoons by a privately-owned Bangladeshi shipyard (*Bangladesh Observer* 2004).

Nations also can offer assistance by providing a framework of lifesaving standards for ferries. The U.S. Coast Guard Navigation and Vessel Inspection Circular (NVIC) 1-97 for Shipboard Safety Management and Contingency Planning for Passenger Vessels (*www.uscg.mil/hq/nvic/1-97/n1-97.htm*) is sufficiently flexible to be adaptable by ferry operators in a wide variety of circumstances of geography and use. The NVIC follows a "keep it simple" philosophy that makes it especially useful.

Although not proactive with respect to preventing accidents, the International Red Cross assists with rescue efforts and provides trauma counseling to survivors and the bereaved (BBC News 2003b).

After the issues presented in Tables 2 and 3 are examined, there is still a question of how best to promote a vector of change. The goal of reducing ferry fatalities by 90 percent over 10 years will not be accomplished with data collection and root-cause analysis alone. A well-funded program of projects developed on the basis of analysis is needed to determine what will make a difference. What steps, organizations, and/or stakeholders can be brought to bear?

Like Bangladesh's successful program for infant mortality reduction, this project will have to go beyond traditional central government activities (World Bank 2003). It will need full, active engagement of multiple sectors of society, including the press, local government, labor, trade associations and the international community. State or provincial government can help solve problems by demonstrating innovative solutions. Local government, through its control of land use for ferry landings, can control the industry.

Trade associations offer a unique opportunity to effect change. An investigation into the role of the transportation trade associations in homeland security revealed that roughly half the associations representing liquid bulk carriers prepared model security plans, coordinated with agency guidance, for their member companies. A benefit for the companies was agency endorsement of the plans, customer appreciation, and a greater ease of implementation (Weisbrod and Lawson 2003b).

Employees can be at the front line in pushing for safety. Workers' lives are at stake; they understand the issues from daily exposure to unsafe conditions. Unions could be an untapped resource for safety issues. It may depend on the structure of the

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labor federations and unions. Are their members working for both the private and public companies? Are the unions capable of protecting their members and, if so, can they be successfully integrated into effecting change?

A final opportunity may be the rapid adoption of communication technologies, such as cell phones and other wireless devices. As developing nations expand their use of wireless technologies, citizens will be able to report unsafe situations (Arnold 2001). These communications could make enforcement easier and also serve as receivers for weather information or other news that could influence the safety of ferry sailings.

Concluding Remarks

Reaching the goal of reducing ferry accidents in developing countries by 90 percent in 10 years will take a serious effort by all parties. By systematically examining the evidence and establishing and allocating responsibilities, the partners in ferry safety can make progress on a number of fronts. Concentrating on Bangladesh has immediate benefits. If current efforts produce successful experiences, lessons learned can provide transferable strategies for other countries with similar challenges. What can we do to reduce ferry fatalities? What will be the driver for change in the developing nations? What sectors of society can be mobilized to work with governmental leadership and how can they best exert their locus of responsibility?

End Notes

[1] In terms of incidence of fatalities, road transport accounts for approximately four times the number of ferry fatalities. Road transport, however, accounts for 72 percent of the 73 billion passenger kilometers (km) traveled, while ferry transport accounts for 14 percent (*http://www.adb.org/Documents/TARs/BAN/R183-00.pdf*). By that measure, road transport, at fivefold the passenger km traveled but with fourfold the fatalities, has a somewhat lower incidence rate.

[2] In 2000, there were 550,000 motorized vehicles in Bangladesh (*http://w3.whosea.org/EN/Section1243/Section1310/Section1343/Section1344/Section1836/Section1837_8165.htm*), compared to 213 million in the United States. The incidence rate is between 70 and 160 per 10,000 vehicles versus 2 in the United States. Also, an additional 6,000 casualties required hospitalization; in the United States, for every fatality there are 13 casualties requiring hospitalization, reflecting differences in the emergency medical care.

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About the Authors

Catherine T. Lawson (*lawsonc@albany.edu*) is an assistant professor in the Department of Geography & Planning at the University at Albany in New York. She received her master's degrees in urban and regional planning and in applied economics and her doctor's degree in urban studies/regional science from Portland State University in Oregon. Her research interests include water-related transport (passenger and freight), travel behavior, and archived intelligent transportation systems (ITS) data visualization.

Roberta E. Weisbrod (*weisbrod@sustainableports.com*) is the director of Partnership for Sustainable Ports LLP, a business dedicated to improving the public and private benefits of maritime transportation. Her research interests include water-related transportation (passenger and freight), environmentally sound urban freight transportation, and waterfront development. She was Director for Sustainable Transportation at INFORM, an environmental organization; Director for Port and Intermodal Planning at the New York City Economic Development Corporation; and special assistant to the Commissioner for Harbor Environmental Issues at the New York State Department of Environmental Conservation. She has a Ph.D. in biochemistry from Cornell University Medical College. She is the cofounder with Len Roueche of the Worldwide Ferry Safety Association.

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Terrorism, Transit and Public Safety: Evaluating the Risks

Todd Litman, Victoria Transport Policy Institute Victoria, BC, CANADA

Abstract

This paper evaluates the overall safety of public transit, taking into account all risks, including recent terrorist attacks. It indicates that transit is an extremely safe mode, with total per-passenger-mile fatality rates approximately one-tenth that of automobile travel. It is important for individuals and public officials to avoid overreacting to terrorist threats in ways that increase overall danger. Transit terrorism would cause more total casualties and harm to society if individuals respond to attacks by shifting from public transit to less safe modes, or if decision makers respond by reducing support for public transit.

> "The only thing we have to fear is fear itself—nameless, unreasoning, unjustified terror which paralyzes needed efforts to convert retreat into advance." —*Franklin D. Roosevelt, 1932 Presidential Inaugural Address*

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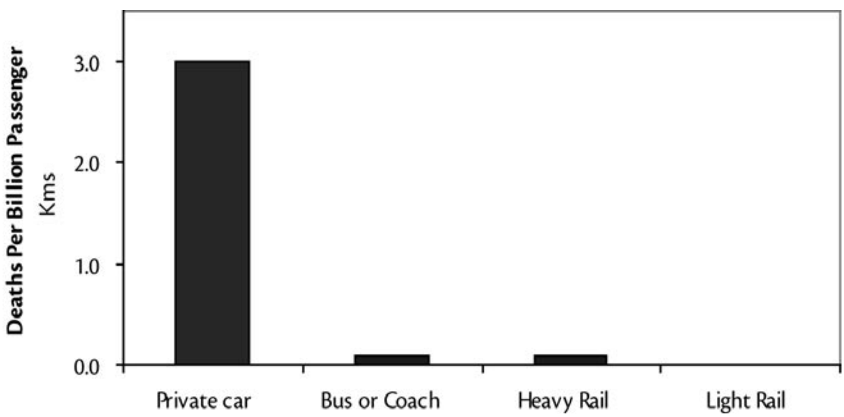
On July 7, 2005, terrorist bombs on London's transit system killed approximately 50 people and injured hundreds. This is not the first terrorist attack on public transit. In 1995, a religious group released sarin gas in Tokyo's subway system, killing 12 and making thousands of people sick. In recent years, bombs exploded on buses and trains in Israel, Madrid, Moscow, Paris and other cities.

Despite such events, public transit is still an extremely safe form of travel. The traffic fatality rate per passenger-kilometer is less than one-tenth that of automobile travel, as indicated in figures 1 through 3 (the analysis for these graph is in the Transit Risk spreadsheet, available from the Victoria Transport Policy Institute website at *www.vtpi.org/transitrisk.xls*). Even including terrorist attacks and other crimes against transit passengers, transit is far safer than private vehicle travel.

Figure 1. U.K. Death Rate by Mode



Source: (Steer Davies Gleave, 2005, Table 7.3)
Note: UK transit passengers have about one-twentieth the traffic fatality rate as automobile occupants.

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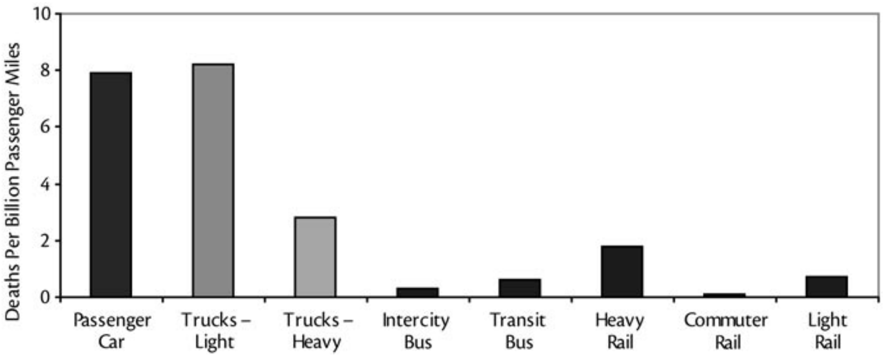
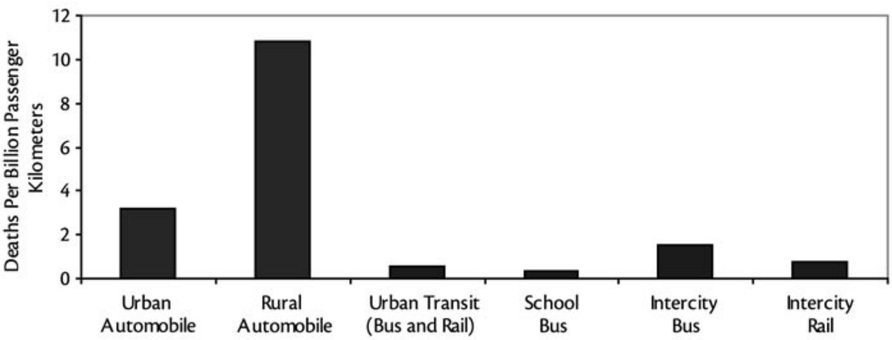
Figure 2. U.S. Death Rate by Mode



Source: (BTS, Tables 2-1 and 2-4; APTA, 2003)
Note: U.S. transit passengers have about one-tenth the traffic fatality rate as automobile occupants.

Figure 3. Canadian Death Rate by Mode



Source: (CUTA, 2000)
Note: Canadian transit passengers have about one-tenth the traffic fatality rate as automobile occupants.

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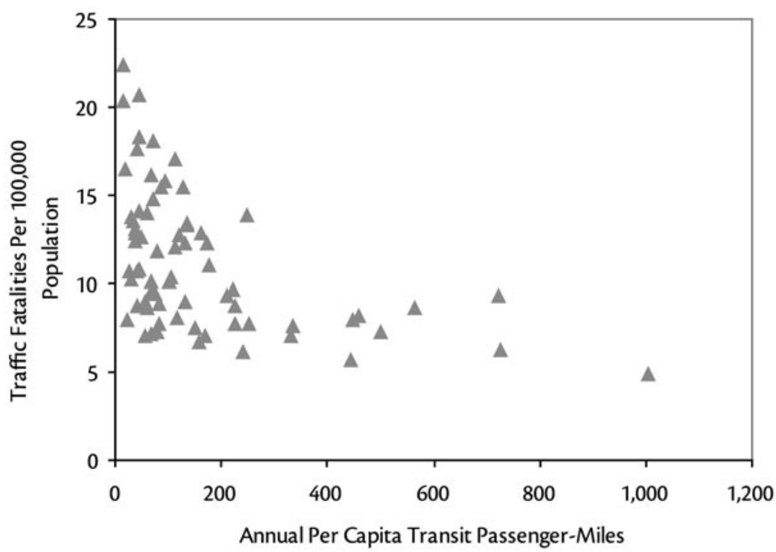
Figures 1 through 3 show only risks to transit passengers. Transit accidents also impose "external" risks on other road users (motorists, pedestrians and cyclists), but the marginal external risk of an additional transit passenger-kilometer is small, since most transit systems have excess capacity (only if additional ridership requires additional transit vehicles would external risk increase) and automobile travel imposes comparable external risks. For more discussion of marginal transit risk, see Litman 2005a and 2005b.

Shifting travel from automobile to transit and creating more transit-oriented communities increases safety for transit passengers and other road users. Total per-capita traffic fatality rates (including automobile, transit and pedestrian deaths) tend to decline as transit ridership increases in a community, as indicated in Figure 4. The decline in traffic fatalities associated with increased transit use probably results from a combination of reduced per-capita annual vehicle mileage, lower average traffic speeds in higher-density areas, and reduced driving by higher-risk motorists, such as teenagers and habitual drunk drivers, due to better alternatives to automobile travel. Transit is a significant contributor to each of these factors.

Figure 4. Traffic Deaths and Transit Mileage, U.S. Cities (based on FTA data)



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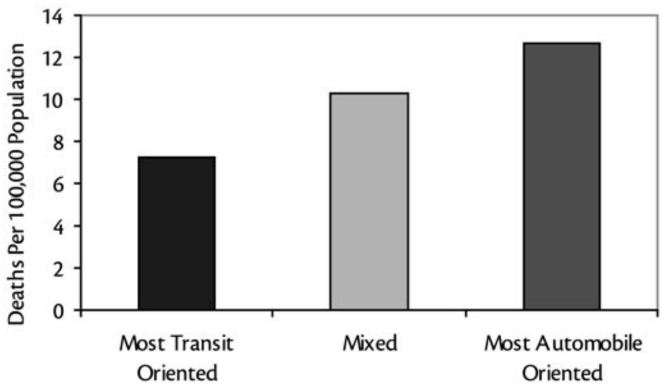
Residents of more transit-oriented urban regions experience far lower per-capita traffic fatality rates than in automobile-oriented regions, as illustrated in Figure 5. Overall, transit passengers are much safer than motorists, and residents of transit-oriented communities are safer than residents of automobile-oriented communities, even taking into account risks from murder and terrorism (Lucy 2002).

Figure 5. Annual Per Capita Traffic Deaths



Source: Litman, 2004
Note: Transit-oriented urban regions have significantly lower per-capita traffic fatality rates than more automobile-oriented cities. "Most Transit Oriented" are the 10 U.S. cities with the highest per-capita annual transit mileage (333 to 1,004 annual transit passenger miles). "Mixed" are the next 20 cities ranked by transit mileage (118 to 254 annual transit passenger miles). "Most Automobile Oriented" are the remainder (15 to 114 annual transit passenger-miles).

