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U.S. Department of Education

**Emergency Evacuation of People
With Physical Disabilities
From Buildings:
2004 Conference Proceedings**

Emergency Evacuation of People With Physical Disabilities From Buildings: 2004 Conference Proceedings



Prepared for: U.S. Department of Education
Office of Special Education and Rehabilitative Services
National Institute on Disability and Rehabilitation Research (NIDRR)

On behalf of: Interagency Committee on Disability Research
Chaired by: Steven James Tingus, Director of NIDRR
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October 2005

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Introduction

A two-day conference on Emergency Evacuation of People With Physical Disabilities From Buildings, sponsored by the Interagency Committee on Disability Research (ICDR), Interagency Subcommittee on Technology (IST), was held on Oct. 13-14, 2004, in Rockville, Md. This document is meant to summarize the conference's presentations and discussions. William Peterson, from the National Institute on Disability and Rehabilitation Research (NIDRR), and the IST cochair, welcomed those assembled. He emphasized that the title of the conference, which was limited only to physical disabilities, was intended to give participants a clear direction and focus. While the ICDR is concerned about issues pertaining to all people with disabilities, Peterson continued, a two-day conference does not allow time to fully explore and develop recommendations for each disability area.

According to Peterson, the ICDR is an interagency committee affording the opportunity to sponsor meetings of this nature. Its purpose is to promote coordination and cooperation among federal agencies to better determine the future direction of disability and rehabilitation research. This is the third annual IST conference. The previous conferences focused on Wayfinding Technology (to assist people with low vision and blindness) and Interference to Hearing Technologies by Cellular Telephones. These conferences brought together a critical mass of expertise from the government, research community, academia, and from consumers and advocates. At the end of the two-day conference, Peterson hoped recommendations for research would be developed to drive this issue forward and allow people with physical disabilities to have better prospects for emergency evacuation from buildings.

Among the 85 presenters and participants were federal employees involved in emergency preparedness; first responders and emergency management personnel; building and life safety code practitioners; manufacturers of evacuation devices; people with disabilities who have used evacuation devices; and leading researchers in mobility devices, human factors and egress modeling. Conference presenters and participants exchanged information and ideas during panel presentations and breakout sessions. The event provided a forum to discuss:

- The impact of building and life safety codes on the evacuation of people with physical disabilities from buildings;
- The current evacuation procedures for people with physical disabilities from the first responder perspective;
- The experiences of people with physical disabilities during emergency evacuations from buildings;
- The design and development of different types of evacuation devices; and
- The current state of research on mobility equipment, human factors and egress modeling.

After panel discussions, participants joined breakout groups to develop recommendations for future research in the field of emergency preparedness for people with physical disabilities.

Keynote Address

**Elizabeth Davis, director, EAD and Associates, LLC
Emergency Management and Special Needs Consultants**

Elizabeth Davis stated emphatically that evacuation protocols, the rules and regulations to support safety measures for people with disabilities, and the equipment to execute an evacuation are not new. People have been discussing them for decades and have even become forceful in the hope that someone would pay attention. This conference, and meetings of this nature, may be a sign that all of the pieces have finally come together, creating the opportunity for real and viable solutions to be implemented.

In discussing the history of fire safety standards and evacuation procedures, Davis highlighted one of the most tragic fires in American history, which occurred on Mar. 25, 1911, on the top floors of a building housing the Triangle Shirtwaist Company in New York City. Twenty minutes after it began, 146 working immigrant women, some as young as 15, were dead. The fire emphasized the following facts:

- The building's terra-cotta-encased support beams held under the fire's heat;
- Fire safety inspections and precautions were woefully inadequate;
- The stairway doors were locked;
- The fire escape buckled under the weight of factory workers fleeing the inferno of combustible materials; and
- Firefighters' ladders were too short and water hoses could not reach the affected floors.

The resulting outcry for people in buildings to be valued more than the buildings themselves led to a state review commission, legislated fire-proofing, and new safety standards, such as the use of sprinkler systems. Davis firmly believes that no matter what the triggering event, people must learn from the past.

The disability community, according to Davis, is not a homogeneous group, and as such, a generic safety solution will not work. People who plan evacuation protocols must account for all persons with disabilities, known and unknown. This includes visible and invisible disabilities; episodic and chronic conditions; and motor, sensory, cognitive, psychiatric and respiratory disabilities—a full spectrum of differences. While the title of this conference and its sessions consider evacuating people with physical disabilities from buildings while focusing on a work environment, any built environment can be included (e.g., residential, commercial or recreation). Davis asserted that the findings from this meeting will have application in other disability areas and for the general population at large. She acknowledged that disability is an equalizing factor and anyone can find himself or herself entering this group at any time.

A fire model is no longer the only hazard that merits consideration when developing an evacuation plan. Other hazards must be considered at the onset of design, as well as individuals with and without disabilities and the structure itself. Prior to the Sept. 11

terrorist attacks, members of the disability community would articulate their emergency plan as “waiting for first responders to reach them in time.” This evolved into establishing the good Samaritan’s role as a buddy. Now, however, the disability community is stating that they too have an active role to play in their own survival and that no one solution implemented in the past is acceptable. All possible life safety tools must be made available to people with disabilities.

Davis affirmed that these tools should include not only actual devices but also rehearsed drills and egress modeling while taking people with disabilities into account, as well as a review of entrenched standard protocols, such as the nonuse of elevators as an evacuation tool even when the mechanical integrity has not been compromised. The most apparent gaps existing today include:

- Evacuation devices: no usability, review or comparison standards;
- Lack of training for first responders to the evacuation needs of people with disabilities, which should be done at the academy level;
- Acceptance and utilization of equipment that has included people with disabilities in every drill or evacuation model;
- Program funding for proper training and deployment of appropriate equipment; and
- Better awareness of the solutions that already exist.

To make a life safety system viable, the following points must be considered:

- Tools, and the use of them for people with disabilities, must be a research priority.
 - Who can safely use a specific device in a specific situation?
 - If a device can descend, can it also ascend or move on a level plane away from an unsafe condition, thereby negating the need for a user’s wheelchair?
 - How does the use of devices impact other evacuation efforts?
 - All research must be user-centered, with first responders considered members of that group.
- All devices must be held to consistent and reputable standards.
 - An evaluation comparison across tasks rather than across makes and models would be most useful.
- Equipment and procedures must be known and practiced by everyone, including the user, coworkers and professionals called to the scene.
 - Procedures must be well crafted so that areas of rescue assistance or help from first responders is a last resort.
- Costs must be reasonable to ensure that devices see widespread placement as a life safety measure and that purchasing officers buy the most appropriate (and not the cheapest) models.
- Liability concerns must be addressed in guidance documents.

- Legislation, regulations and codes must address evacuation devices in emergency planning.
 - While the Occupational Safety and Health Administration (OSHA) has been responsible for improved workplace safety laws over the past 25 years, presently there are no federal laws requiring employers to have emergency evacuation plans.
 - When should devices be used and by whom?
 - Should devices be inspected in the manner of fire extinguishers?
 - Is there a mandated or voluntary compliance or phased-in responsibility for the purchase of devices and the establishment of evacuation procedures?
 - Who is responsible for plan development: individual employers, building managers or a combination?
 - Oversight must be developed to keep up with ever changing technology.
 - Elements of universal design, which benefit everyone during an evacuation, should be standard: wider staircases or single-direction stairways; ramped entrances and exits; wider routes of travel; and larger landings encased in protective materials and designated as areas of rescue help everyone (including response personnel).

With increasing discourse in the emergency, academic, regulatory and disability communities, Davis remarked that a shift is occurring in the paradigm. However, she still extols a jump start to maximize people with disabilities' chances of survival with well crafted plans, appropriate protocols and tools. The attitude that their emergency needs are less of a priority since they impact only a few must be dispelled. In response to a National Organization of Disability (NOD) Harris Survey in November 2001, over 50 percent of people with disabilities employed full- or part-time answered that no plans were in place for a safe evacuation from their workplaces. That response improved slightly in the follow-up survey released in January 2004, signifying movement in the right direction.

Remarks from the Honorable John H. Hager

Assistant to Governor Mark Warner for Commonwealth Preparedness

After the Sept. 11 terrorist attacks, it was difficult to gain traction and access resources to address the special needs community, according to Hager. Currently with the war on terrorism and new challenges being faced by all citizens with respect to safety and security, there is an even greater need to assist citizens with disabilities. President Bush's executive order, titled *Individuals with Disabilities in Emergency Preparedness*, made clear that people with disabilities must be included in emergency evacuation plans and more importantly, included in the planning for emergencies. With the new Interagency Council on Emergency Preparedness, people with disabilities will serve to enhance these efforts and address issues of preparedness and emergency evacuation.

On another positive note, Hager mentioned an emergency preparedness conference held in late September 2004, and sponsored by the NOD in conjunction with the governments of the national capital region, which was attended by Secretary Tom Ridge from the U.S. Department of Homeland Security (DHS). This was perhaps the first conference in the country to focus specifically on the needs of people with disabilities in the preparedness puzzle. On the NOD Web site is a list of resources, protocols and guidelines considered vast in comparison to those published in earlier days.

Hager believes the country has made great strides in homeland security in the past three years. He emphasized three parts that have come together to make this happen. The first part is prevention, which consists of law enforcement, intelligence and communications agencies working in concert with the Joint Terrorism Task Force and Anti-Terrorism Advisory Council. He feels that this has played an important role in deterring terrorism in America. The second part is vulnerability reduction, which begins with every family protecting their property. It continues with small businesses developing security plans, and most importantly, encompasses the critical infrastructure of the U.S. economy, such as information technology, transportation and utilities—the backbone of America. These industries, according to Hager, have formal plans to reduce their vulnerability and assessment plans to evaluate strengths and weaknesses. They prioritize needs and place resources as a top priority. The third part is response and recovery. This country is fortunate to have the best first responders in the world. Hager stated that it is now this nation's job to provide resources to obtain equipment and enhance communication to improve national capabilities and interact more effectively as one entity.

Hager believes we are no longer 50 individual states, but instead one community that cuts across urban and rural jurisdictions. The National Capital Region Senior Policy Group was developed to bring together elements of homeland security in Maryland, Virginia and the District of Columbia. This regional approach is important to emergency preparedness. Ports—an example of cross-jurisdiction—have now been grouped as one team under maritime security. Urban Area Security Initiative funds and the state allocation of funds have also contributed to priority needs for resources. New systems, such as the Emergency Alert Notification System and the National Instant Command

System, are commonplace and have been important factors in better coordination among federal agencies. Cross-agency interaction and communication have also contributed to tighter homeland security.

According to Hager, the next step must be taken by people locally to penetrate all communities (e.g., ethnic, disability, institutionalized, urban and rural). Reaching the disability community is a difficult task given the subsets that cut across the population. He emphasized that what is important is planning ahead and targeting a group, as well as identifying the specific population in buildings, companies and neighborhoods so that it can be determined how to best work with this targeted group. Next, it is essential to involve the affected people, customizing the preparedness communication plan and options for evacuation. It is important to talk about planning, activate involvement, impart knowledge and empower individuals. It is crucial to help people with disabilities to be independent and play a vital role in accomplishing the job of preparedness.

Panel Discussions

Building and Life Safety Codes

Wayne Jewell, chief building official for Southfield, Mich.

Todd Andersen, architect, Rolf Jensen Associates

**David Frable, fire protection engineer, Environmental Strategies and Safety
Division, General Services Administration (GSA)**

Marsha Mazz, (moderator) technical assistance coordinator, U.S. Access Board

Wayne Jewell began the presentation by discussing building code terminology and what the codes do and do not provide. He stated that codes are used by government entities to regulate the built environment and create oversight, providing safe living and working spaces. The majority of codes are developed from performance and prescriptive requirements with an expected performance outcome (e.g., someone safely exiting the building). As long as the performance outcome is achieved, the space configuration is left to the designer. Prescriptive requirements refer to materials utilized, such as concrete or polyvinyl chloride (PVC) piping. Zoning codes control the size and location of buildings in reference to streets, alleys and public areas. Electrical, mechanical, property maintenance and fire codes all impact the built environment. These codes must be comprehensive and coordinated.

