

# AUTOMATED DOORS: STATE OF THE ART REPORT

## EXECUTIVE SUMMARY

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### 1.0 Purpose

This report documents a review of research literature, products, building codes and facility management practices related to automated doors. It also provides recommendations for revising the Americans with Disabilities Act Accessibility Guidelines (ADAAG). These recommendations provide comprehensive attention to the accessibility needs of people with disabilities. The term automated doors includes full powered automated doors such as those that are commonly used at supermarkets and transportation terminals and "low energy" and "power assist" doors that are used in less demanding situations. Full documentation of the research activities is available in a two-volume final report. Volume 1 documents the research findings from the state-of-the-art review. Volume 2 provides recommendations with extensive rationale for each.

## **2.0 Objectives**

The objectives of the project were to:

1. Assess the state of the art in human factors research on doors related to accessibility of buildings.
2. Identify the range of automated door products currently available.
3. Investigate constraints related to the use of automated doors.
4. Identify the scope of regulations and standards related to automated doors at the national and state level.
5. Assess international developments in product design and accessibility regulations.
6. Prepare recommendations for revising ADAAG.

## **3.0 Summary of Results**

### *3.1 Human Factors of Door Use*

The human factors review is organized around a model of the door use process that includes seven subtasks:

1. Perceiving and understanding door operation.
2. Altering gait, adjusting body posture and maneuvering within reach.
3. Reaching and grasping handles, switches or locks.
4. Applying force to overcome resistance of handles, switches or locks.
5. Applying force to overcome resistance of the door, mechanical door closers and pressure differentials.
6. Passing through the doorway, including making adjustments in posture and continuing to apply force.
7. Closing the door and locking it by repeating tasks 1-5 above on the other side of the door.

The abilities of the person, the ambient environment and the social context play a major role in successful completion of the task. They can affect the perception and understanding of door use as well as the level of stress involved in the task. Stress may be related to limitations in ability, difficult environmental conditions such as low levels of illumination or social pressures caused by the presence of others eager to use a door quickly. Automating doors offer an effective way to reduce the stress of door use. Automated doors are specifically designed to reduce congestion and increase access, but they also can be helpful to control access and improve security. Although automated doors can reduce accidents, their mechanical operation, which is outside the control of the individual user, can create potential safety problems. Door use is a critical aspect of safe egress from buildings in emergency situations. Building safety codes and standards reflect this fact through many detailed design criteria. Automated doors must address these emergency concerns if they are part of designated exits.

For people with disabilities, difficulties with door use are more pronounced and often a stressful aspect of everyday experience. Automated doors can make the door use task easier. But, as the analysis and model above make clear, there are many human factors issues that should be addressed in the design of these door systems. Although much research has been completed about door use, there is little research specifically on automated doors. The model of door use can be useful to summarize what is known and to identify the research gaps.

**Understanding Door Operation.** From existing research, we know that understanding the operation of automated doors can be a problem for people with disabilities and the elderly. We do not know how widespread the problem is since the existing research has observations from only a few subjects. New and innovative products, like automated revolving doors, seem to create the most serious difficulties. Although the existing safety standards require signage on automated doors, we do not know if those provisions are adequate. Furthermore, no research has been done on how information about door operation should be conveyed to visually impaired individuals. Since people who cannot see use their hands and canes to learn about the operation of doors and devices they encounter, attention should also be given to safety for tactile exploration.

**Maneuvering.** Although research has investigated the need for maneuvering clearances in front of doors, no attention has been given to what clearances might be needed in front of power assisted doors or if the required maneuvering spaces are consistent with automated door safety standards.

**Using Door Controls.** There has been considerable research on the use of handles, switches and locks by people with disabilities. This research includes specific studies on card slots, push buttons, keys and other devices that are used with locks. Often doors equipped with power operators have high-tech security devices such as card readers. However, there is no research on how to

communicate the location and operation of such devices to people with visual impairments.

**Force to Operate Controls.** Automated doors are activated either through detection systems or manual controls. There is enough research on the use of controls by people with disabilities to make recommendations on size, location and operating forces for these devices.

**Force to Open Doors.** The accessibility of automated doors is related to the force required to open manual doors. Establishing maximum thresholds for these operating forces essentially determines when automated doors will be required. Much research has been completed on the subject of opening doors against the resistive forces of mechanical closers and air pressure differentials. Although some of the findings are divergent, they can be explained by differences in research methods and sample selection. Given the purpose and intent of an application, it is possible to use the existing data base to make appropriate recommendations for maximum resistance forces (minimum opening forces) at manual doors. Research indicates that the abilities of the more severely disabled population to overcome resistance of door closers are very limited. Closers are not currently designed with a level of efficiency that would allow all doors to close properly if the opening force were set at the limit that people with severe disabilities could manage on an everyday basis. Furthermore, people with severe disabilities have limited use of their hands and arms. Therefore, there is a rationale for requiring automated doors. Only one study has been completed on emergency use of doors (Johnson, 1981). When compared to other studies, the findings indicate that, under emergency conditions, people with disabilities can exert relatively high forces to overcome the resistance of door closers. Thus, there is a rationale for treating doors used only for emergency use or emergency modes of automated doors differently. However, since the documentation of sample selection and findings in that study is not very thorough, it is difficult to evaluate its recommendations.