International data also indicate that per-capita traffic fatalities decline with increased transit ridership, as indicated in Figure 6.

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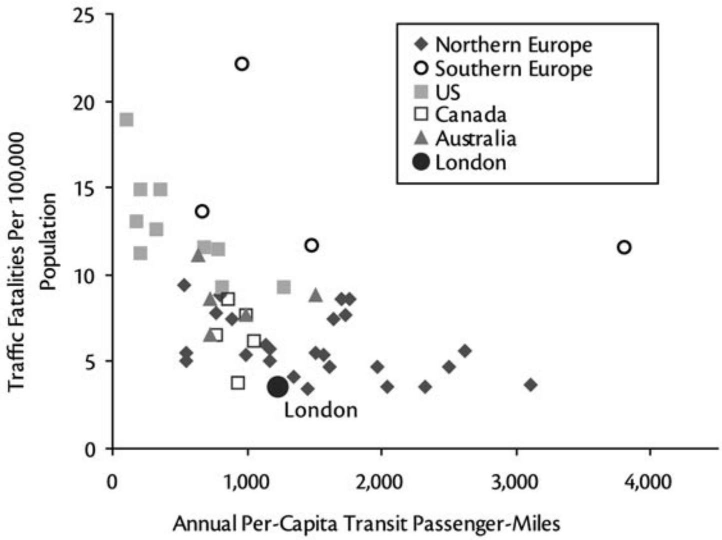
Figure 6. International Traffic Deaths



Source: (Kenworthy and Laube, 2000)

Annual road and rail traffic deaths total 286 in the London region, about 3,500 in the U.K., and more than 43,000 in the U.S., of which only a small portion involve public transit passengers, as summarized in Table 1.

Table 1. Traffic Fatality Data Summary

	London	U.K.	U.S.
Automobile/motorcycle passenger deaths	143 (50.0%)	2,574 (73.6%)	37,192 (87.2%)
Bus transit passenger deaths	7 (2.4%)	11 (0.3%)	64 (0.1%)
Rail transit passenger deaths	9 (3.1%)	12 (0.3%)	45 (0.1%)
Rail passenger deaths	- (0.0%)	20 (0.6%)	3 (0.0%)
Non-motorized deaths	127 (44.4%)	882 (25.2%)	5,371 (12.6%)
Total Deaths	*286 (100%)*	*3,499 (100%)*	*42,675 (100%)*

Source: (TfL, 2004; DfT, 2004; BTS, 2004)

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Of the 286 transportation fatalities in London, only 5.6 percent involved public transport passengers, although public transport provides 24.2 percent of total passenger trips and 20.1 percent of passenger-kilometers, as indicated in Table 2.

Table 2. London Area 2003 Travel and Fatalities By Mode

	Million Trips	Million Kms	User Deaths
Bus	1,430 (14.3%)	5,128 (8.1%)	7 (2.4%)
Underground	953 (9.5%)	7,451 (11.7%)	9 (3.1%)
Docklands (DLR)	41 (0.4%)	207 (0.3%)	0 (0.0%)
Car/motorcycle	4,015 (40.0%)	46,976 (73.8%)	143 (50%)
Taxi	99 (1.0%)	503 (0.8%)	0 (0.0%)
Walk	3,366 (33.5%)	2,693 (4.2%)	107 (37.4%)
Bicycle	131 (1.3%)	693 (1.1%)	20 (7.0%)
Total transit (bus, underground, DLR)	*2,424 (24.2%)*	*12,785 (20.1%)*	*16 (5.6%)*
Total automobile (car, motorcycle, taxi)	*4,114 (41.0%)*	*47,478 (74.6%)*	*143 (50.0%)*
Total non-motorized modes (walk, bicycle)	*3,497 (34.8%)*	*3,385 (5.3%)*	*127 (44.4%)*
Totals	**10,034 (100%)**	**63,649 (100%)**	**286 (100%)**

Source: (TfL, 2004)

If public transit had the same fatality rate per passenger-mile as automobile travel, there would have been 104 more deaths in London, 300 in the U.K., and 148 in the U.S. in 2003 (calculations in *www.vtpi.org/transitrisk.xls*). These are lower-bound estimates because they assume that each transit passenger-mile replaces just one automobile passenger-mile. However, when people shift from driving to transit, they tend to reduce their annual mileage, because transit users often choose closer destinations and avoid unnecessary trips. As public transit ridership increases in a community, per-capita vehicle ownership tends to decline, and land use patterns

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become more accessible and walkable, further reducing vehicle mileage. Described differently, as a community becomes more automobile-oriented, destinations tend to disperse, due, in part, to the need to dedicate more land to roads and parking facilities, causing people to travel more to maintain a given level of accessibility.

As a result, each transit passenger-mile often replaces several automobile vehicle-miles (Litman 2004). This is one of the reasons that increased per capita transit ridership provides such large reduction in per-capita traffic fatality rates, as indicated earlier. If residents of the "Transit Oriented" regions described earlier in Figure 5 had the same traffic fatality rate as the "Automobile-Oriented," there would be about 2,500 additional traffic fatalities in the U.S. (calculations in *www.vtpi.org/transitrisk.xls*).

These safety benefits of transit are much larger than deaths and injuries caused by recent terrorist attacks. In addition, public transit provides other health benefits, by reducing air pollution and increasing physical exercise, since most transit trips involve walking or cycling links. Although these health benefits are difficult to quantify, they appear to be large, indicating far greater total health benefits from transit and, therefore, much larger disbenefits when people shift from transit to driving (Litman 2003). Travelers would increase their total risk if they shift from transit to driving in response to terrorist threats.

Transit risks tend to receive more attention than automobile risks. Because they are rare, incidents that kill or injure a few transit passengers often receive national or international media attention, while automobile crashes that kill a few people are so common they are considered local news, and injury accidents often receive no media coverage at all. For example, in 1995 the death of three passengers in a Toronto subway crash was widely reported in British Columbia. The same week, the death of four teenagers in a car crash was a local news story without media coverage in Toronto. This suggests that a transit passenger death receives about 100 times as much media coverage as an automobile passenger death.

Traffic accidents actually represents a much greater risk than terrorism (Adams 2005):

- On an average day, 9 people die and over 800 are injured in British road accidents. The July 7 London terrorist deaths represent about six days of normal traffic fatalities.

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- The 191 people killed March 11, 2004, by Madrid bombers were equivalent to about 12 or 13 days of normal traffic deaths in Spain.
- During the 25 worst years of sectarian violence in Northern Ireland, twice as many people died there in road accidents as were killed by terrorists.
- In Israel, the annual road traffic death toll has been two or three times higher than civilian deaths by Palestinian terrorists during the violent years of 2000 through 2003.
- The September 11, 2001, terrorist attacks killed about the same number of people as a typical month of U.S. traffic accidents. According to official reports, terrorists killed 25 Americans worldwide in 2002, 23 in 2003, and none in 2004, while about 42,000 Americans died in traffic accidents each of these years.

There are several reasons that people react particularly strongly to terrorist attacks (Adams 2005). Such attacks are designed to be highly visible, producing intense media coverage. The fact that the harm they cause is intentional rather than accidental makes them particularly tragic and frustrating. And they raise fears that such attacks may become more frequent or severe, so risks may increase in the future. For these reasons, it is not surprising that transit terrorism tends to instill more fear than other risks that are actually much greater overall. That is exactly what terrorists intend.

This is not to suggest that transit terrorism risks are insignificant and should be ignored. On the contrary, transit terrorism is a serious threat that harms people both directly, through injury and property damage, and indirectly by creating fear and confusion. Strong action is justified to protect transit users' safety and sense of security.

Society should work aggressively to prevent terrorists attacks, respond to incidents, and bring terrorists to justice. Transportation professionals, and transit operators and users should be cautious and vigilant (for more discussion of strategies for increasing transit security, see the "Address Security Concerns" chapter of the VTPI *Online TDM Encyclopedia* at *www.vtpi.org/tdm/tdm37.htm*). Many transport organizations are currently working to increase transit security (APTA, 2005; FTA, 2005; MTI, 2005; Loukaitou-Sideris, 2005). Much more can be done. The federal government spent $22 billion—more than $9 per passenger—on air transportation security after September 11, 2001 attacks, but less than 1¢ per passenger to increase railway and subway security (Howitt and Makler 2005).

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But it is important for individuals and public officials to take *all* risks into account and avoid overreacting to transit terrorism risks in ways that increase overall danger. Transit terrorism would cause greater total casualties and harm to society if individual travelers respond to exaggerated fears by shifting from public transit to less safe modes, or if decision makers respond by reducing support for public transit.

Such shifts have occurred. Analysis by Gigerenzer (2004) and Sivak and Flannagan (2004) indicate that in the three months after the September 11, 2001, terrorist attacks, shifts from air to automobile travel caused several hundred additional roadway traffic fatalities. Since air travel is safer per mile than driving, particularly on rural roads, total travel deaths increased. Had these trends continued for more than a year, the additional deaths would have exceeded the September 11 terrorist deaths. Because of actions by governments and the airline industry to increase air travel security, these travel shifts have been reduced, reducing excess traffic deaths.

After a high-profile transit accident or attack, news reporters sometimes stick a microphone in front of transit riders and ask, "How can you possibly continue using transit after what just happened?" with the implication that riding transit is dangerous and foolish. This reflects the myopic tendency of news media to consider just one issue at a time. But people and policy makers must balance many factors, including *overall* safety, efficiency, and affordability. It would be foolish for travelers to reduce their transit travel in response to a terrorist attack, despite the fact that transit is an extremely safe mode of travel and provides other benefits to users and society.

When terrorist attacks occur, responsible leaders rightfully recommend that people return to their normal habits, including public transit travel. Cities repair their public transit systems and people use them, both for practical reasons and to show they are not intimidated by terrorism.

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About the Author

Todd Litman (*info@vtpi.org*) is founder and executive director of the Victoria Transport Policy Institute, an independent research organization dedicated to developing innovative solutions to transport problems. His work helps to expand the range of impacts and options considered in transportation decision-making, improve evaluation techniques, and make specialized technical concepts accessible to a larger audience. His research is used worldwide in transport planning and policy analysis.

Mr. Litman is author of the *Online TDM Encyclopedia*, a comprehensive Internet resource for identifying and evaluating mobility management strategies. He has worked on numerous studies that evaluate the costs and benefits of various transportation services and activities. He authored *Transportation Cost and Benefit Analysis: Techniques, Estimates and Implications*, a comprehensive study of transport impacts, which provides cost and benefit information in an easy-to-apply format.

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Assessment of Passenger Security in Paratransit Buses

Andrzej Morka, Military University of Technology, Poland
Lesław Kwaśniewski, Warsaw University of Technology, Poland
Jerry W. Wekezer, Florida A&M University-
Florida State University, College of Engineering

Abstract

The main objective of this study was to assess usefulness of 3-D, nonlinear dynamic, explicit computer codes for transit safety and security research. An analysis of response of a paratransit bus structure under loading caused by high explosive (HE) detonation is presented. It was assumed that the cubic HE charge detonates in the air near the bus. The ground was modeled as a rigid stationary wall. The problem was studied using LS DYNA, an explicit, 3-D, dynamic, nonlinear finite element program. The HE detonation and the processes of shock propagation in the air were modeled using the mesh with the Euler's formulation. The Euler's mesh was modeled as a rectangular prism sufficiently large enough to cover the entire bus structure. The nonreflecting boundary conditions on the top and side surfaces of the Euler's domain and the sliding interface on the bottom side for the contact with the ground were assumed.

A finite element model of the Ford Eldorado Aerotech 240 paratransit bus was developed for this study. This model consisted of 73,600 finite elements and had 174 defined properties (groups of elements with the same features) and 23 material models.

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Computational analysis provided useful information about dynamic deformations and damage inflicted to the bus structure under load blast wave activated by the HE detonation. It allowed for detailed, rigorous analyses of time histories of accelerations, velocities, deformations, and stresses. Resulting acceleration and overpressure histories were correlated with expected blast injuries of the bus passengers. The data obtained can be used to improve passenger safety and to reduce the threat of suicidal terrorist attacks against public transit. Changes in the bus structure and replacement of some materials to build a safer class of vehicles can be carefully considered and implemented.

Introduction

Two different approaches can be used for analysis of the structural response of a bus under loading caused by high explosive (HE) detonation. The first method is based on applying a previously known function of loading (pressure surfaces) to the structure. The time space characteristics of pressure loads can be defined based on data collected in a series of experiments. The same methodology is used for building the mine impulse-loading model (Westine et al. 1985). Although simple, this method of analysis of the structure behavior under blast loading leads to serious limitations. First, no interaction between the structure response and the acting force (blast wave) is included. Yet the actual response of the structure may have a significant effect on magnitude and distribution of air pressure in time, which resulted in this response. Moreover, extrapolation from a finite set of data to specific conditions (geometry, type of HE, its location, etc.) introduces additional modeling errors. Simultaneous modeling and interaction of both processes—the response of the structure and the explosion with shock generation and its propagation in the air—is free of these disadvantages. Insufficient computational power of commonly accessible computers did not allow for implementing this concept in the past. Rapid growth of CPU speed in the new generation of mainframe computers allows for solving these problems. For example, Vulitsky and Karni (2002) successfully analyzed a ship structure subjected to HE detonation. The authors simplified their model to a plate loaded by a pressure wave. Another work presented the results of calculations for a response of protective structures to an internal explosion with blast venting (Kivity 1993), where a rectangular prism shell with venting holes was used as a structural model. A concrete structure with ambient inside and outside air was modeled. One-fourth of the entire physical problem was considered due to symmetry. More examples can be found in the literature,

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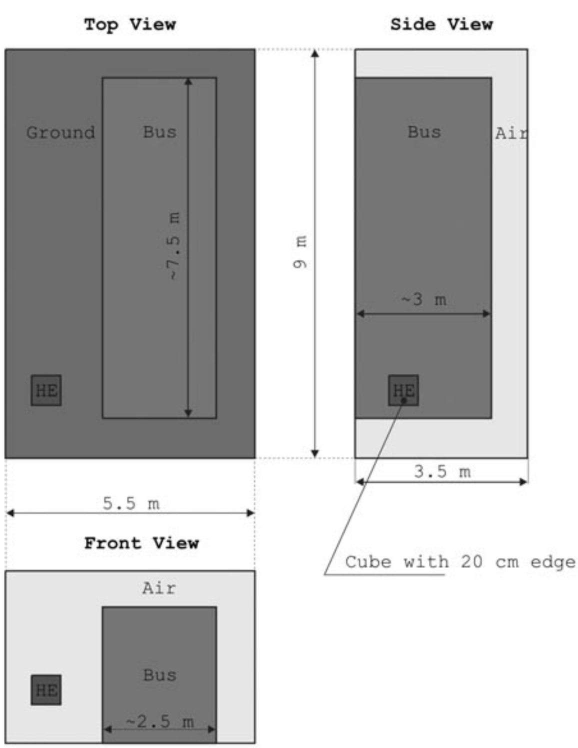
which provide evidence that this approach is becoming dominant. This study continues these trends, which combines advanced modeling of bus structure with simultaneous modeling of blast pressure waves.