Buildings must be accessible in accordance with design codes. Accessible means of egress is evidenced by a continuous, unobstructed route from any place in a building to an area of refuge, a horizontal exit or a public landing to the street. Building codes only regulate the built and constructed environment. No provisions exist for furnishings or equipment, which sometimes allow the placement of these objects to become an obstruction to egress. It is left to the states to establish a code that covers those concerns. While Jewell believes that codes are an efficient and effective means of regulating the built environment, and for the most part accomplishing what they are established to do, there are times that codes must be reexamined. He encouraged participants to become involved in the process to create change.

Jewell considered the following next steps for building codes:

- Reexamine existing building exemptions (i.e., areas of refuge);
- Reexamine sprinkler-equipped building exemptions (i.e., areas of refuge);
- Examine intermediate stair landing sizes; and
- Reexamine scoping requirements for fire plans and fire drills.

Todd Andersen is an architect working for a firm that also employs fire protection engineers who design sprinkler systems, provide code consulting, and model smoke migration to determine time frames for the evacuation of buildings. He discussed the role of codes in design and referenced land use and flight patterns as factors that determine what can be built on a particular site. While building codes address the built

environment, fire codes reflect a limited set of operational issues. Property maintenance codes rarely have an influence on office buildings.

The designer's role is to create a building that is safe and accessible through code processes that are privately established. There are many community groups that represent building codes as well as groups that maintain standards. Jurisdictions are moving toward rehabilitation codes that refer to varying levels of work. With increasing levels of work, the builder is asked to remedy any additional problems. Accessibility may not be accomplished in an alteration project, particularly in a multi-tenant office building, where the egress system may not be under a particular tenant's control. None of the codes are retroactive; therefore, none require buildings to have larger stairwells or larger elevators in structures with undersized systems. Even in a major renovation, accessibility may play a secondary role to safety. During new construction, there are competing social values that can defeat an alternative system for accomplishing safety standards.

Presently, there are no codes that regulate non-fire events (e.g., gas leaks, acts of terrorism or hazmat spills) that require alternate responses. Andersen suggested that participants review the codes for their buildings and identify the people in charge of life safety issues. Creation of task groups within agencies can help to push the code development process forward.

David Frable spoke about the GSA's involvement in codes and standards development, present problems and what to expect in the future, and evacuation strategies. As the "landlord" of the civilian federal government, the GSA owns approximately 1,600 buildings and leases an additional 6,200. It is involved in codes and standards development, ensuring that proposed changes:

- Improve overall building safety;
- Are based on sound engineering data; and
- Do not increase construction and maintenance costs without improving safety.

The GSA participates in the International Code Council, the National Fire Protection Agency's (NFPA) public hearings on codes and standards development, and is represented in many national technical committees.

Frable believes the problems with codes include a:

- Lack of data and funding to verify, through research, the level of safety provided by code requirements;
- Lack of emphasis in code requirements that adequately address evacuation issues for persons with disabilities; and
- Lack of collaboration and coordination within the disability community to ensure that codes address issues that impact them.

Key issues related to evacuation strategies include:

1. *Building familiarity.* Prior to developing an evacuation plan, one must take into account the unique characteristics of the building, its occupants and the first responders. It is important to know the occupants' ages, physical abilities and familiarity with the building. First responders must also be familiar with the building and the persons with disabilities who work or reside there.
2. *Full evacuations.* Usually, everyone leaves a building when the alarm sounds. However, this may not be practical in tall buildings in addition to being physically demanding—bottlenecks may still occur at stair door exits with congestion on the stairs.
3. *Phased evacuations.* When an alarm sounds, people listen and then react. Occupants at risk are notified and then relocated or evacuated from the building; occupants who are not at risk may stay in place. During a phased evacuation, automatic sprinklers are essential for controlling the fire at its origin, thereby eliminating toxic byproducts and the effects of exposure to those byproducts. A voice communication system is also essential, as is training.
4. *Alternate strategies.* Included in blueprints are refuge areas and refuge floors that keep people away from smoke and fire. For example, “protect-in-place” or “shelter in place” refer to rooms or other physical barriers that prevent fire and smoke from moving from one area to another. A horizontal evacuation involves relocating individuals to another area on the same floor. A safe elevator is a means of egress from towers, provided that the necessary protection (e.g. architectural, reinforcement, back-up power supply) is in place to ensure that the elevator will run safely. In addition, the use of a combination of strategies (mixing these and other strategies in the same building) will promote the safety of building occupants.

Codes currently under development:

- Recent proposals have been developed to permit the use of external devices or systems in addition to the required means of egress.
- Proposals have been developed to require occupant emergency plans in buildings previously without requirements.
- Code proposals are being developed to require evacuation drills in buildings that previously had no such requirements.
- Proposals are being developed to provide more stairway illumination and markings with photo luminescent materials.

Future code developments include:

- In less than 10 years, research and technology will allow people to use elevators to egress a building and allow fire department personnel better access. Codes

will recognize safe elevators, speeding the evacuation of buildings, and will address people with mobility impairments.

- Exit stair widths and landing widths will increase from 35 inches to a larger width, depending on the total occupant load served by the exit stairwell. This will also increase the speed of evacuation and address counterflow problems.
- Codes will expand the requirement of emergency voice communication systems or public address systems to notify occupants in all types of emergencies.
- Proposals will reexamine the concept of occupant evacuation from buildings with the development of unique strategies.
- Proposals and standards will be developed for the design and performance of evacuation devices.

Questions and Comments:

- Visual alarms are only located in public-use spaces and not in private offices where someone who is hard-of-hearing may be located. What provisions does the GSA have for employees and visitors in private offices?

Changes in the revised *Americans with Disabilities Act (ADA)* and the *Architectural Barriers Act Accessibility Guidelines (ABAAG)*, in respect to work areas, do require wiring serving employee work areas so that a visual alarm can be readily installed. Voice communication systems come with visual devices under mass notification code proposals. Occupant emergency plans address all persons with disabilities through a buddy system employed in office settings.

Current Practices of Emergency Management and First Responders Toward Evacuation of Persons with Physical Disabilities

Jim Reddington, director of emergency programs, U.S. Department of Agriculture, Emergency Command Center

Elgin Browning, captain, Orange, Texas, Fire Department

Glen Blackwell, (moderator) captain, Baltimore County Fire Department

Jim Reddington believes conferences like these are essential for developing effective emergency management programs. His program at the U.S. Department of Agriculture (USDA) is based on the participation of advocacy groups, such as the Secretary's Advisory Committee on Employees With Disabilities, which review materials and provide feedback. He suggested to the conference participants with disabilities that their emergency program managers would welcome their comments and insights.

Reddington oversees all of the USDA's facilities in the Washington, D.C., area. This includes the headquarters complex on the National Mall, which houses 8,500 people, and 19 other facilities in the region built between 1879 and 1936. While these buildings have wide hallways and stairwells, elevators that are too small to accommodate a

stretcher present a challenge. A gradual modernization process will bring these buildings “up to code.”

Reddington discussed the new threat spectrum (from fire to chemical to nuclear) and its impact on emergency programs. While the USDA has a good fire emergency plan, it did not have a plan for other emergencies. Evacuation is only one option; other options include sheltering in place and moving personnel to more secure places within the building. With chemical and gas emergencies, plans call for moving people from the basement and subfloors to higher levels. All of these considerations require a communication system that effectively relays options and solutions.

To track and manage resources, every facility should maintain a command and control system. The USDA based its program on a four-service (planning, operational, logistical and financial) incident command system. This includes personnel such as a standard safety and information officer and a special needs advisor, the latter of which makes sure that the needs of people with disabilities are met. They generally have a staff of 60 wardens (responsible for monitoring floors) and employ 700 stairwell monitors who use elevators for shelter-in-place, reserving them for personnel with disabilities and health issues. Twenty Evacu-Trac chairs have been strategically placed in the upper levels of the building, and Garavanta Stair-Porters, which are electrically operated, have been placed in the lower levels for moving people to the upper floors. Training is conducted for people who need this equipment, as well as individual helpers and wardens.

Given the design of the main building at the USDA, there is a great deal of horizontal movement. Critical to the department’s success is the clean-hall policy, which is stringently enforced. The unique structure of the building makes shelter-in-place possible in interior corridors, where shelter-in-place lockers have been installed with “go kits” that contain food, blankets, medical supplies, cots, water, radios and signaling devices.

To Reddington, the most critical aspect of an effective emergency program is the ability to communicate rapidly with all employees in the building. The USDA’s emergency program includes a public address (PA) system, a computer emergency notification system (CENS), voice and text messaging, an employee information line, a radio network, and an in-house television system that has scrolling capabilities and voice translation. The PA system connects the entire headquarters complex, has multiple entry points, and is zoned for buildings and wings. It has dedicated strobe lights that can be installed as needed in offices for the hard-of-hearing. The CENS, developed by the U.S. Department of Defense, has a software program that has been uploaded to everyone’s computer. When an emergency occurs, a message is sent from the server, which flashes an alert on an individual’s computer screen: a red siren for an emergency; a yellow bell for an advisory; and a green screen for information. A screen reader (voice output) allows a blind person to “read” the actual message. With this system, the USDA can reach 14,000 employees in 75 seconds. Within the emergency center, trained officers issue voice and text messages using the Roam Secure System with dedicated servers.

A USDA paging system dispenses devices to employees with hearing impairments that automatically sends out a signal. A code signals the type of emergency and its location. When the emergency is over, an all-clear signal is immediately sent. The heart of the control system is the radio network, which consists of a two-way radio system with 300 radios for personnel and repeater systems throughout the area to expand the signal strength. It provides the USDA with the capability of expeditiously steering people to safety while keeping them informed. There is a warden phone system that provides 24-hour coverage and links directly to operators in a fire-control center, located in every stairwell.

Personnel are kept informed of emergency procedures through a computer messaging program dedicated to emergency programs. There is a section for employees with disabilities that contains procedures specific to their needs. An e-mail address is available for questions, and Reddington regularly holds town hall-style meetings to keep people informed. Reddington's emergency command center also prints an emergency employee response guide with a section devoted to employees with disabilities.

To maintain this system, a regular training program to practice procedures is critical. Testing of notification techniques takes place routinely, and drills are conducted every quarter that include scenarios for alternate evacuation routes. In the last two years, the USDA has had one real event, one internal bomb threat drill, and four drills for external chemical threats. The emergency procedures are contingent on the emergency command center's ability to identify the threat and issue the necessary instructions, thus keeping people informed throughout the drill or event. During an emergency, it is important to let people know the status of the emergency at least every five minutes. Reddington ended his presentation with the motto, "Practice is crucial."

Captain Elgin Browning from Orange, Texas, discussed rescue considerations from the rescuer's perspective. He pointed out that the rescue of people from any building is the most laborious and mentally intensive function of the fire and rescue service and requires on-the-spot decisions based on building design, patient considerations, the personnel and equipment available, and time. The nature of the emergency dictates how much time is available. While architects have months to design and plan, rescuers are often faced with evolving circumstances that require a change in plans as they are performing the rescue. Rescuers are trained to make intelligent and quick decisions based on the needs and the safety of the victims.

The basic points of consideration are:

- Access
 - Can the occupants' spaces be accessed safely?
 - Is special equipment required?
 - How many personnel are required?

- Victim contact and evaluation
 - Is the person viable?
 - Will emergency medical services (EMS) be required before or during the rescue?
- Number of victims
 - How many individuals are present?
 - Where are they located?
- Victim rescue factors
 - How many rescuers are required for each person? It may require 15 firefighters 30 minutes to rescue one person.
 - Does he or she require special equipment?
 - Will the person be able to assist and understand instructions?
 - Is EMS equipment or other rescue equipment on the floor, or does it need to be delivered?
- Exit from building
 - Where is the patient handed off?
 - Where do rescuers report conditions, rehabilitate or replenish supplies?
 - What are the rescue recycle time and requirements?

The rescue may require more people than the department has on hand for the amount of time that is available. To prevent injury and loss of life, fire departments and building owners may need to address issues as the occupancy of the building changes. The priority is always the safety of the occupants of the building and of the rescuers, before, during and after an incident. For example, it would be beneficial to firefighters to have equipment, such as evacuation masks, in place as they afford 10 minutes of breathing time.