Explosion Model

A preliminary analysis of the structural response of a bus under loading caused by HE detonation was performed. Collected data regarding the amount of explosive materials and their possible location during suicidal terrorist attacks on a bus led to several physical assumptions. An explosive charge of 13 kg of C4 detonated in the air, 1 meter above the ground and at a distance of 1.5 meters from the bus (see Figure 1), was assumed. The HE was considered as a cube with a 20 cm edge

Figure 1. Geometry of a Bus Structure under Loading Caused by Explosion of an HE in the Air Domain



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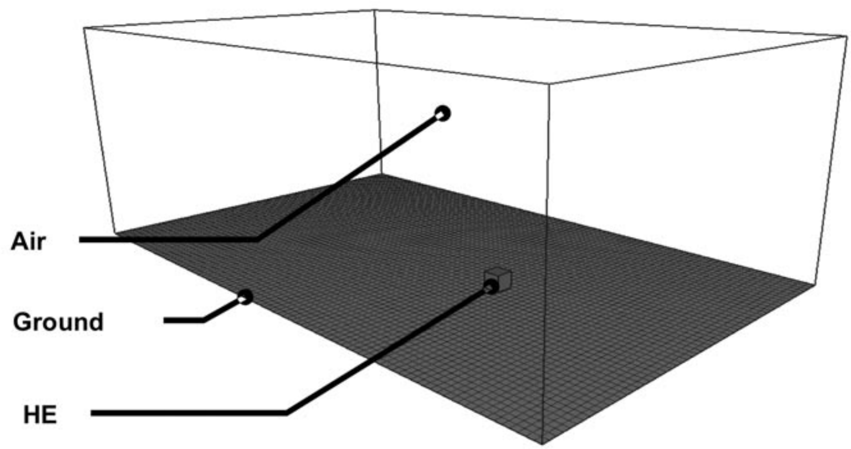
and the point of initiation of detonation in its center. The ground was modeled as a rigid stationary wall. The problem was studied using LS DYNA, an explicit, 3-D, nonlinear finite element code. The HE detonation and the processes of shock propagation in the air were modeled using the mesh with the Euler's formulation. This option was applied using the Arbitrary Lagrangian Eulerian Algorithm (ALE), available in LS-DYNA. The Euler's grid, modeled as a rectangular prism (WxLxH: 5.5x9x3.5 m), was sufficiently large enough to cover the entire bus structure. The nonreflecting boundary conditions on the top and side surfaces of the Euler's domain and the sliding interface on the bottom side for the contact with the ground were assumed. Figures 2 and 3 show the finite element model (FEM) developed for explosion and shock propagation modeling in the air domain.

Figure 2. Isometric View of the FEM with Euler's Domain



The bottom side of the cube in Figure 2 represents ground modeled as a rigid wall. The FE ground model consists of 5,096 shell elements with a typical edge length of 10 cm. Figure 3 presents the cross section of the Euler mesh along with HE charge symmetry plane normal to the bus. The Euler formulation allows for material mixing and mass transfer between FEM elements. The zoomed-in rectangle in Figure 3 shows different grid regions. The entire mesh consists of 241,104 hex elements with a typical edge length of 1 cm for HE to a maximum of 10 cm for air and a suitable intermediate zone between them.

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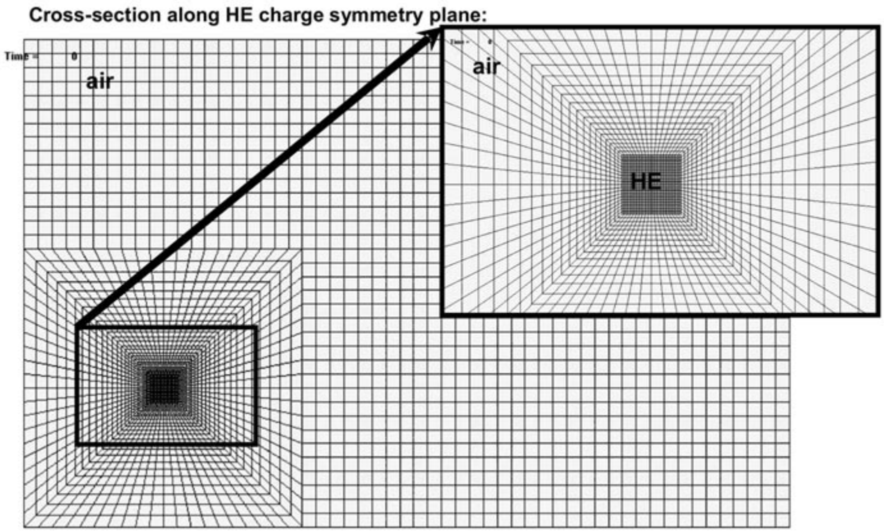
Figure 3. FEM for Euler's Domain: HE and the Air



Cross section along HE charge symmetry plane normal to the bus. The area close to the *HE* location is zoomed in the rectangle in the upper-right part of the figure.

The detonation process was implemented through the automated programmed burn model, supported by LS-DYNA. Velocity of the Detonation Wave (DW) and the thermodynamical parameters on DW front were assumed to be known in this model. A sphere surface was assumed as the best DW front shape since the initiation of detonation begins in the center point of HE charge. The energy contained in the HE was assumed as immediately released inside the front of detonation wave as a result of the chemical reaction

$$HE \rightarrow PD + Q$$

where:

Q represents the heat effect of this reaction

PD are products of detonations

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In addition, 100 percent of HE mass was assumed to transfer to PD. The Jones Wilkins Lee (JWL) Equation (1) was used to characterize the products of detonation of the C4 HE:

$$p = A\left(1 - \frac{\omega}{R_1\bar{\rho}}\right)\exp\left(-R_1\bar{\rho}\right) + B\left(1 - \frac{\omega}{R_2\bar{\rho}}\right)\exp\left(-R_2\bar{\rho}\right) + \frac{\omega\bar{e}}{\bar{\rho}} \qquad (1)$$

where:

ρ	equals $\frac{\rho_{HE}}{\rho}$
e	represents $\rho_{HE}e$
ρ_{HE}	refers to density of the HE
p	represents pressure of PD
e	is specific internal energy of PD
ρ	equals density of PD
A, B, R_1, R_2, ω	are empirical constants determined for the specific type of HE

Table 1 includes values of all these constants found in the JWL equation (Wlodarczyk 1994) for C4 HE used in this work.

Table 1. Constants for the JWL Equation of State for PD of C4

Type of HE	ρ_{HE} [kg/m³]	A [GPa]	B [GPa]	R_1 [1]	R_2 [1]	ω [1]
C4	1,601	609.77	12.95	4.5	1.4	0.25

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The equation of state for an ideal gas with the specific heat ratio of 7/5 was applied for the air. Coupling between Euler (air domain) and Lagrange (bus structure) formulations was accomplished by using an appropriate LS DYNA feature called CONSTRAINED_LAGRANGE_IN_SOLID. The interaction between bus structures and shock was modeled by Penalty Algorithm, an LS-DYNA feature, while shock and ground interaction was modeled as a sliding interface.

Bus Model

Since blueprints and design data of the paratransit bus were not available, the reverse engineering process (Chenga et al. 2001) was adopted to acquire geometric data and to develop the FEM for computational mechanics analysis. The actual bus was carefully disassembled into individual parts to allow for accurate geometric data acquisition. All structural components were taped, scanned, digitized, and mapped into the computer. In addition to geometric entities (e.g., surfaces, curves, points), material and structural properties (e.g., thickness, material type, and weight) were also collected. Subsequently, the scanned geometry for each part was imported into a preprocessor. After all nonstructural components were removed from the bus, its structure was thoroughly examined. The disassembly process resulted in full exposure of the connections of the major components. Joints among the structural parts, such as hinges, rivets, welds, bolts, and rubber pads were identified and were appropriately modeled on the computer using multipoint constraints (MPCs), spot welds, node merging, and node tying.

Scanned geometric data were imported into MSC/PATRAN (2001), a graphical preprocessor, in which FE meshes were constructed and modified. Decisions regarding element formulations, material models, material characteristics, contact algorithms, MPCs and connections, loading and boundary conditions, solution parameters, and others were made to complete the model (Bathe 1998; Omar et al. 1999). Limited laboratory tests were performed for selected structural components and material samples to identify material parameters and connection characteristics.

MPC provided an opportunity to model connection bolts, screws, and welds with failure (LS-DYNA 1999). An example of modeling of spot weld in the bus cage using MPCs can be found in (Kwasniewski et al. 2002).

Self-automatic contact was applied to all the elements in the model. Twenty-three material types were identified for the structural components of the actual bus. The

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bus body was modeled using two layers of composite material with an additional honeycomb layer placed in between them. Composite layers were modeled using shell elements while honeycomb was represented by solid elements.

Significant numbers of the vehicle components were modeled with shell elements since most of the structural parts of the bus were made of metal and composite sheets. A fully integrated quad element number 16, available in LS-DYNA, was selected for analysis as the most reliable element formulation, based on several numerical tests (Alem 1996). The actual Eldorado paratransit bus is shown in Figure 4, while its final FEM is shown in Figure 5.

Figure 4.
Ford Eldorado Paratransit Bus

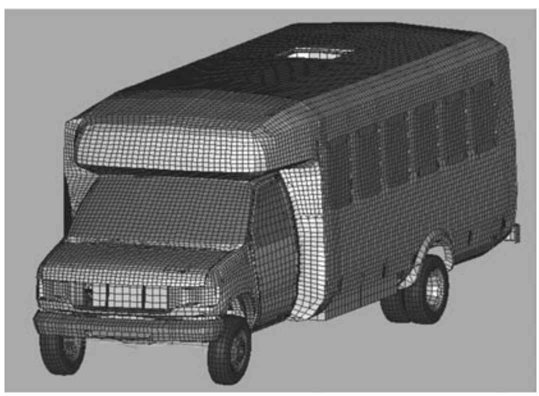

Figure 5.
FEM of the Paratransit Bus

The bus FEM consisted of 174 parts, 23 material models, and 73,595 elements. A summary of the final FEM of the bus is provided in Table 2.

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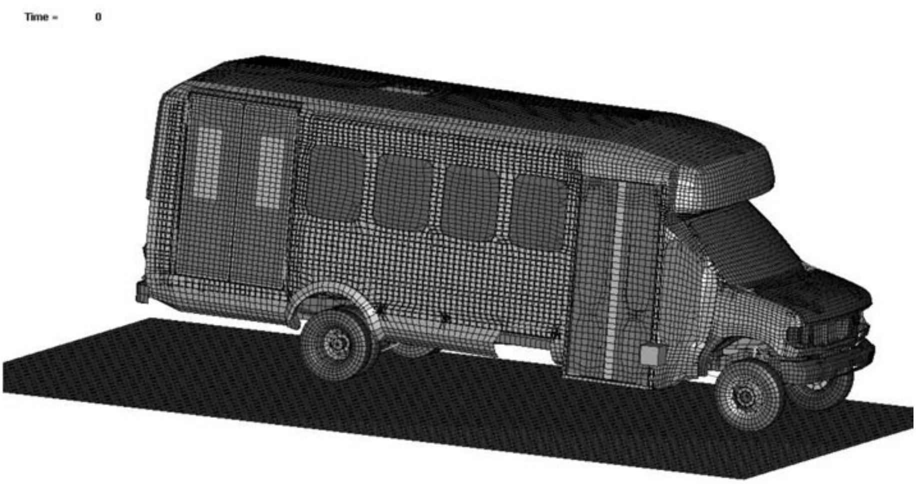
Table 2. Summary of the FEM Bus

1	Number of parts (LS-DYNA)/ Property sets	174
2	Number of material models	23
3	Number of nodes	67,788
4	Number of solid elements	9,612
5	Number of shell elements	63,271
6	Number of beam elements	712
7	Total number of elements	73,595

Analysis and Results

Selected results of this study are presented below. A cube near the front door of the bus in Figure 6 represents the initial position of the HE charge.

Figure 6. Initial Position of HE Charge and Bus Structure



The bus structure was immersed in the Euler air mesh domain so that the distance from an arbitrary element to the nearest boundary was at least 0.5 m. Figure 7 shows the isosurfaces of the pressure in the air after 270 microseconds from the initiation of detonation. The pressure fringes were cut off between 0.101MPa and 0.5 MPa for better visualization. The interior surface surrounds space where the

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blast pressure is larger then 0.5 MPa, while the exterior surface is the boundary of the outside region with the pressure smaller then 0.101 MPa. A blast wave activated by the HE detonation is shown in Figure 7.

Figure 7. Isosurfaces of the Pressure in the Air after 270 Microseconds from Initiation HE Detonation: A Blast Wave Activated by the HE Detonation.

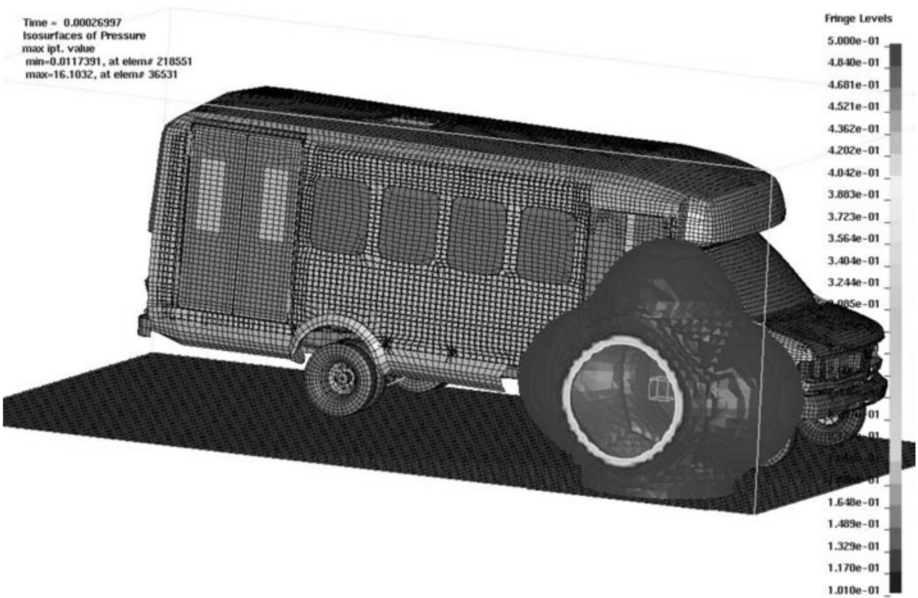

Figure 8 depicts the deformation and damage to the bus structure after the first 30 milliseconds. Interestingly, although HE charge has been detonated outside the bus, the bus structure behaves at some point of time as a pressurized balloon with vent holes. The shock effect and accelerations were examined for four selected points located on the plane of the longitudinal cross section through the bus (Figure 9).

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Figure 8. Damage after First 30 Milliseconds

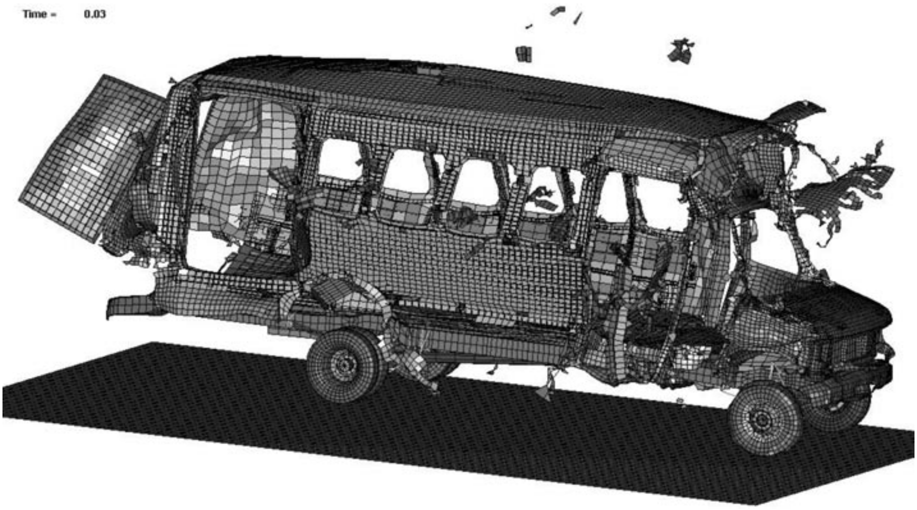
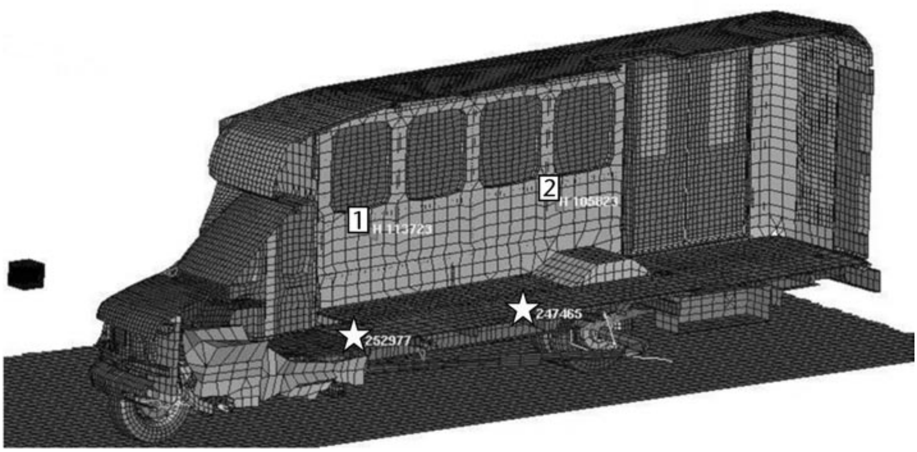


Figure 9. Longitudinal Cross-Section of the Bus Structure



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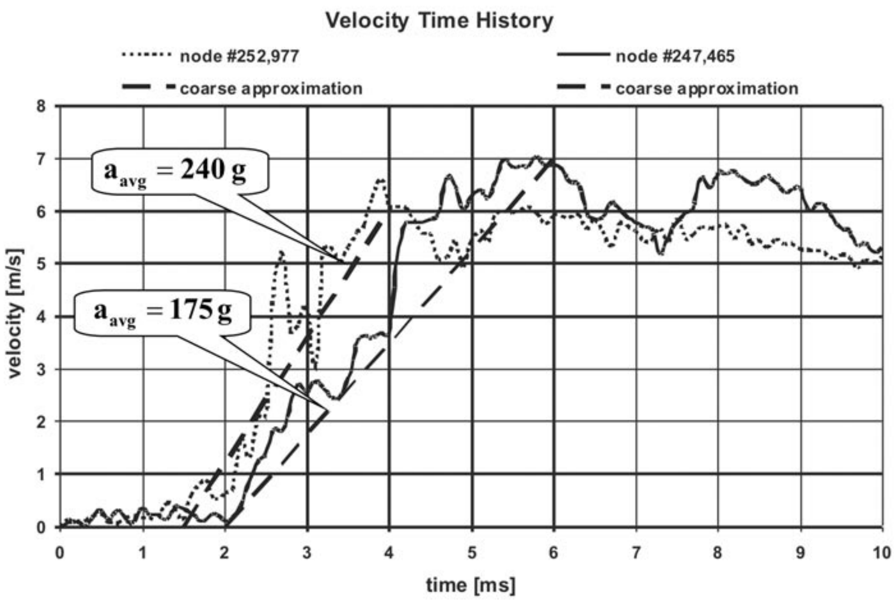
Asterisks were used to mark two points for acceleration analysis; two squares indicate pressure histories. Figure 10 presents the velocity time history for selected points of the bus structure.

Figure 10. Velocity Time History for Selected Points

(see two asterisks in Figure 9)



Average accelerations calculated from coarse approximations of velocity versus time curves reach values of 175g and 240g, where g represents the earth acceleration. Such accelerations result in brain damage or a leg fracture as shown in Table 3. Table 3 shows injury criteria resulting from a mine blast. These criteria were developed by Alem (1996), and were successfully applied by Williams and Fillion-Gourdeau (2002).

Another dangerous factor affecting human life is a short duration of over/under pressure changes, referred to as shock effect. Tables 4a and 4b show the summary of the experimental studies of damage effects caused by high-energy explosives (Turin, unpublished materials). Although rabbits, rats, and pigs were used in these studies, similar effects can be expected for humans. Results from the pig tests are

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Table 3. Mine Blast Acceleration Injury Assessment

Part	*Shock/Acceleration*	*Injury*
Head	a=150g for 2 ms	High risk of brain damage
Pelvis	a=40g for 7ms	High risk of spinal cord damage
Feet	v=3.5 to 5.0 m/s	Apparition of lower leg fracture

Source: Alem 1996.

Table 4a. Overpressure and Blast Injuries

Injury	*Overpressure Values* [kPa]*	
	Rabbits	*Pigs*
Barotrauma	56	56
Mild contusion	134	130
Moderate injury	217	237
Heavy injury	280	371
Lethal injury	490	1074

*Turin, unpublished materials.

Table 4b. Cutoff ΔP Values and Blast Injuries

Injury	*Cutoff ΔP Values* [kPa]*	
	Rabbits	*Pigs*
Barotrauma	33	113
Lung hemorrhage	43	102
Lethal (death)	180	880

*Turin, unpublished materials.

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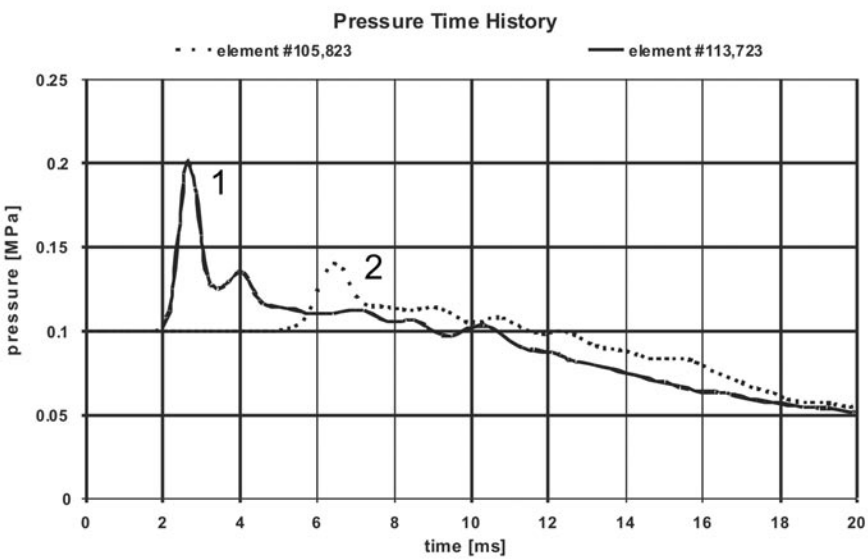
of particular interest because of the pigs' similarity to human mass and structure of body tissues. The cutoff pressure ΔP is also dangerous for humans since it can cause damage, as shown in Tables 4a and b.

Figure 11 presents the pressure time history for selected points of the bus structure marked as two squares in Figure 9.

Figure 11. Pressure Time History for Selected Points

(see two squares in Figure 9)



The overpressure reached a value of about 100 kPa at the first point and 40 kPa at the second one, while the cutoff ΔP pressures were 150 kPa and 90 kPa, respectively. Passengers located near these places were likely to be subjected to barotrauma, mild contusion, and lung hemorrhage.

Conclusions

The principal objective of this project was to carry out the feasibility study of capabilities of FEA for assessment of structural response of a paratransit bus, and survivability of passengers under a suicide terrorist attack. An appropriate meth-

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odology was developed and was successfully used for this problem. Formulation of further, more practical conclusions, would require additional studies. Future research should include a validation process of the bus FEM, numerical data of the shock propagation in the air, as well as validation of shock/structure interaction models through experimental data.

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Partial funding for this project was provided by the Transit Office of the Florida Department of Transportation (FDOT). The FEM of the paratransit bus was sponsored by FDOT. The authors wish to acknowledge the assistance and support from Robert Westbrook, project manager, and Paul Johnson, Jr. The tear down of the bus was professionally performed by QMG Consulting Inc. Thanks are due to Paul Queen and Cecil Carter from QMG Inc. for their excellent work and technical support. Our gratitude also goes to research assistants Hongyi Li and Ravi Nimbalkar for their participation in the digitizing and model development of the paratransit bus.

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About the Authors

Andrzej Morka (*andrzej.morka@neostrada.pl*) is a doctoral candidate at the Military University of Technology, Warsaw, Poland. He worked on a research project related to armor penetration and was sponsored by ARL as a research assistant in the Crashworthiness and Impact Analysis Laboratory at Florida A&M University-Florida State University (FAMU-FSU) College of Engineering from January - December 2003.

Leslaw Kwasniewski (*l.kwasniewski@il.pw.edu.pl*) is an assistant professor at the Institute of Structural Mechanics, Department of Civil and Environmental Engineering, Warsaw University of Technology in Poland. He also worked as a post-doctoral research associate in the Crashworthiness and Impact Analysis Laboratory at FAMU–FSU College of Engineering on several projects between 2002 and 2005.

Jerry W. Wekezer (*wekezer@eng.fsu.edu*) is a distinguished professor at FAMU–FSU College of Engineering in the Department of Civil and Environmental Engineering. He is also a director of the Crashworthiness and Impact Analysis Laboratory where the study presented in this article was carried out.

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Fail-Safe Methods for Paratransit Safety

Joanne M. Sulek and Mary R. Lind
North Carolina A&T State University

Abstract

The purpose of this study was to illustrate that a systems approach to transit safety can be used to develop a methodology to fail-safe or mistake-proof paratransit operations. The fail-safe methodology illustrated in this article was implemented in a small rural transit system in the southeast U.S. Results demonstrated that safety problems often stem from an interaction of service errors and system components. Results also revealed that fail-safe methods that target specific user groups are more effective than more general methods.

Introduction

Mistakes occur in all paratransit systems. Some of these mistakes may lead to significant service failures that could endanger passengers, drive up insurance costs, diminish productivity, and damage the transit system's reputation. Advanced computer software and state-of-the-art equipment do not insulate paratransit systems from errors that could compromise service safety (Einstein 2001). Moreover, many transit systems, especially rural and small urban systems, cannot afford expensive technology or external consultants to help them mistake-proof operations.

Given increasing liability costs, paratransit managers need inexpensive yet effective error prevention techniques that are easy to understand and simple to imple-

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ment. To meet this need, this study developed a fail-safe methodology to help managers identify and correct mistakes before they generate significant safety problems. This fail-safe methodology represents a hands-on approach to reducing errors in service delivery. Like other quality management tools, fail-safe techniques have played a role in industrial quality programs for many years (Stewart 2003). In contrast to statistical process control methods, which require statistical analysis of large amounts of historical data, fail-safe techniques emphasize performance standards, worker empowerment, and information flows to prevent defects. This study will illustrate how an actual paratransit system used a fail-safe methodology to analyze the error generation and prevention process in its operations.