Questions and Comments:

- What is the policy for evacuation devices? The U.S. Access Board has been told they will slow down egress and even impede ingress for fire and rescue.

The USDA does not have refuge areas for protection from a fire for a prolonged period of time. Since there is no place where people could be guaranteed safety, its policy is to use evacuation devices to get people out of the building.

From the fire and rescue viewpoint, that is a decision to be made when the rescue is taking place. It is important to ask the fire department to evaluate a building's fire plan and its fire drills and determine whether they will hinder or help an evacuation. Time is a fundamental factor. Other factors may change as the emergency unfolds.

- Are the stair-chairs common on the fire trucks or on the ambulances? Does it depend on the jurisdiction? How often are they used?

In Texas, it is a required piece of equipment on an ambulance. It is not required on fire trucks. It is one of the most used pieces of equipment for EMS personnel. Firefighters have modified them by using webbing to hold a person in place. Besides the stair-chair, they have used a normal chair or a piece of furniture. They have learned to be innovative and have used whatever tools are available at the time.

- It is a widespread misconception that one has to move fast to get out of a building quickly. If there is a crowd, is it best not to move fast, or is it better to move at a rate of two to four stories per minute? A premise in the field is that it is important to first spend time talking to a person to determine their needs and capabilities. How do you see that in terms of the emphasis on time?

It is important for the individual, the building's emergency management team and the fire service to get together beforehand to determine an emergency plan prior to when it may be necessary to implement an evacuation.

Elgin Browning said he does talk to individuals before the rescue, if there is time.

- A working relationship with the fire department does not exist in the main U.S. Department of the Interior (DOI) building. Their evacuation plan says, "When the fire department arrives, they will know what to do." This conference is emphasizing the need to create a plan with the fire department ahead of time. What is your sense of the fire department's time to do that? Is it a priority?

Jim Reddington stated that the USDA uses, as its first channel, the Federal Protective Service (FPS) as a liaison. A full-time FPS officer has been assigned to the building, and he attends USDA drills and is familiar with its Incident Command System. This person has also brought in fire department personnel to talk to staff at the Incident Command Center; gives classes on shelter-in-place, and has discussed what equipment the hazmat team should bring. Reddington recommended that the DOI starts by working with its FPS liaison and then let that person take the lead.

Panel moderator and Baltimore County Fire Chief Glenn Blackwell suggested that safety educators and fire inspectors go out and review the plan with a building's emergency management staff and then bring in a representative from the local fire department for fine tuning.

- What are your thoughts about people with disabilities waiting for assistance during a fire emergency as opposed to pursuing evacuation chairs and other methods?

Now, with the 911 system and the locator system, the dispatcher can let the fire department know if there is a person that needs special assistance. The problem is that people often do not want to release that type of information. If the fire department knows the situation ahead of time, they are much better prepared to handle it.

Current State of Evacuation Devices

David Egen, president, Evac+Chair Corp.

**Norm Cooper, director of marketing, Technical Support and Customer Relations,
Garaventa Accessibility**

Michele Wigley, marketing, Stryker Medical

Mike Warnalis and Steve Warnalis, sales representatives, Lifeslider Inc.

**Edwina Juillet, (moderator) cofounder, National Task Force on Fire and Life Safety
for People With Disabilities**

Edwina Juillet facilitated the panel consisting of four representatives of manufacturers of evacuation devices who addressed the lessons learned in the research and development process and the challenges in the design evolution of these products.

David Egen is an industrial designer who in 1979 began designing the first evacuation device, after his wife (who had polio as a child), had to be evacuated from her 38th-floor office in Manhattan. He spent three years developing his Evac+Chair, which is a light and simple device that is designed to glide down stairs and can be used by anyone with limited training. Egen described the ride as smooth, with rapid braking descent. The braking apparatus is considered unique in that it has a belt that lays against an aluminum extrusion, thereby creating a braking effect. The more weight that is placed against it, the greater the braking action. It works proportionally to the body weight of the individual. It is now used throughout the United States and in Europe, and is coming soon to Japan.

Since 1982, the most difficult aspect of the sale of the Evac+Chair has been for the buyer to determine the source of funding for the chair. Egen considers an evacuation chair to be a lifeboat for buildings. Much like lifeboats and life rafts, there is no regulatory authority for these devices. When considering future codes and regulations, it is important to remember that revisions and cosmetic changes may occur, but the basic designs have worked well and have benefited many for over 20 years.

Norm Cooper discussed Garaventa's experiences and challenges over the past 18 years. Garaventa was previously a designer and a manufacturer of incline wheelchair lifts that influenced the approach to standards and testing. The company also manufactured the Garaventa Stair-Trac, a battery-powered wheelchair lift that used rubber tracks and that also could be used for evacuation purposes. In 1985, the company was approached to market a product strictly for evacuation, using the design ideas from the Stair-Trac, but without the motor or battery. This new device had an open sling seat, track with lugs, failsafe brake, brake-release level, speed governor, and auxiliary wheels.

Garaventa's initial research in 1985 showed that there was little regulatory awareness of evacuation devices or of the issues pertaining to emergency evacuation and no safety standards. Independent research helped Garaventa to develop appropriate standards and test the new device. The company contacted an independent testing laboratory, located in Vancouver, British Columbia, that initially tested the equipment mechanically,

structurally and operationally. The lab set the target weight capacity at 361 pounds and tested the device with 540 pounds. The speed varied with passenger weight. Testing was completed in October 1986, and certification was issued by BC Research. The evolution of the product included a redesign of the speed governor by switching to a hydraulic governor with fewer moving parts. The new design was released in 1988.

In 1995, Garaventa approached the Underwriters Laboratories (UL) to develop standards and a test program for the Evacu-Trac to achieve the UL labeling. This included concepts that were based on the American National Standards Institute's (ANSI) and the Rehabilitation Engineering and Assistive Technology Society of North America's (RESNA) WC/08 1991 wheelchair standard, Garaventa Evacu-Trac's standards and earlier work by BC Research. Eighteen separate tests were proposed that related to: strength; stability on flat surfaces, inclines and stairs; ease of operation; flammability tests, maximum descent speed and testing of the brakes on stairs; static load tests; and governor endurance and brake endurance tests. The updated Evacu-Trac Model CD7, originally developed in 1997, included many changes for safety and usability; however, due to uncertainty about what the device's requirements should be, Garaventa had to abandon UL labeling. Despite this outcome, its work with UL was worthwhile, resulting in more than 20 changes to the original design. It was introduced to the U.S. market in July 2000.

Although there are still no U.S. national standards for emergency evacuation devices, the U.S. Food and Drug Administration (FDA) claims regulatory authority. The Evacu-Trac is registered with the Medical Device Division under the device classification of "stair-climbing wheelchair." In its statement of intended use Garaventa states:

The Evacu-Trac is intended to mechanically transport a mobility-impaired individual down [a flight of] stairs in a private or public facility... [in the event of an] emergency evacuation The Evacu-Trac must be operated by an attendant.

The implications of the requirement for the FDA approval to market emergency evacuation devices in the United States are significant, given that no national standard exists. Companies that apply for approval may need to comply with the FDA's Good Manufacturing Practices (GMP). This is a sophisticated quality management system that is monitored for compliance with the GMP standards through field audits by the FDA's inspectors. Certain stretchers and ambulance gurneys are exempt from FDA registration, while others need to comply with FDA requirements but do not need to register. Stretchers and gurneys are typically lower risk Class I or Class II devices. Devices such as the Evacu-Trac, which descends stairways with a passenger, are considered a higher risk based on the Evacu-Trac's FDA Class III regulatory classification. This is an issue that requires further dialogue between the FDA and manufacturers of evacuation devices. Cooper believes that while some may consider the FDA's involvement with this equipment unnecessary, the FDA's review and registration of emergency evacuation devices, together with manufacturing in

accordance to the FDA's GMP, offers some measure of control and a requirement for conformance to documented performance standards.

After Sept. 11, 2001, many of the accepted strategies for the evacuation of people with disabilities changed. The concept of waiting in an area of refuge became unacceptable to many. The need to get out of buildings during emergencies created a sudden surge in demand for stairway evacuation devices. As a result, the U.S. marketplace has been flooded with a myriad of evacuation devices that work in different ways and vary significantly in price. With no national standard for design or performance available for reference, building owners and managers with little knowledge of emergency evacuation issues are challenged to select effective and appropriate equipment. Many do their research on the Internet, basing decisions on limited information and price. Unfortunately, very few do hands-on product evaluations using actual people with disabilities as passengers or with their designated evacuation buddies as operators. The devices purchased and installed in public buildings are often not suited to the application. When a real emergency occurs, the equipment is rarely used or is used incorrectly, creating a potentially dangerous situation.

Given the current unregulated marketplace, Garaventa's response has been to focus on education. It provides free educational videotapes and DVDs, checklists on evacuation device evaluation criteria, and sample evacuation device specifications and performance standards.

In the future, Garaventa sees a growing demand for upward evacuation devices that can move people up flights of stairs from below-grade or up flights of stairs to a refuge area higher in the building. Garaventa offers an upward evacuation device that looks much like the Evacu-Trac but is equipped with a motor and battery pack. Cooper further stated that as the expectation and demand for safe, fast and dignified evacuation for people with disabilities continues to grow, the need for an appropriate standard is becoming urgent. This technical standard must address design, performance and usability. It must also be usable as the basis for testing lab certification and FDA approval, assuming the FDA's jurisdiction over these devices continues. These standards must also address the issue of testing lab certifications. Unless there are field inspections and testing of emergency evacuation devices—as are done with elevators and wheelchair lifts—lab testing and certification may be the best way for manufacturers to show consumers that their devices are in compliance with the new technical standard.

Michele Wigley described Stryker Medical as a patient handling company that designs and manufactures hospital beds and stretchers in its EMS division. It was through the company's relationship with first responders that brought about the realization of the need for ergonomically correct stair descent devices, since the patient care market is plagued with back injuries. In the pre-hospital patient-handling market, there is the need for down-stair and up-stair mobility and wheelchair-like capability to bring patients out of their homes. Compact storage is also important, as well as durability.

After the Stair-Pro was launched in 2002, Stryker had a large response from building owners interested in placing the Stair-Pro in their facilities in the event that first responders could not get to the scene immediately. They made a few modifications to the chair to accommodate this market, making it functional for one person to operate. In reference to the evolution of design and the civilian market, Stryker has many options.

Lifeslider, Inc. representatives Mike and Steve Warnalis began their presentation with a video showing the device descending stairs in a simulated rescue. Unlike the other units, the Lifeslider is designed more like a sled that glides down flights of stairs. This product's design and operation is therefore significantly different from the other products'. The device is designed to keep evacuation as simple as possible, according to Mike Warnalis. He further stated that the emphasis is on saving lives and getting out of the building quickly, without a long set up. The Lifeslider is made of ABS plastic, which is an impact-resistant material. It can fold down for easy storage, and its maintenance-free design makes it ready to use at any time. The Lifeslider uses passenger restraints while still facilitating the easy access to and quick egress from the unit. There are hand-holds on the unit for situations that require it to be lifted to a stairway. Although the Lifeslider is lightweight (21 pounds), it still requires proper training to use. The device comes with a training video and on-site training as requested. The unit was developed in 1992 as five pieces and has evolved into a lighter, one piece design. Through an association with Rubbermaid, Lifeslider was able to develop a mold, creating the new, enlarged design. In 1998, the company began receiving advice from emergency medical technicians and firefighters. In response, Lifeslider changed the seat cushions and added additional accessories as options. They received a U.S. patent in August 2003.

Questions and Comments:

- The presentation on the Lifeslider was more pitch than a discussion on evolution and process. How do you address transfers from wheelchair height into the Lifeslider, then transfer from the Lifeslider to another mobility aid at the other end? It also appears that this device is designed for a single-flight descent, not taking into account narrow stairwells that do not allow for turning. On the ground level, assuming the successful completion of a downward evacuation, all of the devices suggest movement on a flat surface. It has been found in emergency situations that there is not always a smooth, flat surface (due to debris, broken glass, tree limbs, etc.) in which to maneuver, necessitating transfer to another system to be safely evacuated to a designated area of rescue.

In many places where the Lifeslider is used, a physical therapist is brought in to demonstrate how to move the person in and out of the unit. The Lifeslider has rails and castors that can maneuver over any type of surface and a handle on the back of the unit that facilitates pulling something up an incline.

- Ann Ferriter from the FDA: How many other manufacturers besides Garaventa have submitted a 510K (premarket notification) to the FDA? How do the manufacturers feel about device regulation?

David Egen from Evac+Chair indicated that they currently import the chair from two countries, England and South Africa. The FDA approves these importations. Stryker is aware of the regulations entailed, and all of the equipment comes from the headquarters in Michigan. Lifeslider had no comment.

- Is anyone aware of a device that allows the wheelchair user to stay in the chair and be evacuated with it, other than Garaventa's stair unit?

There is no other stairwell device, except for wheelchair platform lifts. Vertical platform lifts are battery powered, which means they can operate independently in the event of a fire. Codes are now allowing them to be used as an accessible means of egress, if there is backup power. These lifts could bring people out of the building. There is also a device that fits onto the back of the wheelchair and can ascend or descend stairs.

- Do these device manufacturers offer training to transfer people from their wheelchairs into the device?

The difficulty is that people in wheelchairs have individual problems. The manufacturer cannot give instructions for a uniform, universal transfer. They must leave it to those with the knowledge and expertise about the particular condition at the scene. Research has shown a need for manufacturers to incorporate the use of a physical therapist in their training.

User Perspective: Actual Experience During Emergencies

David Jamison, chief, Promotion and Research Branch Dairy Programs, USDA
John Abruzzo, Sept. 11 survivor, Port Authority of New York and New Jersey
Bruce McFarlane, director, USDA Target Center
Brian Parsons, (moderator) supervisory policy advisor, Office of Disability Employment Policy, U.S. Department of Labor

This panel focused on the unique experiences of individuals who have used evacuation devices in emergencies or in drills. It raised issues about the complexity and individuality of evacuation procedures.

David Jamison has utilized the Evacu-Trac chair in emergency drills at the USDA. He has been in a wheelchair for 25 years and cannot stand or walk. With the introduction of the Evacu-Trac chairs to the USDA in the 1990s, Jamison went through training and had a team assigned to him. The device enables people of many sizes and with many conditions to be evacuated safely from buildings. As a paraplegic, he was able to use his upper body to transfer independently with moderate difficulty. For Jamison, the

experience was an emotional one. While the team that assisted him was helpful and professional, being strapped into the device without his wheelchair and the ability to be independent was extremely difficult. Although the Evacu-Trac chair was functional and relatively safe, there were other factors that came into play. The device was purchased in mass quantities without first consulting the people who would be using them. Jamison was also concerned about his positioning in the device, the lack of ergonomic design and his lack of dignity.

The USDA has taken a proactive approach to evacuating people since Sept. 11. There have been many drills, a PA system with computerized messages has been installed, and a warden phone system is now operational. It is now possible for Jamison to egress to another part of the building and for the Emergency Control Center to keep track of where he is and what his needs are. This system, with a host of tools to assist egress, is forward thinking and caters toward the specific needs of a person with a disability.

John Abruzzo, an employee of the Port Authority for 22 years and a quadriplegic survivor of the World Trade Center (WTC) attacks, was carried down 68 flights of stairs by 10 coworkers in an Evac+Chair on Sept. 11, 2001. He was also evacuated from the WTC after the 1993 bombing, carried in his own chair. That experience led to a change in procedure and the purchase of the Evac+Chair that saved his life eight years later. Before he spoke, participants were shown a video interview of Abruzzo and his rescuers who described the harrowing experience and the perils of the rescue, such as having to carry him down the steps and from one stairwell to another at the 44th floor when the smoke became overpowering. They were able to egress the North Tower just 10 minutes before it collapsed. Prior to 1993, the quarterly drills at the WTC consisted of an audible alarm, fire wardens manning posts, and employees exiting perimeter office spaces and congregating in corridors in the core of the building. Abruzzo had always been instructed to wait at a specific location to be attended to by emergency personnel. During the 1993 bombing, with smoke filling the office space, he waited with a handful of others for help to arrive. As conditions worsened, they decided to leave the floor without the necessary safety equipment, bouncing him down the stairs in his wheelchair, slowing the egress of those from the floors above. At the 43rd floor, he was transferred to a stretcher and taken the rest of the way to the lobby.

Among the other changes the Port Authority made after the 1993 bombing was the purchase of a number of Evac+Chairs. When the chair's use was first demonstrated, Abruzzo remembers saying aloud that there was no way they were going to get his 6-foot-3-inch, 275-pound body into the chair. When the plane hit the North Tower on Sept. 11, Abruzzo was at his desk and felt the building sway. The floor was immediately evacuated except for 10 people assigned to make sure that everyone exited the building. It was clear that the group was not going to leave Abruzzo behind, and they retrieved the Evac+Chair, strapped him in, and started their descent. Eight of the 10 people, working in shifts of four, carried the chair as quickly as possible, stopping periodically to rest or change chair handlers. At the 20th floor, firefighters asked Abruzzo's rescuers if they wanted to leave him behind with them; the answer was a definitive no. It was at this location that they heard the collapse of the South

Tower. The water on the North Tower steps made their descent even more treacherous, and the debris in the lobby made it necessary to intermittently roll or carry the Evac+Chair. The group had made their way to a local high school nearby when the North Tower collapsed.

Abruzzo credits his life to his 10 coworkers and the Evac+Chair, which was located at arm's length from his workstation. Other factors that contributed to his safe egress from the building were that the stairwells were not as crowded as they were in 1993, and it was fortunate that Abruzzo and his rescuers were on the 20th floor when the South Tower collapsed and not above that level. Further, the stairway they had switched to on the 44th floor ended up being the only one with egress to the lobby.

Bruce McFarlane, who discussed training based on his experience at the USDA, indicated that the development and implantation of the USDA's occupant emergency plan began in 1993. The diversity of its notification system allows for a response to be dictated by an incident, either internal or external. The notification system can help or be a hindrance to different disability groups. For instance, it is hard to hear voice-over fire alarm systems. At the USDA, the fire alarms are triggered strictly for evacuation. If multiple systems are used for evacuations or relocations, it compounds the complexity of the communication, making it difficult for people with mental or cognitive disabilities who need simple instructions to understand. Their other communication systems are used for designated types of movement, such as shelter-in-place.

The USDA's training programs make people better aware of the issues of people with disabilities. They include sensitivity awareness for security personnel; the impact of smoke, fire and chemicals on the senses for first responder personnel; and training on how to deliver and relay accurate information, elevator usage, and sensitivity awareness for monitors and wardens. Training programs for the emergency response team include the understanding of a command control structure with one voice, keeping information simple and accurate. Backups exist for equipment and personnel, and computerized programs track the roll calls of chart wardens. The medical unit is constantly on alert, and there is continual communication with other federal and city agencies by the Emergency Control Center.

Training programs for employees with disabilities are always personalized. Transfers into evacuation equipment require personalized regimes and training with the individual and his or her team members. Self-identification must be encouraged to know where people are. Often, people do not identify themselves until a drill occurs. Emergency information is dependent on the type of disability (i.e., bells and strobes, electronic notification system). People with disabilities train individually with a safety officer from operations, an agency safety officer, and a team member.

There are bimonthly meetings among the emergency response teams who conduct quarterly exercises, in which the type of incident and communication methods are discussed in advance to encourage teams to practice. After every incident, there is an

after-action meeting to discuss how to improve the system. A report documenting findings and changes is then sent to all employees and managers.

The USDA recently made the warden phone system capable of working 24-hours a day, instituted the roam and secure alert network, and has instituted online registration for people with disabilities to receive text-based paging systems.

Questions and Comments:

- How do you train with the evacuation device? Do you have a buddy system? Do you cross-train? How is that set up?

With Jamison's agency, there are 10 or more program areas or subdivisions in the agency. Within each program area there is a safety officer, and the people with identified disabilities have assistants who are assigned to them and who volunteer to help them. The team gets together to practice using the chair.

- Once you evacuated the building, into what did you transfer?

When Abruzzo was at the local high school and the cloud of debris dissipated, he was eventually taken, in the Evac+Chair and on a flatbed truck, out of harm's way. He was then transferred onto a stretcher and to a hospital to receive treatment for smoke inhalation. Jamison cleared the building and moved a safe distance away. When the all-clear signal was given, he returned to the building in the Evacu-Trac chair.

- One of the problems in planning an evacuation is the reticence of people to self-identify. Does anyone know of any approaches, strategies or technologies that would make evacuation better or easier for employees with disabilities to self-identify?

The onus is on people with disabilities to make known how they feel and how they are being handled. If the alarm sounds, both Abruzzo and Jamison agreed that they will get out of the building any way they can. Jamison said if the stairwell is clear, he would have someone help him down the stairs in his chair so that he could have the mobility to move independently outside. He is immobile in the Evacu-Trac. He acknowledged that there is a difference between the six-story USDA headquarters building and high rises such as the WTC. One must consider the height of the building and other factors. He believes that people with disabilities must express their feelings and be heard. McFarlane added that agencies and organizations must practice drills to have people volunteer information and reach out for help.

- Were there drills at the work site between 1993 and Sept. 11, 2001?

Abruzzo stated that a fire drill consisted of an evacuation of the floor space to the center of the corridor on his floor. After 1993, he no longer planned to wait for first responders.

State-of-the-Research, Part I: Mobility Equipment

Ed Steinfeld, director, Center for Inclusive Design and Environmental Access (IDEA Center), University of Buffalo

Rory Cooper, distinguished professor and director, University of Pittsburgh

Peter Axelson, director of research and development, Beneficial Designs, Inc.

Lois Thibault, (moderator) coordinator of research, U.S. Access Board

Lois Thibault from the U.S. Access Board facilitated this panel, during which Ed Steinfeld gave a broad view of the design of the built environment and the role of the wheelchair user in that environment; Rory Cooper explored the smaller picture of the mobility device and the individual; and Peter Axelson discussed standards development.

IDEA Center Director Ed Steinfeld relayed information on space requirements for wheeled mobility based on anthropometry. He indicated that there are three areas where space requirements are considered in wheeled mobility issues related to safe evacuation. They are: 1) the clear floor area (the space that the wheelchair takes up) used in refuge areas; 2) the reach space needed to operate controls, alarms and communications equipment; and 3) maneuvering clearances in means of egress. This not only applies to wheeled users, but also to other occupants and first responders.

In 1995, user demographics showed that 1.7 million adults used wheeled mobility devices, with 83 percent using manual chairs. More females than males used devices, and usage increased with age with 56 percent of users over 65. The users of power devices were more likely to be non-elderly. It was estimated that by 2010 4.3 million people would use wheeled mobility devices. The current U.S. standards are based on research and experience from the 1970s and may not be valid today. Recent studies in Canada and in the United Kingdom indicate that wheeled mobility devices are larger and require more space for maneuvering (limitations exist for U.S. application).

Objectives of the research at the IDEA Center are to:

- Measure the structural dimensions and functional abilities of wheeled mobility users;
- Develop and evaluate a more effective measurement method; and
- Support research design and policymaking activities.

The IDEA Center recruits users of a variety of devices; collects demographic information, methods of use and structural measurements; and takes dimensions of the chairs and the bodies, as well as strength measurements. They are doing functional reach studies and studies of maneuvering abilities in confined spaces. Thus far, their sample size is 209 people with a wide range of disabilities; 58 percent are males and 27 percent are using powered wheelchairs and scooters.

In current standards, the wheelchair clearance area is 40 inches long by 30 inches wide. Looking at the results in the 95 percentile, the difference in the length of an average chair from the 1970s compared to today is five inches, and the difference in the

width is three inches. Given the results of the current standards thus far (without a representative sample) for overhead reach, horizontal reach and maneuvering clearances, they do not accommodate all contemporary mobility devices and their uses. Changes are therefore needed in the building design to include:

- Increased dimensions of clear floor area in places of refuge for wheelchair controls and hardware;
- Increased maneuvering clearances in means of egress; and
- Reduced reach limits to wheelchair controls and hardware.