The next section provides an overview of the systems approach to the mistake-proofing process for service safety. A discussion of the research context and the methodology follows this overview. An application of the methodology in an actual paratransit system is then presented. The article concludes with the managerial implications of the study.

A Systems Approach to Paratransit Safety

The delivery of safe transit service requires a coordinated effort between transit workers and transit customers, as well as the effective use of technology and management and control systems (Prioni and Hensher 2000). Since a safe operation is the product of the entire transit system rather than a single component of the system, preventing mistakes that could endanger passengers or lead to injury, accidents, or property damage requires a systemwide approach (Sulek and Lind 2000). In describing their framework for service delivery, Chase and Bowen (1991) emphasized the need for a systems approach when analyzing and improving service operations and identified technology, systems and people as the three major components of service operations. This article will adopt Chase and Bowen's systems framework to study how potentially harmful mistakes may be generated in a paratransit system and how these mistakes could be prevented before they endanger system employees, the public, or property.

Like Chase and Bowen's (1991) framework, the systems approach that will guide this fail-safe study models technology, systems and people as the three major components of service delivery. In a paratransit system, the technology component includes vehicles, lift equipment, machinery, and tools, as well as facilities like garages and administrative offices. The systems component involves procedures

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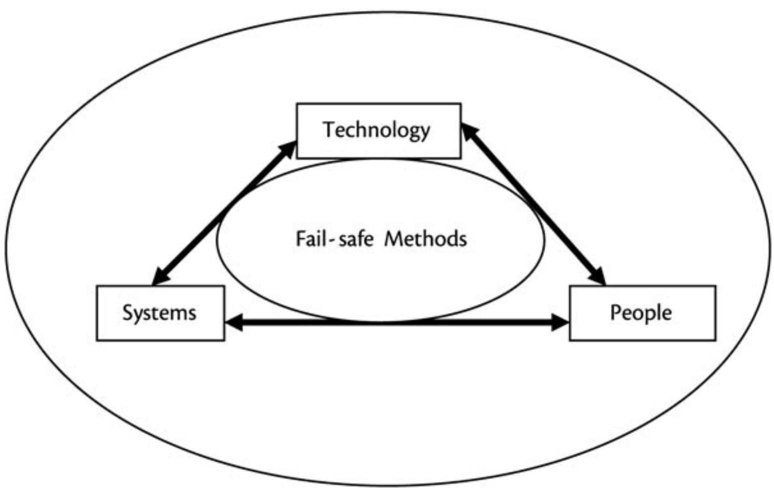
and software for scheduling, routing, maintenance, transport, inventory, planning, and performance evaluation. The final component, people, encompasses both the service providers, such as drivers and office personnel, and community stakeholders, such as riders, local agencies, medical providers, and industries.

An effective fail-safe methodology should address all three system components and help the manager anticipate how these components might interact to produce errors that could endanger others or damage property. For example, if a driver lacks technical skills or knowledge, he may make a serious mistake in operating the van lift equipment and injure himself or the passenger (people-technology interaction). If the scheduling system does not capture critical information regarding a passenger (e.g., the rider is hearing impaired), the driver will not be forewarned of a potential safety problem (people-system interaction). If the maintenance scheduling software is not reliable, it may fail to schedule routine maintenance for a van. Poor maintenance could result in mechanical failure that may endanger the driver and riders (technology-system interaction). If the scheduling software does not remind a driver that it is time for a routine physical, a health problem may go unnoticed until driver impairment causes a traffic accident (people-system-technology interaction) (Figure 1).

Figure 1. Systems Model of Paratransit Service Delivery



Not all service errors arise from an interaction of two or more system components. Some mistakes result from the people component alone (Friman et al. 1998). For instance, a dispatcher could jeopardize an elderly dialysis patient's health by not promptly notifying a van driver that the patient was ready for pick-up from the doctor's office. A driver may spend too long taking a break and later try to compensate for lost time by rushing passengers. A front-office worker may forget to notify a passenger about a change in rider eligibility status. These types of worker-generated mistakes clearly require fail-safe measures.

Fail-safe measures also apply to the behaviors and attitudes of paratransit customers. In many services, a significant proportion of problems stem from mistakes made by the customers themselves. Chase and Stewart (1994) identified three major sources of customer mistakes: (1) failure to understand and anticipate the customer's role during service delivery; (2) failure to follow instructions, remember crucial steps, or communicate service needs during the service process; and (3) failure to alert management about service problems once the service is complete. Since riders and other paratransit customers can make any of these mistakes, fail-safe methods that target customer participation skills and information access can help promote paratransit safety.

In particular, elderly riders may benefit from such fail-safing efforts. The number of elderly citizens in the United States is expected to increase significantly as baby boomers age. Mobilty needs of the elderly are expected to increase as larger numbers of older adults try to lead active lives, despite age-related problems that impair driving skills (Rosenbloom 2001). Elderly drivers tend to experience high accident rates (Burkhardt 1999); moreover, even conservative projections indicate that, by 2030, the number of fatalities in automobile accidents involving elderly drivers will quadruple the 1996 level (Hildebrand 2003; Burkhardt and McGavock 1999). Paratransit services that are safe and easy for elderly riders to use can reduce the need for older adults with serious health problems to drive. In addition, fail-safe methods can help elderly riders use paratransit systems safely.

In addition to addressing the people, technology and systems components of service delivery, a fail-safe methodology must also analyze the relationships among the various stages in paratransit service. There are two arguments for modeling paratransit service as a multistage process. First, the consequences of the interactions among technology, people, and systems may vary with the service stage. For instance, if a dialysis patient unbuckled one of his safety belts during transport, serious injury could result if the driver had to slam on the brakes suddenly. If

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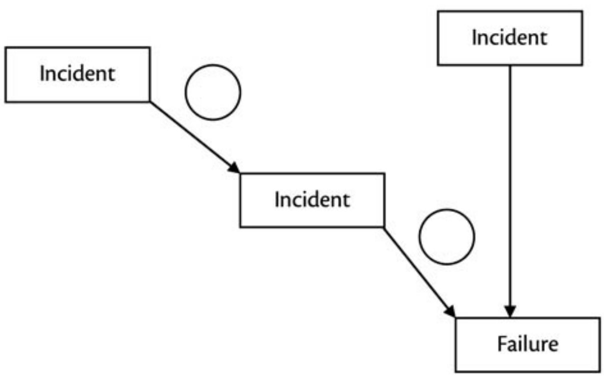
the van has already stopped at the dialysis center when the rider unbuckles the belt, risk to the patient is not nearly so great. Second, the stages of paratransit service are not independent of one another. What happens at one stage may affect service delivery a later stage. If unchecked, small mistakes made during an early, or upstream, stage of the service process may "snowball" into problems at a downstream stage (Perrow 1984) (Figure 2). These problems may involve minor incidents or catastrophic failure. For instance, if the first passenger on a route is late for pick-up, the driver may not be able to pick up other passengers on time. These other passengers could arrive late for their medical appointments or miss them entirely, thus endangering their well-being.

Figure 2. System Failure/Snowball Effect



Although interdependency among service stages is quite common in many service operations, little research has been done to illustrate the effectiveness of a multistage approach to process improvement (Sulek 2004). However, a few recent articles in the service management literature have argued that a stage-by-stage analysis of a service operation can reveal problems that could be overlooked by organization-level analysis alone. For instance, Souteriou and Hadjinicola (1999) used a multistage approach to optimize customer perception with service delivery. Armstrong (1995) modeled the effect of service interventions in multiple service stages as a function of customer perceptions and service attributes at each stage. Sulek, Marucheck and Lind (2005) analyzed labor productivity in a multistage service process consisting of serially dependent stages.

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A fail-safe methodology based on multistage analysis can do more than help managers avoid routine errors; it can also help to prevent major service failures that appear to occur simply by chance. Perrow (1984) discussed such failures and concluded that many result from an unanticipated interaction of multiple errors that arise from multiple sources. These errors, taken individually, may not seem significant, yet their interaction can produce catastrophic consequences.

Since even small mistakes can cause major problems, paratransit managers cannot afford to be reactive or adopt a hit-or-miss approach in error prevention. Instead, managers need a more rigorous approach that will help them break the chain of service errors that can lead to safety problems or catastrophic service failures. The following section describes such a fail-safe methodology and discusses how it was used to mistake-proof operations at a small urban transit system.

Research Context and Method

A rural paratransit system located in western North Carolina served as the research context for this study. The system served an area covering 500 square miles and operated 27 lift vans. The system's exposure to safety problems had risen significantly over the past decade, with vehicle miles increasing from 325,000 miles per year to 750,000 miles per year and the number of passenger trips growing from 50,000 trips per year to 90,000 trips per year. Providing safe, dependable transport was a priority for the manager of this system. The manager realized that mistakes had led to accidents and service incidents in the past and decided to apply fail-safe procedures to aspects of operations that could compromise safety.

To begin the fail-safe effort, the manager and the authors used system records, the manager's expert knowledge, and process mapping to model service flows and identify key service stages or links. Problem areas that needed fail-safe attention were determined for the stages in the process map. An iterative process, as shown in Figure 3, was used to trace problem causes and devise and assess fail-safe solutions.

From this collaborative analysis, a fail-safe methodology was developed. The following activities constitute a continuous fail-safe process:

- Develop and revise a process map of service delivery. By indicating the individual service delivery stages, the process map will make it easier to determine where service problems occur (Chase and Stewart 1994).

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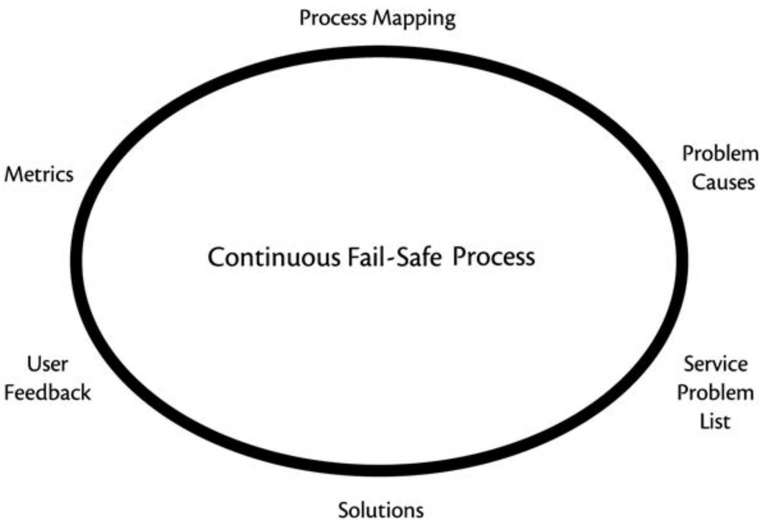
Figure 3. Fail-Safe Process



- Create a list of service problems that occur at each service stage in the process map. Maintaining a list of problems and complaints as they arise will help with this step. Using this list, feedback from transit employees and customers, system performance metrics, and maintenance and repair records, the manager can anticipate future safety incidents and problems.
- Identify the causes or errors that could lead to the problems listed in the preceding step. Finding the causes often involves working backward through the process to identify the original mistakes that "snowballed" or escalated into downstream service failures.
- Devise fail-safe solutions to prevent the types of mistakes that were identified in the preceding step.
- Develop service performance metrics based on operating data to assess the effectiveness of the fail-safe methods.
- Gather feedback from service customers to assess quality of service delivery.
- Use the performance metrics and customer feedback to update the fail-safe methods and improve service performance.

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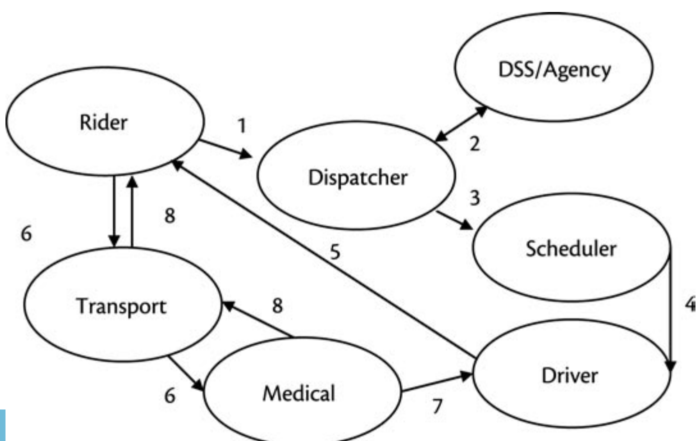
An initial activity in the fail-safe process involves charting all of the critical stages that service delivery entails. The process map should accomplish three important objectives: (1) trace the rider's participation in service delivery; (2) highlight critical back-office tasks; and (3) identify all major points of interaction between transit employees and riders. It is important to meet all three objectives because riders' mistakes, employees' errors, and problematic interactions between transit workers and customers all contribute to safety problems.

Figure 4 presents a process map for paratransit services provided by the small system that served as the research context in this study. The process map depicts eight critical stages in this paratransit operation: (1) the rider's initial request for service, which is shown as the Rider-Dispatcher link on the diagram; (2) confirmation that the rider is eligible for services, which involves the Department of Social Services (DSS)/Agency-Dispatcher link; (3) ride scheduling, which involves the Dispatcher-Scheduler link; (4) manifest creation, which involves the Scheduler-Driver link; (5) rider pick-up, which involves the Driver-Rider Pick-Up link; (6) transport of riders to their appointments, which is shown as the Rider-Transport link; (7) rider pick-up after their appointments, which involves the Doctor's Office-Driver link; and (8) transport of the riders back home, which is shown as the Return Trip link.

The next phase of the fail-safe process involves an examination of each critical link in transit service delivery. A close look at each link can help the manager

Figure 4. Transit Process Flow



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determine the types of service problems that could occur at each stage and make it easier to identify the mistakes that caused them. The analysis should include all service problems—not just apparent safety problems—because an interaction of even minor service errors can sometimes generate serious incidents. Tables 1 and 2 illustrate the problem/cause analysis phase for two service links: the Driver-Rider Pick-Up link and the Transport link. (Similar tables were developed for the other service links but are not shown.)

Table 1. Driver-Rider Pick-Up Link:
Service Problems and Mistakes

Problems	*Causes*
Driver is running behind schedule	Schedule creep
	Driver misjudged pick-up time and travel time
	Rider provided the wrong pick-up address
	Time of day
	Adverse weather conditions
	Delays en route—accidents, road construction, etc.
Driver must wait for rider	Rider does not understand that he/she must be ready prior to pick-up time
Rider no -show	Rider misunderstanding
	Nursing home does not have patient ready
	Rider forgot to cancel ride appointment
Rider has mishap while boarding	Physical barrier to safe boarding
	Rider not able to board due to illness
Driver does not allow rider to board	Parent brings along child without approved child seat
Driver needs help in getting rider safely on board	Inadequate, homemade ramps at passenger's home
	No ramp and no sidewalk so driver cannot push wheelchair from door to vehicle
Paratransit van cannot get near the house	Tree limbs obstructing driveway Ruts in driveway
	Fallen trees in driveway
	Driveway too long to drive down
	Driveway too steep
	Rider did not inform the dispatcher of barriers to boarding the vehicle
Passenger is not aware that van is waiting	Hearing-impaired rider does not hear driver blowing the horn and has not informed the dispatcher about the impairment

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In the Driver-Rider Pick-Up link, both riders and drivers face such service problems as late pick-ups, boarding mishaps, and physical barriers to boarding. As Table 1 illustrates, these problems stem from a variety of causes.

Riders can cause pick-up delays if they are not ready to leave when the van arrives, if hearing impairment prevents them from hearing the driver blowing the horn, or if they simply forget to cancel their ride appointments. Agencies like nursing homes also cause delays and no-shows if they do not have patients ready for transport when the van arrives. All of these mistakes involve the people component of the service system. On the other hand, there are a number of other causes for late pick-ups that are beyond an individual's control. These include heavy traffic, accidents, road construction, and adverse weather conditions. Schedule creep also contributes to late pick-ups.

Boarding mishaps can occur if riders who use wheelchairs rely on inadequate homemade ramps to help them exit their homes. Such ramps can easily collapse, injuring both the passenger and the driver. Without an adequate ramp, a driver may require a great deal of extra assistance with the passenger. In some cases, it may be impossible to get the rider on board safely, and the driver may have to refuse service to the passenger. A driver will also refuse service when parents try to bring children on board without approved safety seats. Both of these problems involve both the technology and people components of service delivery, since rider ignorance and faulty equipment can diminish safety.

Sometimes a driver in this paratransit operation cannot get the van close enough to the rider's home for a pick-up. A number of physical barriers can block safe access to a rider's home. For instance, fallen trees or tree limbs may obstruct the driveway; the driveway itself may be too steep, too winding, or too long to travel over safely; or the road surface may contain deep ruts or be too muddy. Drivers may find that even if a driveway is fairly safe, there is no way to easily push a wheelchair across the passenger's yard to the van. A driver may need a great deal of extra help in conveying a wheelchair rider to the van if no sidewalks are available.

Table 2, which shows the Rider-Transport link, describes the kinds of problems a passenger might experience during an actual ride. The worst problems include traffic accidents, which stem from poor driving technique by the van operator; driver inattention, driver impairment and on-board distraction; passenger injuries, which result from traffic accidents; failure to secure passengers in their seats; and passengers' misunderstanding of the rider's role during transit. At this paratransit system, some wheelchair riders have been injured after unfastening seat belts and

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Table 2. Transport Link: Service Problems and Causes

Problems	*Causes*
Traffic accident	Following too closely
	Driving too fast
	Ignorance of traffic laws
	Unable to read or comprehend English well
	Erratic speed changes
	Erratic direction changes
	Inattentive driver
	Poor road conditions
	On-board distractions
	Driver impairment
Ride is not smooth	Vehicle suspension
	Tire failure
	Sudden stops
	Quick starts
	Sudden or fast turns
Temperature is too hot/cold	Driver inattention
	Inadequate equipment
	Equipment malfunction
Passenger creates disturbance	Rude passenger behavior
	Passenger misunderstands rider responsibilities and rules of travel
	Passenger is frightened
	Passenger is mentally unstable
Passenger injuries	Wheelchair not properly secured
	Seat belt and shoulder strap not securely fastened
	Children not secured in appropriate child safety seats
	Passengers do not understand responsibilities
	Safety strap left in the aisle
Vehicle breakdown	Equipment malfunction
	Poor preventive maintenance
	Hazardous environment
On-board medical hazard	Passenger illness/accident
	Driver illness/accident

straps while the van was nearing the dialysis center. These passengers thought they were being helpful by speeding up the unloading process and did not realize that their behavior was inappropriate and unsafe until it was too late. To a large extent, these problems involve the people component of service delivery.

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Vehicle breakdowns and equipment malfunction can also give the impression that a ride is not a safe one or can lead to accidents. These problems may stem from poor preventive maintenance, unsuitable operating environments (such as badly rutted dirt roads), or inadequate equipment (such as an air conditioning system that is too small to cool the van if the doors are opened frequently). These types of problems pertain mostly to the systems and technology components of service delivery.

Even if a passenger considers a ride safe, he or she may find it unpleasant. This can occur if the driver is rude or unhelpful to passengers, if the ride is not smooth, or if fellow passengers are disruptive or threatening. The passenger may also believe that the service is too slow. While poor road conditions can make a trip seem longer, a driver's failure to stay on schedule can also delay a trip. The people component of service delivery contributes to many of these service problems.

Development of Fail-Safe Methods

Once a manager identifies mistakes that cause service problems, fail-safe methods can be developed to reduce the chance of service errors. These fail-safe methods may involve improving access to information, instituting some new operating procedures, and modifying worker or rider behavior.

As Table 3 shows, the chief causes of late pick-ups and boarding problems on the Driver/Rider Pick-Up link stem from schedule creep, adverse road or weather conditions, rider mistakes, and physical barriers to boarding. Better training of drivers in the importance of on-time pick-ups may help reduce schedule creep. Reduction of the number of no-shows can also help diminish schedule creep. To help minimize no-shows, the dispatcher at this system could phone elderly riders the day before their appointments to remind them of the pick-up time. The dispatcher could also phone nursing homes with high no-show rates 10 minutes before scheduled pick-ups and ask personnel to have the patient ready for pick-up. In the event of adverse travel conditions, the dispatcher at this system could call the doctor's office to try to reschedule the rider for a later appointment or might call the rider to cancel the pick-up if the roads are unsafe. The dispatcher also can help prevent some of the riders' mistakes by asking them to be ready one hour early for pick-ups on long routes or by reminding a parent to bring along an approved child's seat if his or her child will be riding in the van.

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Table 3. Driver/Rider Pick-Up Link: Problem Causes and Fail-Safe Solutions

Causes	*Fail-Safe Solutions*
Schedule creep	Minimize no-shows
	Greater emphasis on time pick-up in driver training classes
	Monitor drivers' driving times
Time of day	Add extra van
	Choose different routes
Adverse weather conditions	Dispatcher calls rider to cancel pick-up if roads are dangerous
	Post notice on local radio, TV, and cable TV stations
Delays en route — accidents, road construction, etc.	Dispatcher calls doctor's office to see if rider can be late for appointment
Rider does not understand that he/she must be ready prior to pick-up time	DSS representative
	Reminder cards for riders
	Dispatcher gives nursing home a phone call 10 minutes prior to van arrival
	Dispatcher gives the rider a window on pick-up time when he or she calls for a ride
	Dispatcher reminder
Rider misunderstanding	DSS/agency representative
Rider forgets to cancel ride appointment	DSS/agency representative
Physical barrier to safe boarding	Volunteer agencies
	City or county services
Parent brings along child without approved child seat	Signage, newsletter, driver intervention, local radio and TV spots
Inadequate, homemade ramps at passenger's home	Volunteer groups
No ramp available	Volunteer groups
No sidewalk so driver cannot push wheel-chair from door to vehicle	Help from EMS, operations manager, transit manager, another driver, or neighbors
Limbs obstructing driveway	Volunteer groups, city, county or state agencies
Ruts in driveway	Volunteer groups, family members
Fallen trees in driveway	Volunteer groups, family members
Driveway too long to drive down	DSS/Agencies
Driveway too steep	DSS/Agencies
Hearing-impaired rider will not hear driver blowing the horn	Rider instructed to watch for the van and driver goes to the front door or window

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The Department of Social Services and individual agencies can also help to educate parents about the importance of approved safety seats when their children ride in the van and can explain how to obtain these seats free of charge from the local fire department. The fire department currently trains parents in the correct use of the safety seats. The DSS can further decrease rider error by educating riders about the need to cancel pick-ups if their plans change.

The preceding discussion illustrates that the people component of the system can help address many of the errors at this service link. In particular, better education of the riders and agencies in their roles as paratransit customers represents a promising fail-safe approach.

Fail-safe methods that deal with the systems component of service delivery can also be used at this link. For instance, the transit manager regularly addresses the problem of physical barriers to boarding. If low tree branches obstruct access to a rider's driveway, either the transit manager or the operations manager will inspect the problem. Usually, they ask the city utility service to clear away the overhanging tree limbs. In this transit system, volunteers from the local churches and the Senior Center help to fix ruts in riders' driveways or clear fallen trees from driveways. Volunteers also build safe ramps for riders who need but cannot afford them. As mentioned earlier, safe ramps are essential to boarding safety; a driver may refuse to board a rider if the ramp appears unsound. If a rider's yard is inaccessible, the driver can call the local Emergency Medical Service (EMS), the operations manager, or the transit manager for immediate help with the passenger.

Service problems and potential fail-safe solutions for the Transport link are summarized in Table 4. This table reveals that some of the technical mistakes that drivers make, such as following too closely or driving too fast, stem from insufficient time to complete the route safely. Poor planning by the driver can cause this time shortage, but so can schedule creep from no-shows and delays that riders cause during pick-ups. If a driver attempts to compensate for these delays with aggressive driving, accidents can occur. Thus, fail-safe measures that address no-shows and rider-generated delays at earlier service links may help reduce the likelihood of accidents during transport.

Driver training, vehicle inspection, and managerial observation of driver performance also constitute fail-safe methods for the Transport link. Training classes can target various issues, such as driving techniques, dealing with disruptive passengers, first aid/CPR, and drug and alcohol awareness. Reinforcement of material covered in training classes also serves as a fail-safe method. For instance, a sign with

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Table 4. Transport Link: Problem Causes and Fail-Safe Solutions

Problem Causes	*Fail-Safe Solutions*
Driving too fast	Not allowing appropriate amount of time to complete the route
	Poor planning by the driver
	Drivers instructed to drive 5 mph below speed limit on secondary roads
	Drivers instructed not to exceed 60 mph on highways and interstates
Following too closely	Manager observation of driving habits; Training
Erratic driving habits	Manager observation of driving habits
	Manager rates driver's performance
Driver inattention	Retraining
Poor road conditions	Alternate routing
On-board distractions	Passenger conduct rules enforced
Driver impairment	Driver physicals; testing
	Driver trained to call for assistance
	Drug/alcohol training
Equipment malfunction	Daily inspection preoperation by driver
	Daily inspection by driver during operation
	6,000 mile oil change and inspection
	Annual vehicle inspection
	Spot inspection by managers
	Incident report
Rude passenger behavior	Passenger conduct rules enforced
	Incident report
Passenger is frightened	Driver trained to reassure passenger
Wheelchair not properly secured	Check for correct fastening at all 4 points prior to transport
	Check seat belt and shoulder strap prior to transport
Passenger illness/accident	Hazard treatment kits
	Incident report
	Annual first aid and CPR training

a single question about correct safety procedure (e.g. "How should you hold a baby to administer CPR?") can be placed where drivers will see it before they begin their route. The manifest pick-up point is a good location for such "memory ticklers."

The preceding discussion shows that many of the fail-safe methods appropriate to this link involve the people component to a large extent; however, the technology

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component also plays a critical role. Since mechanical failure can cause serious safety problems with the vehicle or lift equipment, preventive maintenance fail-safe methods are especially important. For instance, at this system, each van driver must inspect his vehicle prior to beginning his route. Among other things, the driver must measure air pressure in the tires and check the oil level for the engine, the coolant level, the power steering fluid level, and brake fluid level. After completing the inspection, the driver must complete the pretrip inspection form and note any problems with the vehicle. He must then either correct the problem or request another van. Prior to using the replacement van, the driver must conduct an inspection and complete a pretrip form for the new van. If the manager discovers that a driver either overlooked a problem or did not report it on the pretrip form, the manager will do the pretrip inspection with the driver until the manager determines he need no longer do so. The 6,000 mile oil change and inspection for each vehicle also captures how well each driver maintains his or her vehicle.

Testing the Effectiveness of Fail-Safe Methods

After a manager implements fail-safe methods, he needs to gauge their effectiveness. There is no way for a manager to know if the new methods actually improved service quality unless he selects and monitors performance metrics for those aspects of service he was trying to fail-safe. For instance, at this transit system, the manager created a demand response form to capture data on assigned pick-up times and actual pick-up times for each rider. The data enabled the manager to estimate variances in pick-up times and determine if the system was doing a better job in reducing wait times for passengers. Analysis revealed that a slight variance reduction (<5%) occurred after driver training classes placed increased emphasis on meeting pick-up times.

Similarly, the manager collected data on the number of riders that were "no-shows" when the van arrived for pick-ups. This type of data was useful for determining if fail-safe measures helped riders do a better job of being ready for pick-up. Analysis showed that reminder phone calls to elderly riders who were frequent no-shows reduced the no-show rate for this particular group by 50 percent. Analysis also showed that the call-ahead policy to nursing homes whose patients were habitually late resulted in an almost 100 percent improvement in the problem.