Researchers now must determine how this data should be applied and what the relative emphasis should be during an independent evacuation, or evacuation in equipment. In considering the use of a device that would carry a chair, the combined weight of the individual and the chair could reach up to 550 pounds.

Research questions considered important for future evaluation are:

- What are the implications of demographics and utilization?
- What do people who depend on wheeled mobility do in an emergency evacuation?

Better data is needed to answer these questions.

Rory Cooper related the wheelchair research that he is involved in to what is applicable to an emergency evacuation. From an epidemiological standpoint, over two million people in the United States use a wheelchair or scooter as their primary means of mobility, and the population of people with disabilities is doubling every 10 years. When the *ADA* and the *ABAAG* considered guidelines for accessible egress, they did not take into account issues that are of concern today.

In discussing what needs to be done to make emergency evacuation plans for wheelchair users more effective, Cooper mentioned that they must have a plan that incorporates family and friends. In Pittsburgh, first responders have a list of where people with disabilities live. Neighbors are enlisted and designated to assist in their evacuation. Private organizations must also develop emergency evacuation plans. Along with increased planning is the need for new technologies.

According to Cooper, reference to emergency preparedness, there is a dire need for first responder training for transporting people with disabilities, especially someone on a ventilator. They must understand all of the factors, including when to evacuate just the individual or the individual in a wheelchair and how to lift the person so as not to cause harm. It is necessary to have medical professionals who not only educate first responders, but who are also available to work with them as a triage team. This requires planning and prevention, and after a disaster, ensuring that medications and equipment are provided for and accessibility requirements are prioritized.

At the University of Pittsburgh, staff members worked with a multipurpose wheelchair as part of a NIDRR-sponsored project. It collapses to be stowed in a closet, and it can be converted to access narrow entryways. It was originally designed for aircraft and travel purposes. This type of chair can be made available at evacuation shelters for individuals whose wheelchairs were not brought with them. Most wheelchairs are designed to operate only in an ADA-described environment and are not feasible in areas affected by disasters. There are devices, however, that can also do obstacle negotiation to assist individuals in evacuating themselves. There are also stair-climbing devices that are commercially available as well as others in development. Most of this work is taking place in Europe and Japan where the architecture is older and their societal concept is geared toward accommodation of the individual, rather than accessibility of the buildings. There is also a device (used frequently in Europe and meeting German and Scandinavian standards) that attaches to the back of a wheelchair, and with rear wheel clusters, can climb up and down stairs with little assistance. Independence Technology's iBOT, a mobility device, can climb stairs with an assistant, and a number of prototypes (of which Cooper showed pictures) can also climb stairs. All devices depend on stair quality (railing and strength) and the combined weight of the chair and the individual. Advanced technologies may help in the future. Cooper is working on way finding technology for individuals who are both mobility and visually impaired or for individuals with cognitive involvement to provide safety and help disabled individuals navigate the environment.

Cooper suggested that conference attendees prepare an emergency plan if they know someone with a disability and to be ready to offer assistance. He believes that better training materials, new technologies for facilities and individuals, new codes and regulations, and research and development to support these activities are needed.

Peter Axelson noted that performance standards could help with the entire emergency evacuation process. While Axelson and Cooper both write test procedures for typical manual and power wheelchairs, Axelson believes there is room for standards that would help: building managers choose products; manufacturers test products; emergency personnel recommend products for buildings; and people with physical impairments determine the best equipment for their homes. He further believes that standards would stimulate product development and provide better performance, quality and safety. Standards can produce barrier-free trade between countries and facilitate comparisons between products. The development of standards can stimulate and focus people's energies on a problem by bringing together expertise in the area. For instance, an FDA official is typically present, along with manufacturers and emergency personnel, to address problems and quantify the performances of these devices.

The structures of standards organizations begins with the International Organization for Standardization (ISO) at the top, which meets every six months for the working groups. There is a working group focused on stair-climbing technologies. The U.S. member represented at the ISO is the American National Standards Institute (ANSI). The Rehabilitative Engineering and Assistive Technology Society of North America's (RESNA) Technical Standards Board (TSB) is the standards body accredited by ANSI.

It has numerous committees that focus on wheelchair standards, seating standards, and wheelchairs and transportation standards. To develop a standard, they propose a work item within RESNA's TSB and identify a host organization to provide funding; they recruit a diverse membership; and develop a draft document. Interlaboratory testing takes place to document test methods, and once further refined, the document (standard) is sent out for voting. The typical development process takes five to eight years. In the interim, the industry is stimulated; a lot of new product development takes place, and manufacturers revise technology in line with the standard.

The anatomy of a standard includes scope and references, terms and definitions, performance requirements, test apparatus and conditions, test methods, setup procedures, and reporting and labeling requirements. These represent the areas addressed when a standard is written relative to assistive technology.

Questions and Comments:

- There is a question of transfers from wheelchairs to evacuation devices with the view that it is so idiosyncratic that it would be impossible to develop standard designs that would enable that process. Would you agree that one cannot develop standards that would facilitate that process? Is it strictly a procedural problem?

Axelson indicated that seat height is one of the measurements that is readily available for every commercial wheelchair. It can be viewed relative to body height to determine whether the seating dimensions will accommodate the user, as well as the ease of transferring on and off. When looking at the device and knowing that most people are sitting in wheelchairs that are 20 inches off the ground, the seat height is something to be considered. Cooper believes users need options. Some people need to be transferred into a device, others need to be transported in their wheelchairs, and others are flexible enough that they do not need special technology. He stressed the need for prior planning and sharing information with first responders.

- At the end of your research, will there be a subset of measurements for those people using mobility devices who are also capable of independent use? This is referring to those people capable of independently exiting a building.

Steinfeld stated that the current work does not refer to the ability to egress a particular facility. Researchers know who uses attendant power chairs, and they can use that research data by type of chair. They have developed a user interface for their database, which includes videos of people using the chair, so an individual can set the percentile range to get data on other tools in the database interface. The database is being specifically developed so designers and code officials can make use of it.

- Is there a standard that has been produced or is in progress on the types of devices seen in the other session?

There is one ISO standard that has been completed for attendant-operated devices and another ISO standard for user-operated, stair-climbing devices. Due to holes and flaws in these standards, there is a third standard that will wrap those two into one for stair-climbing wheelchairs. It is currently being processed and has been approved as a new work item at the ISO level. This will preempt the previous two standards. While intended for stair-climbing devices, the scoping will allow a transferring device to be included, though there is an assumption that these are all power devices.

- Through your experience with RESNA, where do you think a standard for evacuation devices should reside in terms of the various code-sponsoring groups? Should it reside with ANSI or RESNA?

RESNA, as the standard organization, would be the perfect organization for that work and it would also let the United States propose a standard for evacuation devices as a new work item at the international level so that the standardization can happen worldwide. Preliminary work could be done in the United States, instead of being put forth at the ISO level.

- What about usability studies? Are there usability studies for wheelchairs? Have usability studies been developed for evacuation devices? The people purchasing evacuation devices are safety and security personnel who know nothing about people with disabilities or the many types of disabilities. The purchase may not be the best evacuation device for the person or the building.

Cooper has spent most of his academic career working on usability studies of wheelchairs and assistive devices. Unfortunately, there are no good usability studies of evacuation technology, but the techniques that have been used previously can be applied and those studies can be done.

- When evacuating a person in a wheelchair, they sometimes happen to be on a ventilator too. Do you know the rate of that occurrence and whether there is an optimal chair that has the greatest use over a variety of modalities and situations? If so, what kinds of features would it contain? How are people with disabilities, given everything happening around them, supposed to articulate to an uninformed first responder what their needs and conditions demand?

The best data on people using respirators is the Spinal Cord Injury Model System that NIDRR maintains. About 5 percent of power wheelchair users with tetraplegia are ventilator dependent. There is no ideal chair. There are many chairs on the market due to a lot of individual needs and accommodations. The chair is also a reflection of the individual's lifestyle, capabilities and the environment. There are simple ways for the person in an emergency to communicate with a first responder. An information card that lists needs in bullet form is one. Or a person could utilize smart chip technology where sensors in the building indicate location and specific needs. First responders could be uploading that information while driving to the building.

State-of-the-Research, Part II: Human Factors and Egress Modeling

Norman Groner, associate professor, John Jay College of Criminal Justice

**Robyn Gershon, principal investigator, WTC Evacuation Study,
Columbia University**

**Erica Kuligowski, fire protection engineer, National Institute of Standards and
Technology (NIST)**

Jim Shields, professor, Ulster University, Ireland

**Dennis Miletic, (moderator) retired, former director, Natural Hazards Center,
Institute of Behavioral Science, chair, Department of Sociology, University of
Colorado at Boulder; NIST: 9/11 Task Group**

Norman Groner noted that both the premise and title of his presentation are: *User-Centered Applied Research Will Produce Tailored Designs That Work Better for Evacuating Persons With Disabilities From Buildings*. He advocates research questions that focus on design issues. User-centered design is from the *Handbook on Human Factors* and considers users' roles and responsibilities as the key design objective to be met and supported by advancing technologies. On the other hand, system-centered design treats users as just another resource to be assigned and optimized to meet operational goals. There are certain applications, according to Groner, when system-centered design is wonderful, such as modeling human movement inside of buildings. This perspective, however, does not credit human beings with the ability to adapt to the chaotic circumstances that occur during emergencies.

The goals of both approaches, to evacuate or move people without casualties, are the same. The difference is in the implementation of the design solution. The user-centered design approach is particularly suitable to the disability community since goals, such as evacuation without casualties, are central to the design process. It generates specific design solutions, not general design theory. Groner believes that standardization from a usability standpoint is a good thing, because it recognizes an interface from one standard to another. However, he cautions against standardizing on bad design. It should always be supported by empirical research as opposed to an arbitrary standard.

Groner organized his presentation based on levels of design analysis of user-centered research. These include biomechanics, equipment and interface usability, team performance and organization, and community performance. Biomechanics is the study of the physical interaction of workers with their tools, machines and materials so as to enhance the worker's performance while minimizing the risk of musculoskeletal disorders. Biomechanics views human beings as machines, looking at the stresses imposed to prevent injury. He posed the following research question: "How can equipment and procedures be designed to transfer persons with physical disabilities without injury to either the person being transferred or the person providing assistance?" The biomechanics approach uses accelerometers to measure the forces on a person's musculoskeletal system when using different transfer strategies.

In the equipment and interface usability, a person understands how a system works by interpreting the basic design elements of that system. The research question that Groner posed is: "How can we design evacuation carrying devices that require little or no training to use?" The training issue is important in built environments where there is a high level of attrition, particularly in multi-tenant buildings. There are also untrained visitors and limited training for emergency response teams. Usability for these devices is dependent on "affordances." They are the clues that provide users with information about how to manipulate or interact with the device. They ensure transparency, where operation is obvious, without the user having to figure it out. Usability research involves watching people unfamiliar with devices attempt to use them in order to determine the errors that are made. Products can be improved by asking users to think aloud when using them and can be compared by recording errors and the time frame for using each. If people have a problem using a product during non-stressful times, the situation will be compounded during the stress of an emergency.

In an emergency evacuation, permanent teams and ad hoc or emergent teams are relied on. A design issue, according to Groner, is to develop equipment and protocols that support the work and goals of the teams. An example of a research question is: "How can we support building emergency response teams so that they can reliably facilitate the evacuations of any and all persons with disabilities during emergencies under conditions of uncertainty?" It is now known that it is no longer acceptable to leave people on the landings of stairs. Considering the needs and goals of people with disabilities adds considerable complexity, Groner added. The first thing to be done is to identify the decisions to be made. These include:

- How to locate persons with disabilities;
- How to identify hidden disabilities;
- How to match disability to assistance;
- Who has priority; and
- How to restore people to assistive devices.

From a human factors standpoint, this requires a cognitive task analysis to determine the decisions that need to be made, and the cognitive demands and the information people need to make those decisions.

Organizational and community performance work on a larger level and require socio-technical systems to work during times of emergency. An example of success at this level is the Incident Command System. The research question asked was: "How is it possible to best construct, maintain and effectively use a special-needs registry?" Issues to be considered are the community and organizational cultures and the constraints they may impose. Designers should also take into account the concerns of the disability community. Groner cautioned that research methods should ensure that user goals and cultural values are accurately characterized. Groner added that data is best collected in the field instead of in focus groups.