Another set of metrics for this system reveals the effectiveness of the fail-safe methods for preventive maintenance. As mentioned earlier, a variety of methods

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such as pretrip inspections, pretrip inspection forms, spot checks by the system manger and the operations manager, the 6,000-mile oil change and inspection, and an annual inspection are used to make preventive maintenance fail-safe. Results reveal that the number of wrecker calls for disabled vans declined by 90 percent. The severity of the problems also declined; before preventive maintenance was made fail-safe, many wrecker calls involved serious mechanical failures like broken axles or brake failures. After fail-safe procedures were initiated, most wrecker calls involved a flat tire or a vehicle stuck on a muddy or flooded road. Other performance metrics confirmed the effectiveness of the fail-safe methods for preventive maintenance: tire wear improved from 18,000 miles before the fail-safe program began to 30,000 miles afterward, while brake lining wear increased from 14,000 miles to 40,000 miles.

The manager also used the wrecker calls, tire wear, and brake wear metrics to gauge the effectiveness of the driver training programs. These metrics and tire wear patterns are also used to compare driver performance and identify which drivers exhibit erratic driving techniques.

In addition to collecting operating data to assess service quality, the transit manager gathered information on perceived service quality from customers and analyzed their suggestions and complaints. The manager at this system routinely administered a survey on needs and resources to agencies served by the system. This survey consisted of both scaled questions and open-ended questions. The scaled questions dealt with such issues as overall satisfaction with paratransit service, timely provision of service, dependability of service, professional skills of the drivers, interpersonal skills of the drivers, and courteous and professional treatment by front-office employees. The open-ended questions asked what the system could do to improve service to the agencies and their clients, what agencies considered the major shortfalls in current service, and what gaps existed in transporting clients. Analysis of the comments revealed that not all clients were aware of the range of transit services provided by this system and that some customers simply did not understand how to use the system properly. For instance, one respondent did not realize that transport of patients on oxygen was already available, while others felt that the system was not responsive to the timing of their scheduling requests. The manager decided that "refresher" training sessions for clients at participating agencies would be helpful. At such sessions, the trainer could not only review the procedures for requesting service but also explain why certain rules were in place.

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In addition to explaining how to use paratransit services, the trainer at these sessions could also distribute wallet-sized cards listing the most important rules a rider must follow. Some attendees may benefit from having a handy "reminder card" to help them remember what to do to successfully access services. If the print is easy to read and the color of the cards is bright, riders may be more likely to keep them and refer to them.

Managerial Implications

The purpose of this study was to illustrate that fail-safe methods constitute a simple, low-tech, low-cost approach to reducing errors that could lead to safety problems in paratransit operations. While a small paratransit system served as the study's research context, the methodology presented in this article is applicable to other transit operations and to nontransit services.

Results from this study showed that at this transit system, fail-safe measures that targeted a specific rider group were far more effective in reducing mistakes than more generic fail-safe methods. For instance, the "call ahead" policy resulted in almost 100 percent improvement on delays caused when nursing home patients were not ready for pick-up. In contrast, an increased emphasis on drivers' attention to pick-up times produced only slight improvement (<5%) in pick-up time variances.

This study also reveals that paratransit managers should not rely just on technology solutions to prevent service errors, because safety problems can arise from a variety of interactions within the service system. These interactions may be complex and may involve transit workers, riders, health care providers, vehicles, equipment, software, operating procedures and control systems. Safety problems can also arise from the combined effect of several relatively small mistakes. Technology alone cannot eliminate these mistakes or control all possible interactions in the system. Instead, a comprehensive fail-safe methodology that simultaneously addresses the people, technology and systems components of service delivery at each stage in the service process can help the manager anticipate and prevent mistakes that compromise service safety.

It is important to recognize that paratransit service is a multistage process. Moreover, the individual stages are not independent. Some problems that occur at later stages actually began with mistakes or service errors that originated at earlier stages. For instance, at the paratransit system in this study, late arrivals, missed

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appointments and poor driving techniques—all of which can endanger a dialysis patient—are partly affected by poor rider participation skills. Riders who are not ready at their pick-up times or are frequent no-shows can cause serious delays in the transport of other passengers. Rider/caregiver training—a fail-safe method based on the people component of service delivery—can reduce the likelihood that poor customer participation skills early in the service delivery process will generate service errors in later service stages.

The fail-safe methodology presented in this study represents a process approach for anticipating the complex interactions that produce safety problems. At this paratransit operation, specific fail-safe solutions were devised and continue to be refined. While these fail-safe solutions were based on cause and effect relationships that were observed or anticipated, they did not involve mathematical modeling techniques. Future research is needed to determine if dynamic quantitative modeling techniques could outperform the seasoned, expert manager using system fail-safe methodology.

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About the Authors

Joanne M. Sulek (*Sulekj@ncat.edu*) is a full professor at the School of Business and Economics at North Carolina A&T State University, where she has been a member of the faculty since 1986. She earned a Ph.D. in Business Administration from the University of North Carolina at Chapel Hill. She has published in numerous journals, including *Management Science*, *Decision Sciences*, the *Journal of Public Transportation*, *IEEE Transactions on Engineering Management*, and others. Her research interests include service quality, quality control, and forecasting.

Mary R. Lind (*Lindm@ncat.edu*) is a full professor at North Carolina A&T State University, where she has been a member of the faculty since 1985. She earned a Ph.D. in Business Administration from the University of North Carolina at Chapel Hill and has over 20 years of college-level teaching experience and 10 years of industry experience in systems design and development. She has over 20 referred journal publications, which include *Management Science*, *Organization Science*, the *Journal of Public Transportation*, and the *Information Systems Journal*. She has been a member of the board of directors of the Association of Information Systems and the International Conference on Information Systems.

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Intermodal Transportation Safety and Security Issues: Training against Terrorism

Ronald W. Tarr, Vicki McGurk, and Carol Jones
University of Central Florida

Abstract

Since 9/11, our world has changed. The threats now facing us are extreme and unpredictable. The potential for terrorists to use public transit to deliver bombs or turn public transit vehicles into bombs underscores the importance of training—training that can help us prepare to deal with the advent of terrorism on a devastating scale. This paper explains how training in teamwork and decision-making aided the reaction of mass transit agencies during the 9/11 attacks. It also describes the new techniques and technologies that can be used to provide even better training for future attacks.

Introduction

Jennifer Dorn, Federal Transit Administrator, highlighted the risks facing mass transit when she said:

> *The State Department reports that in 1991, 20 percent of all violent attacks worldwide were against transportation targets; by 1998, 40 percent involved transportation targets, with a growing number directed at bus and rail systems. The recent attacks on the World Trade Center . . . reminds us all that we must*

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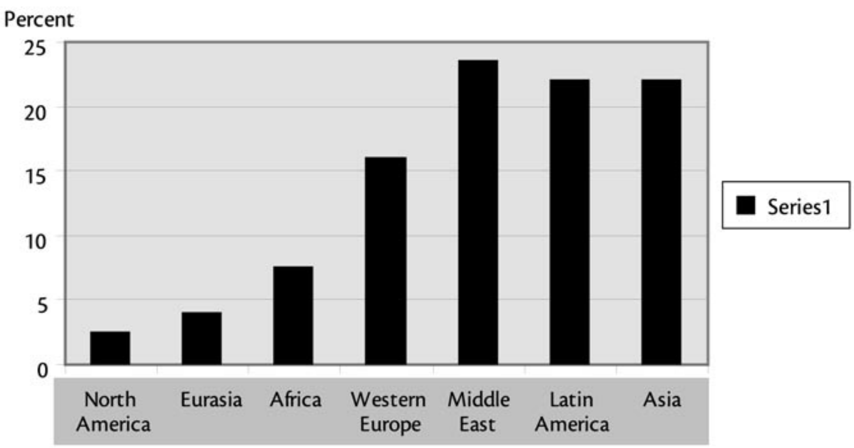
> *respond to a new terrorist reality—terrorism that is well-financed, well-organized and ruthless. The credible threat of increasing terrorism directed toward our nation's transit systems requires that we take immediate prudent action to prevent, prepare for and respond to violence—the nature and magnitude of which was once unimaginable (APTA 2001).*

Intermodal transportation systems can be defined as any transport of people or freight on our soil, we must consider countless ways to prepare for more attacks and lay out plans to avert another tragedy. This article will focus on the types of threats from terrorists our intermodal transit systems face (Figure 1.).

Figure 1. Terrorist attacks against transportation by world region, 1998



Source: *http://www.bts.gov/publications/the_changing_face_of_transportation/html/figure_07_09.html*

The article is organized into three broad areas:

1. Current situation regarding security and terrorism for intermodal transit
   - Response of mass transit agencies on 9/11
   - Types of terrorist threats facing intermodal transit facilities and intermodal transportation systems

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2. Current solutions
   - Increased tracking and inspection of certain shipments
   - Employee training
   - Inspection of priority tracks, tunnels and bridges
   - Increasing security for school buses, trucks, subways and trains
3. Future solutions proposed by University of Central Florida's Center for Advanced Transportation Systems Simulation (UCF-CATSS), using research and an advanced application approach to security
   - Awareness education and training
   - New performance technologies to provide the critical response to terrorist attacks and also to avoid or defuse threats

Current Situation Regarding Terrorist Security for Intermodal Transit

The Response of Mass Transit Agencies on 9/11

In the aftermath of 9/11, virtually every mass transit system around Ground Zero was prepared to help. Many systems provided free transportation, created detours, accepted each other's riders, and took food and blankets to victims. All in all, the outpouring of sympathy and generosity was astounding, and the ability to reroute lines and get people home showed remarkable training. The response by the mass transit systems demonstrated that many transit agencies could respond to emergencies, make quick decisions, and come up with creative solutions because they were prepared.

"America Under Threat: Transit Responds to Terrorism" was a special report describing how mass transit agencies in cities all over the United States responded to the terrorist attacks of 9/11. In each city's section of the report, similar actions were taken—transit employees made quick decisions and depended on teamwork to help reroute riders and lines so that people could be evacuated from Ground Zero. When the Federal Aviation Commission closed airports, this rerouting included transit personnel finding transportation for passengers stranded at airports, as well as setting up lodging for them. In Austin, Texas, armed police in full uniform drove the mass transit buses transporting these stranded travelers (APTA 2001).

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Mass transit agencies in cities all over the nation have had to reconsider safety and security procedures in the face of terrorism. This has caused a rise in requests for new security devices, such as:

- electronic employee ID targets and vehicular gates at all metro facility entrance points;
- metro-rail fiber optic network, vital for video recording devices;
- programmable intrusion equipment to alert police of the location of any unauthorized intrusion into the subway system;
- closed-circuit TV and motion detection alarms for metro-rail yard perimeter fencing and shop facilities;
- personal protection equipment, training and satellite telephones for employees;
- expansion of the chemical emergency sensor program;
- bomb-resistant containers at all metro-rail stations; and
- high-visibility uniformed patrols at vulnerable stations with additional K-9 teams and vehicles for explosive detection.

Figure 2. Closed Circuit TV (CCTV) camera

Source: Fugro OCEANOR, *http://www. oceanor.no/ products/cctv*

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Security devices are critical to protect passengers from terrorist attacks. They are also critical to keep our public transportation vehicles from being used as weapons. Norman Mineta, the U.S. Transportation Secretary, speaking at a national transportation security summit, stated that U.S. transportation systems are "at risk of being targets of terrorists. They are also at risk of being used as weapons against Americans—weapons delivery systems used to damage or destroy our communities" (APTA 2001).

Because of 9/11, many transit agencies have decided to strengthen their current protocols, while also developing and implementing new internal policies and procedures. In-house security work groups have been formed; staff members are participating in seminars on terrorism, bioterrorism, anthrax and other security and safety measures.

Atlanta and San Francisco transit agencies were able to respond quickly to handle stranded passengers and create new routes because of previous training. The Atlanta police had participated in several training programs in preparation for the 1996 Olympic Games (APTA 2001). Training included sending special teams to biological and chemical response classes offered by the U.S. Army. Atlanta also has a bomb team equipped with a computerized robot and K-9 units.

Figure 3. K-9 unit training

Source: *http://www.ventosakennel.com/training*

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The San Francisco Bay Area Rapid Transit (BART) also was prepared because of its experience with counterterrorism efforts. BART has been involved in local, regional and national planning for counterterrorism since the Gulf War (APTA 2001). BART hosted a federally sponsored counterterrorism forum in 1997. Since the subway attack in Tokyo in 1995, BART police, station agents and other key personnel have received specialized training.

Other cities have participated in training seminars or sent employees for training. In Cleveland, the Regional Transit Authority (RTA) hosted an FBI terrorist and operational response training seminar that outlined tactics related to incidents using explosives or chemical, biological, or nuclear devices.

In addition to the seminars and off-site training that some cities have had, drills have provided effective training. A drill in Miami-Dade County (Florida) showed the transit authorities how easily anyone in a recognizable uniform, even those without badges, could get into their facilities. This provoked new training to help employees learn how to challenge people who have no identification. In addition, Miami-Dade has changed access to secure areas, moving from keypad to a proximity card in conjunction with a personal code.

Our mass transit agencies did a highly commendable job in employing their decision-making and teamwork skills to help in a time of great crisis. Now that our transit systems have shown that they can react to terrorist attacks, we need to help them acquire the security devices and training they need to be proactive in preventing another tragedy.

Types of Terrorist Threats Facing Intermodal Transit

Trains. Railroad freight and passengers are extremely vulnerable to terrorist attacks. Between 1998 and 2003, there were approximately 181 attacks worldwide on trains and related rail targets such as depots, ticket stations and rail bridges. Attacks on light rail systems and subway systems are included in this estimate. These attacks resulted in 431 deaths and several thousand injuries (Riley 2004).

In the aftermath of 9/11, the Association of American Railroads (AAR) and the Transportation Security Administration (TSA) have worked together to ensure the safety of the railroad system by increasing:

- security of information systems and property;
- tracking and inspection of certain shipments;
- employee training; and

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- inspection of priority tracks, tunnels and bridges.

One of the areas of greatest concern since the terrorist attacks is the security of the rail industry's information systems network. On March 23, 2004, before the Senate Commerce Committee Hearing on Transportation Security, Edward Hamberger, President and Chief Executive Officer of the AAR, stated: "The industry significantly increased cyber-security procedures and techniques. Employee records were compared with FBI terrorist lists. Security briefings, like safety briefings, became a daily part of many employees' jobs" (Hamberger 2004).