In conclusion, Groner said that the results of this research are focused on specific design problems, not general theories. The design process involves not only equipment, but also interfaces to devices, tasks, jobs and communication systems that minimize casualties and psychological trauma during evacuations of persons with disabilities from buildings.

Robyn Gershon shared the challenges faced in conducting disaster research. The study was funded by the Centers for Disease Control and Prevention (CDC). Their goal was to present the design challenges to evacuees, particularly those with disabilities. They now have preliminary data results and are more than one-third on the way to their quantitative data collection of 1,500. Gershon shared quantitative preliminary data and cautioned that they are not focused specifically on the disabled, who represented a small fraction of occupants in the buildings. She wanted people to realize, as a result of this study, that people with disabilities in high-rise buildings are particularly challenged, and the lessons learned will be informative to other high-rise occupants.

She mentioned that one of the biggest problems in qualitative and quantitative data is that people were tremendously disoriented by the scale of the WTC. These buildings were not designed to withstand the impact of fuel-laden large aircraft; were not designed for full-building evacuation under limited time frames; and were not designed for evacuation above the level of impact. At the time the WTC was built in the 1970s, planners commissioned engineering studies to determine if they could withstand the impact of a Boeing 707, the largest plane at the time; it was determined that they could. The planes that hit the WTC were much larger than 707s, and were filled with 10,000 gallons of fuel.

Design features of the buildings placed stairwells and elevators in the central cores. It was practical from a design perspective to allow office views, but when hit, the buildings lost power, rendering the elevators useless. The staircases were not vertical but led to transfer hallways; in some cases, they required going down another hallway and entering another stairwell, making them less accessible. The Port Authority did have a risk management plan with a fire-safety procedure that was rudimentary. The strategy for people with disabilities was limited to three sentences. Non-mandatory fire drills were conducted twice each year, with occupants exiting workspaces into the hallways where stairwells were pointed out. Tenants requiring special assistance were assigned one or more coworkers. Between 100-1,000 evacuation chairs were purchased after 1993 and placed strategically throughout the buildings. Almost no one knew about those chairs, and no one was trained to use them. The only proposed arrangement for people with disabilities, as in most high-rises, was to defend-in-place; meaning that they would be taken into the hallways, lined up near the elevators, and fire department personnel would come up and take them down by elevator.

There could have been as many as 100,000 people in each building. Fortunately, due to a number of circumstances, the buildings were only 15 percent occupied at the time. In the span of 102 minutes, 15,000 people evacuated the North and South Towers. NIST estimates that if the towers were fully occupied, it would have taken four hours to evacuate. About 99 percent of people below the level of impact were able to evacuate.

This was the worst disaster on U.S. soil with 2,749 deaths, which represented 16 percent of the buildings' occupancy.

The CDC's qualitative data thus far includes 3,000 pages of transcripts with key informant interviews, in-depth interviews and focus groups. Individual barriers for most individuals included such conditions as last minute work-related tasks and waiting for instructions, while facilitators included intuition and prior experience. There was a lack of pre-planning for those with disabilities. They were not sure how to evacuate and it used up precious minutes, according to Gershon. Other barriers evident and addressed at the organizational level included lack of internal communication, poor commitment to a safety climate, lack of orientation to the buildings and lack of information on the buildings' egresses (i.e., poor exit signs).

The quantitative phase is more difficult as people have scattered. When researchers do reach survivors, they are very cooperative and 93 percent have indicated a willingness to be involved in other studies. The sample looks like the populations in the buildings as a whole. The demographics indicate a high percentage of white males, married with children. Their tenure in the buildings was relatively short and many were not that familiar with the buildings. In reference to health factors, 19 percent were smokers and 17 percent said they had a disability or health condition. Five percent said they have a mobility-related disability, which affected their ability to walk down many flights of stairs.

Gershon said the lack of knowledge about the buildings was appalling. If there had been proper fire safety training, 100 percent of the people in the buildings would have known its layout. Leading this list, 86 percent did not know where the stairs would lead; 54 percent did not know that there were three stairwells; 44 percent did not know that exits onto certain floors were locked; 25 percent thought that they could use the roof as a means of egress; and 18 percent did not know where the exits were located. In reference to what people did know, 36 percent reported having a disabled person on their floors; 17 percent said a plan for disabled evacuation was in place; 15 percent said coworkers were assigned to assist disabled individuals; and 14 percent said that there was special equipment.

In reference to preparedness, 35 percent did not recall any announcements over the PA system; 70 percent were never provided with written fire safety instructions; 74 percent were never provided with an evacuation plan; and 73 percent were unfamiliar with the buildings. While 79 percent had participated in a fire drill, only 8 percent had entered a stairwell, and 80 percent had never exited the buildings as part of the drill.

Preliminary recommendations for the individuals:

- Accept degree of personal responsibility;
- Become familiar with the building, especially its exits;
- Determine the time to descend;
- Make disability-specific preparations;

- Wear comfortable footwear; and
- Start evacuation immediately.

Preliminary organizational recommendations:

- Coordinate with local agencies;
- Install communications systems;
- Delineate responsibility;
- Write plans and policies to target full evacuation;
- Provide specific instructions for people with disabilities;
- Require mandatory training and annual orientations;
- Choose leaders with experience; and
- Drill, and include stairwells—especially transfer hallways.

Environmental and structural recommendations:

- Provide redundancy of communications systems;
- Provide communication in elevators;
- Post clear signage;
- Install lighting;
- Plan egress; and
- Increase stairway widths.

Next steps:

- Develop and evaluate model evacuation plan;
- Meet with the Occupational Safety and Health Administration (OSHA) and Freedom Tower builders; and
- Disseminate widely to reach all stakeholders.

Erica Kuligowski next gave an overview of evacuation models and their capability of simulating occupants with disabilities. She defined a disability in reference to her evacuation model as impediments to evacuation, especially on stairwells. She gave examples of physical impairments and aids used and listed mental impairments and medical conditions, such as asthma and heart disease. She also listed not speaking English, incorrect footwear and disabilities that occur because of the event.

An evacuation model is a prediction tool used to give designers an idea where bottlenecks occur in buildings and public transportation venues, such as rail stations. It helps to understand movement from city to city as well. Evacuation calculations can be done for multiple scenarios, making it possible to identify and visualize the evacuation of a client.

Some models focus on movement, while others highlight behaviors. The structure can divide the model into a fine grid with small nodes, or into a course grid with the floor

divided into rooms. It may track individuals, visualizing where a person is moving at any given time. There can be a simulation of slower movements, as well as occupant flow, showing smoke and other toxic effects on the occupants.

One of Kuligowski's models included a 3-D view of a building with people moving around on various floors. She also showed a simulation model with a 3-D visualization that included behavior patterns.

Evacuation scenarios involving people with disabilities that can be simulated include:

- Disabled occupants traveling to areas of refuge and waiting;
- Occupants using elevators for evacuation;
- Occupants using evacuation devices inside stairwells;
- Occupants waiting on landings inside stairwells—possibly in wheelchairs;
- Occupants using the stairwells (with or without help), possibly at a slower pace;
- Occupants resting at various positions inside stairwells (on landings or on steps);
- Firefighters' ingress and aiding occupants' egress;
- Incorporation of trained staff into the evacuation; and
- Evacuation from special buildings (e.g., hospitals, special-care buildings, schools, etc.).

Various models have the following capability in the simulated scenario:

- User adjusts walking speed of groups or individuals.
 - Predicts interaction of slow movers with no disabilities.
- User adjusts body size of the groups or individuals.
 - Predicts interaction of larger bodies (i.e., wheelchairs) with others.
- User identifies the initial mobility status of all occupants.
 - Occupants may perform assistance or rescue behaviors.
 - If an occupant needs assistance, occupant will follow decisions made by the rescuer.
 - Affects agility and speed of the occupant.
- User develops an itinerary for groups or individuals.
 - User can specify a movement schedule for certain individuals (e.g., an occupant will move to a certain room and wait for five minutes for firefighters to rescue, rest, etc.).
 - The CRISP simulation model can actually define a rescue activity.
 - The EVACSIM simulation model allows the user to label an occupant as disabled, which affects speed and response profile.
 - The BGRAF simulation model lets occupants have goals they want to achieve; speed depends on mobility.

Kuligowski provided recent data on people with disabilities during evacuations and a bibliography of research. Data has indicated thus far that models need to be more sensitive to what is actually occurring in a building.

Gaps in current evacuation models include:

- As of 1993, the majority:
 - Simulate based on invalid assumptions;
 - Do not accommodate people with mixed disabilities;
 - Do not allow for inputs of management fire safety profiles; and
 - Do not allow for simulation of counter-flows.

- As of 2004:
 - Simulate the interaction of occupants with the fire (in real-time) during egress to understand the consequences of opening doors, moving to an area of refuge and staying there.
 - No single model can incorporate all disability scenarios.
 - Few models can incorporate the use of stairs, elevators and fire department rescue all in one.
 - No single model can incorporate the entire process (the times associated with) using an evacuation chair device (e.g., finding the device, placing the occupant inside and movement).

Additional data on the following areas are needed:

- Leakiness of the building, especially in areas of refuge;
- Behaviors and times associated with the use of elevators for evacuation;
- Time and speed associated with the use of evacuation devices and aids (e.g., evacuation chairs, crutches, canes, wheelchairs, etc.) inside stairwells;
- Better understanding of the interaction of occupants with evacuation devices and aids in the building and interaction in the stairwells;
- Frequency that occupants will need to rest on stairs (i.e., fatigue, fitness, medical conditions, etc.);
- Firefighter movement inside the stairwells with full turnout gear and their need to rest;
- How smoke, fire and stress affect disabled and nondisabled occupants in an emergency;
- Disabled movement on horizontal components, ramps and stairs;
- Effect of trained staff on occupant evacuation;
- Physical disabilities;
- Mental disabilities;
- Non-English speaking occupants;
- Frequency that occupants and staff assist those in need and the interaction of the helping group with others;
- Impact of guide dogs on evacuation on stairs; and
- Impact of footwear on stair movement.

Conclusions:

- While modeling sophistication has advanced, many modeling issues remain to be resolved.
- Much more data need to be collected on the evacuation of disabled people.
- How can we go about collecting this type of data?
 - Drill using evacuation chairs and people with disabilities from buildings with various characteristics.
 - Acknowledge that other types of disabilities will occur because of the event itself.
 - Collect suggestions; drills are not always sufficient.

Jim Shields from Ulster University, Northern Ireland, was the next to present. He indicated that the first meeting to address the issue of evacuation from buildings was in 1974 in Edinburgh, Scotland, followed by meetings in Washington, D.C., in 1979 and in the early 1980s. An International Council for Research and Innovation in Building and Construction (CIB) W14 (a task group of CIB members whose present emphasis is on fire safety engineering needed for performance-based fire codes or regulations) meeting took place in Ulster in 1993, which produced three books of proceedings. Since then, the Symposium on Human Behavior and Fire was held in Ulster in 1998 and 2004 and in Boston in 2001. These symposia are a global transition toward performance-based fire safety design.

Shields believes that people who own and operate buildings must provide for the safety of its occupants. He has argued that there must be accessible and available means of egress for all people who occupy buildings, without distinction. Building regulations introduced in Northern Ireland in 1975, for accessibility in buildings for people with disabilities, affirm his conviction. He also advocates the use of elevators, which have been a means of escape in the United Kingdom for 20 years. Rescue by a fire department is not always a valid evacuation strategy. In rural communities in Northern Ireland it takes 35 minutes for the fire department to arrive.

Shields introduced the idea of occupancy as an analytical tool. It represents the population of people someplace, in a defined space, at a given time. Occupancy allows one to examine the micro-occupancy associated with complex buildings. Only when this analysis is done is it possible to determine how best to evacuate the spaces. He posed the question about the length of time it would take to evacuate the meeting space being used for this conference in the event of a fire, given the distribution of people and their needs. That is one of the key pieces of information needed for performance-based design. The time available is fire-dependent. The time required to evacuate a person is people-dependent. There is a recognition and response time, and for people with disabilities there is also a preparedness issue that is more time consuming than the actual movement.