According to the U.S. Department of Transportation, freight railroads have a large physical infrastructure and are heavily dependent on information technology in their daily operations (Mosely 2002). These types of systems are vulnerable to terrorist or hacker activity intended to bring about one of three scenarios.

1. Denial of service—terrorists make a direct attack on an information system that results in a disruption of service among a number of unprotected computers on the Internet.
2. Hazardous material control—terrorists gain control of hazardous materials by cyber attack and cause an accident, resulting in the release of hazardous materials.
3. Weapons of mass destruction shipment—terrorists gain access to sensitive freight information systems in order to move weapons around the country.

Subways. The first attack on a subway system using weapons of mass destruction took place in 1995 when the Japanese doomsday cult Aum Shinrikyo released sarin gas into the Tokyo subway system, killing 12 people and sending more than 5,000 to the hospital. Since 9/11, there have been numerous general warnings of possible terrorist attacks on parts of the ground transportation system, including subways. Unlike airlines, which have several security checkpoints that screen passengers and luggage, subways are designed to be easily accessible and are therefore harder to protect (Council on Foreign Relations 2004).

The physical design of a subway system—enclosed spaces packed with people during specific times of the day—makes it a tempting target for terrorists. Biological or chemical attacks in a subway would have devastating results. This is because air currents above ground, as well as those generated by the movement of trains through the tunnels, could spread germs or gases throughout a subway station

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and through ventilation systems to the streets above, leading to the infection of large numbers of people (Council on Foreign Relations 2004).

Trucks. According to Gary Petty, president of the National Private Truck Council (NPTC), the threat of terrorists using trucks as weapons in the United States is high, largely because trucks have become the weapon of choice for terrorists. Petty says, "There have been 150 terrorist attacks worldwide over the last 10 years using trucks—trucks are the modality of choice for terrorists" (Kilcarr 2003).

A large percentage of trucks carry hazardous freight that would provide terrorists with a weapon that could be exploded on impact or detonation. Each day, gasoline tanker trucks across the United States make about 50,000 trips. Another segment of the trucking fleet hauls other dangerous materials, such as chlorine, that could be deliberately released. These trucks often are left unattended at refueling depots with their engines running, or they deliver their loads to deserted, unprotected areas (Wilen 2003).

Buses. Buses remain a favorite target for terrorists. According to the FBI, between 1920 and 2000, nearly 40 percent of mass transit targets internationally were buses, including school buses. Why would terrorists target school buses? Because, basically, they are easy targets—they have predictable routes and are highly visible. In addition, although schoolchildren pose no threat to terrorists, by hijacking a bus full of children, terrorists can "crush the heart" of a nation (Paul 2004a). Because school buses are easy targets, state directors of student transportation concur that antiterrorism programs are vital for school bus safety. Terrorism on school buses ranks third on a list of potential U.S. targets. When you consider that there are 450,000 school buses in daily service, the ranking is not surprising (Paul 2004b).

In the aftermath of 9/11, school security has much broader applications than it did when domestic violence was the extent of school and transportation security concerns. At least four high-profile hijackings have occurred in recent years in the United States. Although these hijackings were not committed by terrorists, they still showed the ease with which an unauthorized person could gain control of a school bus. Although the United States has not had an actual terrorist attack against a school bus, school buses with children on board were targeted in Israel, Thailand and Malaysia in just the past two years (Paul 2004a).

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Current Solutions

Increased Tracking and Inspection of Certain Shipments

Embedded processors, such as radio frequency identification tags, e-sensors and e-seals that are read by electronic readers at all points, are increasingly being used to track freight shipments as they make their way across the country. E-sensors can detect and document changes to a shipment that occur along its route. For example, if terrorists were to tamper with a container of hazardous waste, e-sensors would notify the proper security organization of the container intrusion (National Research Council 2003).

Other types of security devices being used to track shipments and employee activity include cryptography, the basis for most secure Web-based activities; biometric devices that identify persons on the basis of one or more physical attributes, such as a fingerprint or retina pattern; and wireless communication tracking systems that report shipment data to control points (National Research Council 2003).

Employee Training

Train operators and employees are routinely taught emergency response skills. These skills were critical to limiting casualties in the immediate aftermath of the 9/11 terrorist attacks—for instance, when Port Authority Trans-Hudson (PATH) trains helped evacuate more than 5,000 persons from the basement of the World Trade Center. Since the 9/11 attacks, passenger systems have conducted further drills, testing and preparation for emergency situations. Some systems are experimenting with chemical and biological detection systems. The Washington, D.C., Metro subway system recently initiated a program for identifying suspicious packages and luggage. In addition, personnel and passengers are trained to report suspicious behavior and be ready for evacuation and emergency actions (Riley 2004).

Many transit agencies build on their existing emergency procedures to integrate steps needed in response to a terrorist attack. For example, the Houston Metro has conducted a terrorism response training exercise with the U.S. Department of Transportation involving local, state and federal emergency responders. In general, emergency plans used in the transit environment provide guidance for reporting and evaluating the incident, using the incident command system, notifying emergency response personnel or agencies, protecting personnel and equipment at the incident site, dispatching emergency response personnel and equipment to the

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site, evacuating passengers, providing briefings and information updates, managing the emergency, and restoring the system to normal (Boyd and Sullivan 2000).

Inspection of Priority Tracks, Tunnels and Bridges

Following the 9/11 attacks, bridges and tunnels into and out of New York City were heavily patrolled by police officers and the National Guard, and truck traffic was restricted. Maintenance doors on high-profile bridges, such as the Golden Gate Bridge and the Bay Bridge, were sealed shut to prevent terrorists from damaging bridge cables and anchors. In July 2002, Amtrak received a $76 million federal grant to make New York City rail tunnels safer, including the modernizing of ventilation and communication systems and improving emergency access and other measures (Council on Foreign Relations 2004).

Increased Security for Subways, Trucks and Buses

Subways. To prepare emergency workers to handle terrorist attacks, the Washington, D.C., Metro subway system began training a select group of commuters on ways to evacuate trains and subway tunnels and help fellow passengers during a rail disaster (Layton 2004). Metro Transit Police Chief Polly L. Hanson recognizes the vulnerability of subway tunnels to explosive devices and has pointed out that the tunnels pose particular hazards during an emergency, which requires specialized training. The Metro training program includes walking the volunteer passengers into dark subway tunnels to teach them to navigate live tracks as trains roll by. "When you walk down the street, you don't have a third rail that's got 750 volts," Hanson said, referring to the high-voltage rail that powers the trains (Layton 2004).

Trucks. Although trucks haul nearly 70 percent of the nation's freight, the federal government spends significantly more on airplane safety than it does on trucking safety (Center for Strategic and International Studies 2004). However, recognizing the inherent security problems of the trucking industry and the fact that truckers are on the road 24 hours per day, the Department of Homeland Security has pledged a $19.3 million grant to Highway Watch, a program formed in 1998, to give truckers training in spotting terrorist activities and to provide a national hot line to report trouble. During a one-day training session, truckers learn about truck bomb terrorism around the world, how terrorist attacks play out and the ways someone might case a target. So far, about 400,000 professional truckers have been trained, with many more to go (Center for Strategic and International Studies 2004).

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There also have been security measures taken to ensure control of a truck that has been stolen or hijacked. In 2002, the U.S. Department of Transportation began a two-year project to test satellite-tracking systems with devices that can disable a truck if an unauthorized driver takes control. GPS (global positioning system) tracking also is being used by fleet operators to detect the exact location of trucks as they follow their routes and make deliveries (Wilen 2003).

Buses. Some recommendations to provide transportation safety for buses include identifying security threats and suspicious people, monitoring suspicious objects and activities, responding to a security, incident and reporting suspicions to the dispatcher.

Video cameras and GPS are two technologies that could be added to enhance bus security and help thwart terrorists. GPS allows transportation managers to know where the buses are at any given moment. In addition to using GPS to track commercial buses, Lee County Florida is thumbprinting students as they board and exit school buses so that schools know not only where each bus is, but which children are on board.

Although these technologies will be highly effective in tracking hijacked buses, they will not protect riders from other terrorist acts. For example, many buses run on gasoline, which is highly flammable. Converting buses to diesel fuel, which is more difficult to cause to explode, would be another safeguard against an attack. Unfortunately, in the case of school buses, school budgets do not stretch to cover all of these safety measures.

Training bus drivers and teachers to be prepared to implement safety plans is another measure many of our schools are trying. Modesto City (California) schools held a simulated training session for their school bus drivers, in which the adult drivers pretended to be students on a bus that was "hijacked" by "terrorists." The training was powerful because members of the County Sheriff's Department SWAT team, pretending to be the terrorists, wielded real guns (which shot blanks) and demanded to send messages. Participants said the training was frightening but also highly effective (Chrismer 1999).

Future Solutions Proposed by UCF-CATSS

It has long been recognized that the key element in prevention and proper response to security threats is operators, drivers and personnel who are well trained and prepared to act when they encounter dangerous or threatening situ-

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ations. When personnel on the scene can react and organize a proper response, situations can be resolved. UCF-CATSS was established to conduct research and to provide simulation and advanced learning technologies to enhance the performance of the transportation community.

Although traditional training practices are important, the military and the Federal Aviation Authority have learned that interactive methods that place someone in a dangerous virtual world provide realistic training in a safe environment. The simulated situation provides opportunities for trainees to consider their actions and to try out different solutions. Virtual worlds and simulation are excellent media for security training, requiring role-playing and learning technologies that are focused on the most pressing needs of the community.

Awareness Education and Training

The Federal Transit Authority has developed numerous guidelines to provide practical assistance to transit personnel and other individuals and organizations whose responsibility is to plan for, manage and recover from emergencies and disasters. Transit Watch is a campaign intended to raise the awareness of transit employees, riders and the general public. The campaign is also designed to help foster the role of transit as a safe facility in communities across the country.

The challenge to this campaign is how to raise employees' awareness without scaring them. In addition, if too much information is disseminated, employees may ignore it, especially if it is being distributed in the same way as other safety information. Identifying innovative measures for informing employees and being able to measure the utility of these measures is one of the approaches that UCF-CATSS will be implementing, using a broad multimedia approach.

New Performance Technologies

Simulation Technology. Simulation is the ultimate training technology. It allows transit agency employees to "encounter" a terrorist situation and then initiate an immediate action. Simulation technology can offer training in a realistic, virtual situation, one that mimics day-to-day transit activities and requires an immediate response to deter or mitigate a serious incident. The transit agency employee initiating the immediate response could be a bus or rail operator, station agent, or someone working in close proximity to significant numbers of patrons and other employees. However, all employees—including executive, administrative, maintenance and security employees—may find themselves in a situation where immediate action is needed.

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Knowing what to do in an emergency is critical for protecting and saving lives. Waiting for emergency response from police and fire crews may take as long as 10 to 30 minutes, depending on the type of incident. For example, in a suspected chemical attack or spill, the fire department's HAZMAT team members may take several minutes to get to the scene, put on their breathing apparatus and chemical suits, and gain access to the site. This does not mean that a transit agency employee is expected to confront a criminal or terrorist and put his or her life at risk. Instead, the employee can observe, assess and take immediate actions that reduce risks.

Computer Gaming Technology. One area in which UCF has done extensive research is the use of personal computer (PC)-based computer games as an alternative to traditional education and awareness. This is especially useful with the newer, younger employees who have grown up playing computer games. Several off-the-shelf PC games have the potential to provide engaging, realistic information as long as proper scenarios are developed and the games are implemented appropriately. For example, gaming architecture could be adjusted to allow for user-controlled enemy combatants. Users could carry out scenarios to thwart them. City transit systems are frequent targets and users could plan surveillance and security tactics. Allowing some gamers to be "the enemy" would add innovative complexity to the games and also provide valuable information about the variety of ways an enemy might attack a target.

The military services and UCF have been looking at the use of game-based learning for over five years now. Sponsored by the Navy, the Army and the Department of Defense, UCF has developed several techniques to tailor game applications for education and training requirements.

Summary

Our community is faced with new challenges in security and, in some cases, these new challenges are almost unbelievable. Many transportation personnel cannot comprehend what happened on 9/11, nor can they fathom the future attacks they may confront. The events of 9/11 seem more those of a Hollywood script than something real. Although it is not easy for people to forget such a tragedy, many return to business as usual because that is the way they choose to deal with what happened. But the world has changed. We no longer can expect "business as usual" and we must ensure that people consider events that might occur.

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Only by taking a systematic, performance-oriented approach that is relevant, credible, and engaging and that can be tailored as needed can we ensure that personnel are prepared to take immediate and appropriate action when faced with perilous situations. Much can be learned from the military and the Federal Aviation Administration's work in training their people to deal with dangerous situations and in their use of desktop computers and simulation technologies to provide training. We must use these technologies and the knowledge that has been gained to prepare intermodal transit employees and riders to deal with future potential terrorist activities.

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About the Authors

Ronald W. Tarr (*rtarr@ist.ucf.edu*) is a senior research faculty member at the University of Central Florida, senior principal investigator at the Institute for Simulation and Training, program director for Simulation and Performance Technology at the Center for Advanced Transportation Simulation Systems, and program manager for Project Prime Skills. He has conducted research and workshops on distributed simulations and learning technology applications across the full spectrum of the simulation and training community. Recent projects include research and analysis of current technology approaches in adult learning, research into the utility of commercial-off-the-shelf PC-based video games for support of education, and applications of advanced performance technology to ground transportation needs.

Vicki McGurk (*vmcgurk@ist.ucf.edu*) is an instructional designer with more than six years of experience in instructor-led and computer-based instruction. Ms. McGurk has most recently been involved in the design and development of the Prime Skills System to teach, assess and certify the soft skills of high school students to help them prepare for jobs.

Carol Jones (*cjones@ist.ucf.edu*) is a technical writer with 20 years of experience in the computer arena, where she has designed workbooks and instruction guides for banking, credit card, education and government software systems. Ms. Jones worked for six years as a computer programmer and has taught computer science at the community college level.

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