He indicated that it is necessary to know much more about the capabilities of people. He then posed the following questions:

- What are the difficulties likely to be?
- Do we learn anything from historical events?
- What are the issues arising?
- What are the implications for design and management?

A census of people with disabilities in Northern Ireland in 1990 showed that 17.5 percent of the adult population was disabled, and 87 percent of those people left their homes on a regular basis. He believes there is no excuse for building managers to not know the numbers of people with disabilities in their buildings and the range of those disabilities. With 8 percent of the population having a locomotion disability, it is important to consider alternate doors, fixtures and handles. A person with arthritis may not be able to open a generic door due to the force required. People often do not have one disability, but several. Shields said it is critical to look at the disability and the activity necessary to evacuate. He mentioned the need to know: walking speeds for the ambulatory disabled on all surfaces, descending and ascending; the same data for people using manual and power wheelchairs and their maneuverability factor; the issue of arthritis and handrails; and the force needed for door openings and closures.

There are sets of individual studies that are not sufficient to generalize. Studies conducted in the future may not be compatible with what was done previously, which raises the question of how the data will be used and integrated. Performance-based design needs homo-generic data that is usable, but does not preclude occupancy-specific data. How people behave will be a function of the setting and how it is managed. When observing people on stairs, it is a one-step process. It is not a fluid movement, which indicates that much is unknown about vision in regard to negotiating stairs.

Final thoughts about evacuations:

- Cueing only occurs when people have a low perception of threat; as the threat level increases, other behaviors may be induced.
- Not enough is known about contra-flows, though they can be modeled.
- Little is known about merging flows.
- The dynamics of group behavior has not been examined.
- There is a need for effective communication.
- People have died in refuges because the level of protection was not matched to the severity of the fire.
- There is a need to train people to assist people with disabilities as part of their employment contract and to quantify and enforce that training.

Questions and Comments:

- The issue of stair width is hotly debated. In terms of the protocol used in the investigation of the WTC attacks, particularly in relationship to people with disabilities, how are you finding answers to appropriate stair width in the WTC?

There were three stairwells. Two were 44 inches wide and one was 56 inches wide. Many people evacuating the WTC used all three for a variety of reasons. The 44-inch stairwells were clearly problematic and led to delays. People said they were walking sideways as fire department personnel were coming up. However, the presence of the firefighters was a motivating and comforting factor, reducing a sense of panic. In 1993, a key finding was to widen the stairwells. Due to cost, they declined to do so. The new Freedom Tower will have wider stairwells. Shields added that above a certain floor level, congestion occurred and people were not getting off the floors. He indicated that the problem of flow and counterflow must be modeled, and there may be an arbitrary level at which to increase the width of stairs.

- Were stairwells in the WTC pressurized? Was there panic in the stairwells due to people with disabilities blocking the descent?

Given that smoke entered the stairwells, Gershon does not believe they were pressurized. There was little panic, even when people were blocked for 20 minutes in a hot, smoky area. Briefcases, shoes and clothing blocked the stairs, making them dangerous. Heavy people and people with disabilities walking slowly started to make people feel panicky; but only when they reached the concourse level and understood the full magnitude of the disaster was there a real feeling of panic.

- In the models shown, how would children impact egress?

The model would handle it with a smaller overhead body size, using data available on movement and speeds of children. Elizabeth Davis, who gave the keynote address, added that the answer is not only to downsize the people in the model, but the model must take into account the impact of secondary and tertiary decisions based on day care facilities needing assistance.

- How do you model the factor of memory over time affecting behavior? As one moves further away from a triggering event, there is a decline in willingness to participate. How do you take that into account as a factor in these models?

The psychological impact of these events causes post-traumatic stress disorder, which in one case caused a woman who had experienced the WTC bombing in 1993 to freeze in 2001. The literature speaks otherwise, but that is not always the case when someone is still suffering. The issue is about prevention, but it is hard to motivate and regulate people until it is in the forefront of their minds.

- What do you do about people with disabilities in museums and art centers when staff does not know where those people are? How do you set up guidelines?

Museums must have technology for assistance. One museum that Shields was aware of consulted with the local fire department about their internal landscaping and added emergency exits. Another way to handle this is control at the entry desk; only allowing a certain number of people in wheelchairs into the building, based on numbers the museum can manage, then revisit training.

State-of-the-Research, Part III: National Fire Protection Association (NFPA)

John Hall, assistant vice president, Fire Analysis and Research, NFPA

Ron Coté, fire protection safety engineer, NFPA

John Biechman, (moderator) vice-president, Government Affairs, NFPA

John Hall of the NFPA gave a comprehensive overview of the characteristics that put people at risk for fire. Often these indicators are found in clusters since people have more than one problem. He explored sources of high risk, including behaviors that make a fire more likely and life-threatening; environmental factors; unusual vulnerability when exposed to fire; and the reduced ability to escape, which Hall addressed as a concern for people with disabilities. The disability, however, can play a role in behaviors and environments.

Behaviors that make fires more likely are smoking, playing with matches and lighters, and equipment-related misuse. Behaviors that make a fire more life-threatening are the use of alcohol and drugs, the lack of a well-practiced escape plan, ill-protective activities, and failure to clear exit paths of clutter. An environment is more life-threatening when smoke alarms are not operative, upholstered furniture does not comply with requirements, homes do not comply with construction standards, and risks such as medical oxygen are not dealt with safely. Unusual vulnerability includes respiratory conditions such as asthma and emphysema and other conditions that cause a compromised immune system. Reduced ability to escape includes physical disabilities, physical limitations that limit the ability to perform (e.g., old age, developmental limitations, and mental or emotional handicaps). Education, poverty and household structure also play a role.

Hall offered statistics on the numbers of people who are at risk, and deaths that occur as a result of the behaviors and conditions mentioned above. Smoking, for example, is the number one behavior that contributes to fires and causes 850 civilian deaths a year in the United States. The combination of smoking and old age put people at an even greater risk. The reduced ability for people with physical disabilities to escape each year causes 300 civilian deaths. Two-thirds of those people are 65 years of age or older, which does not include another 100 people that are coded as too old to act effectively. Fourteen percent of adults have a great difficulty with nine physical activities, including

walking a quarter mile. Fifteen percent of adults have a hearing difficulty without a hearing aid, and 9 percent of adults have visual difficulties, even with glasses.

Less than 12 years of formal education (i.e., 11th grade) is the strongest socioeconomic variable to explain different fire rates between U.S. states and correlated with other factors of high risk. This may be related to the learning of safe behaviors, but there is most likely a more general source, such as the use of smoke alarms. Poverty is also a factor that is correlated to other issues such as health and lack of affordability of safer products. In some households, family structures such as the single-parent family is as strong an indicator as education and poverty. Hall further stated that the age of a home is not a strong indicator if one controls for the economic status of the occupants.

In his final thoughts, Hall indicated that direct data on fire risks associated with high-risk characteristics are under-reported. They do not address conditions that fall short of what would be called disability. Very young children may not be a high-risk group in the near future due to child-resistant lighters. Older adults remain a high-risk population and are the fastest growing population. Proxy indicators like education and poverty are of limited value because they can not be trusted to indicate why the risk is high, making it difficult to design programs that can reduce the underlying risk. Whatever strategies are pursued must be done with the awareness of the clustering of multiple problems.

Good, sound decisionmaking about strategies requires comprehensive assessment methods. This requires: the full range of disabilities in other risk conditions and in combination; the full range of fire scenarios and behavioral scenarios; and the full range of fire phenomena and the behaviors that are exhibited. With good models and a full range of scenarios, comprehensive assessments can be done.

Ron Coté, also from the NFPA, spoke next about his presentation saying that it refers more to codes and standards. As a follow up to Hall's talk, he indicated that poor rural families do not know that they are at risk. In contrast, the perception of affluent people living carefree in high-rise buildings has changed since Sept. 11, 2001; these tenants now identify themselves as being at risk. Means of egress have been designed based on statistics, but if behaviors have changed, the proper systems may not be in place for evacuating the building.

In low- and mid-rise buildings, people are usually able to evacuate before flow and counterflow issues become troublesome; the only people who are at risk are people with disabilities. In contrast, high-rise codes are in place based on a building's size and egress system, yet without determining occupant load on each floor. Now that people's perceptions have changed, they will make different demands on the egress system.

The NFPA will be working on the issues that have been raised during this conference and on other issues they will handle in future code revision cycles. Life Safety Codes (LSCs) NFPA 101 and 5000 are both occupancy-based documents, meaning that an evacuation is based on the type of building being affected. The protection packages are different, depending on the number and population of people. For instance, in a health-

care occupancy, a defend-in-place plan is deployed. The technical committees that determine the occupancy chapters have expertise in the needs of the population they are protecting. These chapters refer to the core chapters in *NFPA 101: Life Safety Code*. The people who develop the core chapters, such as the means of egress, do not have specific expertise about a given occupancy. Instead, their expertise is on topics such as crowd movement.

These codes have worked well for sizing the egress system for any particular floor in a building. A problem occurs when people from multiple floors attempt to leave the building at the same time, especially with the counterflow of first responders. A suggested change to the code recommends 48 inches of clear, unobstructed width between stair rails. People paying for modifications want to balance safety and price and only make changes if they are absolutely necessary. Another issue is the lack of elevators as a means of egress. A protected elevator, used by Federal Aviation Administration (FAA) control towers, has changed the attitudes of people who produce and maintain elevators. The American Society of Mechanical Engineers' Elevator Code Committee is now addressing the upgrading of elevators and the addition of qualifications to their codes to have a protected elevator package. This will force the isolation of an elevator lobby from the remainder of the floor within the envelope of protected construction.

Recognition of a wide variety of secondary evacuation devices is also before the NFPA's Means of Egress Committee. These will require deployment during emergency conditions, but are not a substitute for true means of egress such as stairs. In reference to evacuation chairs, the NFPA is waiting for product standards to be developed. A task group met after conference hours and reported back to the NFPA at their meeting in San Diego two weeks later. The NFPA's LSCs were the first in the United States to have a performance-based approach from all of the fire and life safety building codes. Elevators and extra chair widths are prescriptive, while the performance-based option sets up goals and objectives that are specified by the code. Design scenarios and modeling are also required.

The NFPA recently created an *ADA* Advisory Committee. This committee, comprised of 13 members, will report to the NFPA president directly. One hundred percent of the committee makeup will be persons with disabilities. They will have free rein to review the entire codes process and make recommendations to a variety of committees. For further information, visit www.nfpa.org.

Questions and Comments:

- Excluding from your statistical presentation the value for home fires, what would be the mix that would result?

There has been a sharp reduction in fires in every type of building other than homes. Looking at particular types of properties, there has been only a two-digit death toll each year. There is a correlation between the level of construction and confining a fire to the

first room. However, that may be as much about associated design and layout choices as it is about the properties of construction. Most of what is contained in the statistics is what happens in homes. Statistically, on a per square-foot occupancy rate, one is at lower risk of dying in a fire in a high-rise building since more of those properties have sprinklers, smoke alarms and fire-resistant construction.

- The contents of a place differ greatly between a commercial space and a home setting, since there are controls over the contents in a non-home setting.

Point well taken; however, there has been a considerable push through the U.S. Product Safety Commission for the past 25 years to control the burning properties of upholstered furniture, mattresses and clothing.

- In reference to the evacuation device outside the building (shown in your presentation), is it always sitting outside the window or does it have to be lowered? Who controls it? Are there standards? How accessible are they? Is there interoperability?

The device would be engineered to a particular building. There is an American Society for Testing and Materials committee presently working on a standard for these devices. They are deployed by professionals and not by laypeople. Multiple firms in Israel are producing this device.

Final Charge

Dennis Mileti, former director, Natural Hazards Research and Applications Information Center

Dennis Mileti told participants to turn their attention to the future in exploring recommendations, research needs and ideas. He charged them to think outside of the box of knowledge they know to come up with four research agendas in the areas of:

- Buildings: design codes and construction;
- Emergency management and first responders;
- Current state of the research of evacuation devices and mobility equipment; and
- Human factors and egress modeling.

He directed them to answer the following questions in the domain of research:

- Who should do the research—private consultants, federal agencies or universities?
- How much will it cost?
- Who will pay for it?
- What is the payoff potential? Will it make a difference and be adopted and used?
- Is the research applicable to buildings that currently exist or only to ones that are yet to be built?

Mileti cautioned that human beings must prepare for the disasters that they have experienced, not the ones they may face. In President Bush's executive order titled *Individuals with Disabilities in Emergency Preparedness*, it is made clear that the federal government supports the safety and security for individuals with disabilities in situations involving disasters, including earthquakes, tornados, fires, floods, hurricanes, and acts of terrorism, through emergency planning. Mileti emphasized that participants should consider all hazards, not just fires. Solutions for fires may not be solutions for other events.

He noted that some of the worst earthquakes in the continental United States occurred over a century ago, not in our time frame. Mileti asked, "If there was a catastrophic, Southern California earthquake, where all of Southern California became isolated, how would people be evacuated if staircases lost their structural integrity?" If the earthquake had occurred, Mileti stated, this issue would already be on the forefront of the agenda. Ninety-five percent of victims in earthquakes (and possibly other hazards) are rescued by other victims. Emergency responders only represent 5 percent of rescues in catastrophic events, according to Mileti. The time to get ready to assist people with disabilities is now, and this role falls to coworkers to do the assisting.

People live and work in groups. Mileti urged participants to build emergency response plans and codes inside of existing social structures and not in spite of them. People evacuate in groups and not as individuals, and he cautioned not to violate this human

characteristic when considering actions to support the safety and security of people with disabilities. This is about human beings, not just technology.

Mileti charged participants to give serious consideration to requiring state-of-the-art emergency plans in the nation's largest federal buildings to support the safety and security of people with disabilities. He asked why some cities with high-rise buildings having numerous occupants do not yet have emergency plans. He knows of the two plans that existed in the WTC towers and the fact that there were gaps in those plans. He ended by telling each person to consider research, policy needs and future steps when developing recommendations.

Breakout Group Recommendations

Participants debated in small groups and identified numerous needs for research and other activities. The ICDR membership, which includes many federal agencies, will carefully review these recommendations and suggestions and collaborate to develop crosscutting action plans to begin to address these critical concerns.

Buildings: Design, Codes and Construction

Recommendations for research:

- Find a safe way to use elevators in existing buildings by occupants in emergencies.
- Member agencies of the ICDR should fund the development of guidelines for emergency plans for all occupancies and building types.
- Member agencies of the ICDR should fund research on effective means of communicating the same information that is communicated to everyone to people who are deaf or hard-of-hearing.

Other recommendations:

- In new construction, buildings with sprinkler systems should require communications systems that are consistent with an approved emergency plan.
- Require an accessible means of egress based on thresholds for alterations of existing buildings undergoing substantial renovations, and offer an exemption for sprinklers.
- NFPA 1 (uniform fire code) and 101 (life safety code) should reduce thresholds for requiring the development and maintenance of occupant emergency evacuation plans for all occupancy groups.

Emergency Management and First Responders

Recommendations for research:

- Identify the best strategies for keeping people with disabilities safe during an emergency event.
- Appropriate provisions for people with disabilities need to be tested.
- Identify the best way to communicate with people with disabilities during an emergency.
- Identify strategies for coordination of the dynamics of simultaneous evacuations of individuals and groups.
- Address the specific issues of people with multiple disabilities.
- Identify gaps (disconnects) between planners, responders and occupants.
- Find out how many first responder personnel it takes to complete a rescue (need for better data and times).

Other recommendations:

- Inclusion of qualified people with disabilities into the evacuation decisionmaking process.
- Extend tools for assessment of alternative plans and strategies to include people with disabilities and first responders.
- Respond to the community of people with disabilities in their own homes; benchmark plans, responses and results.
- Find out what programs are needed to educate first responders about how people respond to an emergency.

Tools and Model-Building

Assessment tools and calculation models of the performances of safety management systems for buildings should consider the disabled and the role of emergency responders.

Recommendations for research:

- Identify an agreed upon set of experimental studies and needed data to improve the models.
- Involve many different fields and organizations under coordination and leadership from appropriate groups (e.g., disaster research centers).
- Set up funding in three phases, beginning at \$250,000 and working up to \$1 million. This would lead to more comprehensive, substantiated and effective decisions by all parties in a position to influence outcomes.

Other recommendations:

- Integrate first responder actions into timelines for fire development and occupant movement, or into timelines for any hazardous events represented by the timelines for hazard development and the corresponding timelines for people's movements (suitable for use in performance-based design analysis, for analysis of programs for greater safety, and for planning for emergency response) during a safe building evacuation—including the disabled—as the goal.
- Provide guidance on choice of interior versus exterior (of structures or other enclosed spaces where hazards develop and where people are endangered) approaches by first responders.
 - When, in the course of a fire emergency, do first responders arrive?
 - Separately address homes, high-rise office buildings, high-rise hotels, large buildings used for assembly or retail purposes, and health care facilities.

Lessons Learned—Literature Review and Syntheses

Recommendations for research:

- Collect from repository of lessons learned: after-action reports, civil rights complaints, anecdotal evidence from disability communities, and syntheses of nationally and internationally published studies that are cross incident.
- Use a team composed of cross-disability groups, first responders, and the U.S. Department of Justice and start the funding amount at \$5 million. Lessons learned are translated into effective practice and cross-training material.

Data Before and During Events

Recommendations for research:

Develop data collection points for a response profile for first responders as they arrive at a facility for disasters:

- Anticipate resource needs for a response based on who will be there (the number and composition of occupants, including people with disabilities).
- While on-site, employ effective procedures to assess the evacuation of people with disabilities that has occurred thus far, and determine who might be left behind.
- Track the impact of the disaster on people with disabilities, first responders and others.

Anticipated budget need is \$5 million over five years. The benefits include improved resource management on-site, time management, self-preservation for people with disabilities, and increased internal and external planning for integrated emergency medical professionals.

Cross-Train People With Disabilities As Emergency Responders

Other recommendations:

Design a four-hour curriculum to be included in training to orient fire and rescue personnel to special needs.

- Two hours in class studying:
 - A list of disabilities: physical, visual, cognitive, psychiatric, and deaf and hard-of-hearing; and
 - The demography of disabilities: residential or commercial.
- Time considerations:
 - Assessment;
 - Rescue;
 - Fire; and
 - Additional resources (i.e., rescuers and treatment).

- Assistive technology: raise the awareness for first responders of the importance and value of these tools:
 - Assistance to service animals;
 - Wheelchairs; and
 - Computers.
- Two-hour hands-on training to cover:
 - Equipment information;
 - Backboard transfer methods;
 - Surface issues;
 - Manpower; and
 - Lifting techniques.

Design a two-hour course presented to the disability community titled “Response, Rescue and Treatment.” Also:

- Qualify the individuals;
- Include information as to how first responders operate;
- Include best practices;
- Work through advocacy organizations; and
- For each case (i.e., hotels, libraries, etc.), state that training and applicability may vary.

Involve People With Disabilities at All Levels

Other recommendations:

- Entities in charge of buildings (residential or commercial) must involve people with disabilities and first responders in their emergency preparedness activities. This should include town hall-style meetings, condo owners’ and homeowners’ association meetings, surveys, fire drills, and evacuation drills that will develop protocols on how to respond to and evacuate under various scenarios, such as natural or man-made disasters. The information shared should include resources and approaches that will best prepare first responders and individuals with disabilities for evacuation.
- While resources and approaches are provided at local levels, it is critical that local communities receive direction from the national level. The U.S. Access Board could establish a committee to develop a set of specifications (i.e., location of water sprinklers inside a room and width of staircases) to guide builders, architects and others with a vested interest in guidelines, accessibility and safety requirements. The U.S. Access Board conducted such a proceeding when the *ADA* was enacted to develop technical information to guide businesses and agencies to conform to Titles II and III (state and local governments and public accommodations) of the *ADA*.

Current State of Research of Evacuation Equipment and Mobility Devices

Recommendations for research:

- The ICDR should develop and coordinate a federal strategy for the development of technical standards for evacuation devices and a program to develop and provide consumer information on evacuation devices and standards. RESNA develops voluntary standards for wheeled mobility devices and could be an interested partner.
- Support the federal development, implementation and maintenance of a consumer database on evacuation technology. Include the development of technical and performance standards for several types of devices in collaboration with industry, RESNA and the FDA.
- Provide comprehensive consumer information on device usability from a single federal source. Comprehensive and comparable information on the characteristics, use and performance of evacuation devices—including stair, building and operator requirements—is not currently available to assist consumers and procurement staff with the purchase of appropriate devices. Some devices are currently regulated by the FDA, but most are not.

Conference attendees estimated that a budget of \$3.5 million over seven years for standards development and an additional \$4 million dollars for consumer information would be needed. It was anticipated that the industry would maintain the consumer database once it was developed.

During the conference, a wide range of device types were identified:

- Rigid sleds, stretchers and chairs used by emergency responders;
- Transfer-to devices operated by responders or workplace volunteers;
- Emerging aftermarket technologies that could transform an individual mobility device into a stair-descending evacuation device, for use with or without assistance; and
- Portable elevator and lift technologies.

Human Factors and Egress Modeling

Recommendations for research:

The United States needs better evacuation models that can model elements that influence behaviors during evacuations. To identify actual behaviors, certain datasets are needed, including multiple sets, hazards and scenarios.

- Quantitative, qualitative and video data, especially in the stairs (group behavior first hand); and

- Occupancy specific data, not just building specific data.
 - What about tunnel evacuations?

It is important to understand people's responses to their environments (i.e., fire, debris, etc.) It is also important to understand and model groups and emerging leaders (in addition to first responders), especially people with disabilities.

- In emergencies, most people give up their individual agendas.
- Consider counterflow of traffic—people encountering evacuation devices inside the stairwells—and how this affects stair movement.
- Simulate a broader range of disabilities.
- Consider the effect and response of ongoing communication—utilize ongoing decisionmaking as new information on the behavior of the occupants becomes available.
- Consider behavior of occupants in different types of hazards (e.g., occupants evacuating while wearing chemical masks.)
- Implement/utilize models that take into account the actual decisionmaking process of people with disabilities during an evacuation.
- Study data on evacuation and relocation.
- Foster an awareness of one's surroundings—people do not often think while walking into a building, "What will I do if an emergency occurs?"

There is a need to fill the gaps between the factors (independent variables and predictors, such as people running frantically in certain incidences) that affect egress decisions and the trainers or decisionmakers that design the plan.

- It is essential to bring research to practice.
- Research exists from different disciplines. How can planners use this data to create a model? What about decisionmaking analysis models (a collection of past data on decisionmaking in emergencies put into a usable model for plan-makers)?
- Data are needed from other disciplines, bringing them together during emergencies.
- Data are needed on the number of hours of training necessary for occupants to provide a successful response (following proper procedures during drills and actual evacuations). How many hours of training (education) are necessary for occupants to retain emergency procedure information?
 - Multiple-test scenarios and an understanding of the knowledge gained and retained from each hour of training are needed.

Emergency planning: What factors influence emergency preparedness?

- Best practice checklist for evacuation, specifically of people with disabilities.
 - Improve plans for federal buildings.
- Can we rely on the national preparedness standard NFPA 1600, which is a template listing questions to answer when developing a plan?
 - Not necessarily required for buildings as of yet.

What does emergency planning have to do with human factors modeling?

- How people respond is a result of the information that they obtain or receive during an emergency.
- The information is affected by a specific warning system.
 - Should a warning system and corresponding information be part of an evacuation plan?
 - What should the system entail?

Next Steps

William Peterson, program manager, NIDRR

There has been a large amount of valuable information exchanged and relayed on this topic during this two-day conference. The ICDR will now begin to map strategies to move efforts forward and determine how to fund some of this research. Federal representatives will evaluate the feasibility of this research and the extent to which it can be part of future priorities.

Peterson will work through the IST to discuss which agencies have the potential resources and the interest to carry this to the next level once specific research areas are identified. This is in keeping with the mission of the ICDR to reduce redundancy and maximize research dollars and is part of the charge of this subcommittee.

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