**Passing Through Doorways.** Research has demonstrated that passing through doors against the resistance of a closer is quite difficult for many people who use wheelchairs, particularly children. The main problem seems to be that door users have to exert force to keep the door from closing while they are moving through the opening. Safety issues for people who walk or wheel slowly while using automated revolving doors are a special case of this problem. These doors do not really "close", but, the user can be bumped by the leaf behind them. Manufacturers have developed several different approaches to this problem but none has been evaluated in depth.

**Closing Doors.** Automated doors always close by themselves. Thus, this subtask is not an issue in design.

The samples used in research on automated doors are not fully representative of the disabled community. In particular, very few people with visual impairments have been included. No research has been completed with people who have developmental disabilities or hearing impairments. Controlled laboratory studies have only been conducted with children. In the reports of field research, differences between the people who used the door were not examined in detail. Thus, we have limited information about the variation in abilities among people with different types of disabilities and levels of ability to complete activities of door use.

The research that has been completed addresses many different types of doors and related devices. However, there are some issues that have only been studied with very small samples of individuals. In particular, research using systematic variation of different door features on the same type of door is lacking. The ambient environment has received practically no attention. No research has been completed on the impact of differences in illumination, particularly as it relates to signage. The impact of wind and temperature has not been examined. The impact of crowding is another neglected issue. Finally, little research has been completed on the unique concerns of different building types.

### *3.2 Products*

Our product search identified 86 manufacturers of door-related products -- not all of which necessarily make automated products. Letters of inquiry were sent to all of the manufacturers with a request for information on any automated door products they produce. Of the 86 manufacturers, all but 14 responded. Among these respondents, 18 identified themselves as manufacturers of automated door products and sent catalogs on a total of 121 different product lines including 42 activating devices, 39 operating devices and 40 door systems. All the information obtained was catalogued and described in a database. Each product has been categorized by its manufacturer, type (i.e., activator, operator or door) and defining characteristics. Descriptions of a representative set of product types are included in the report. We interviewed representatives of six companies in depth.

The automated door industry is international in scope. The major manufacturers from the U.S. have interests in Europe. The Japanese market their products in Europe and the U.S. European companies sell their products in the U.S. In some cases, foreign manufacturers produce their products in U.S. plants. One Swedish company makes their entire product in the U.S. except for the circuit boards. We found only one innovative accessibility product made overseas but not in the U.S.

Interviews with six manufacturers suggest that there is not a great deal of technical innovation currently underway. They report that most product development is focused on design improvements such as making the devices smaller and less obtrusive, safer and more secure. In the accessibility area, more attention is being given to wireless remote activation devices. Most companies

that produce a large range of different products have specialized devices for accessibility. Other companies specialize only in products to meet accessibility needs. Some products are specifically designed to assist in converting existing manual doors to automated operation.

The manufacturers who produced manual door closers identified a key design problem: code requirements that limit the opening force of exterior doors. The physics behind mechanical door closer design requires the opening force to exceed closing force. As individuals open the door, energy is transferred to the door closer. The closer stores the energy (in a spring or other device) until the door begins to close. The energy stored is then applied to the door through a lever arm. The efficiency of this operation is only about 60%. Thus, an 8.5lbf. (37.8 N) opening force (required by some codes for exterior doors) translates into a 5lbf. (22.2 N) closing force. Manufacturers maintain that such a force is not sufficient to overcome the resistance of door weight, HVAC pressures, wind, gasketing, stiffness of latching mechanisms, installation tolerances, hinge friction, etc. Another problem is that these requirements are difficult to enforce. No one knows what the actual conditions at the site will be. Installation, maintenance and wind behavior, among other considerations, play major roles in determining the actual forces necessary to close the door as well as the force of opening. Such factors cannot be predicted accurately during design and specification of products.

The manufacturers also reported that designers (and possibly code officials) have interpreted the existing codes to mean that low energy and power assisted doors must comply with the manual door opening force requirements so that they can be operated manually when power fails. This results in the development of a product that seems redundant. If a door meets opening force requirements, why would a building owner want to pay extra to automate it? Only facilities that seek ultimate convenience would install such systems.

The market for automated doors is becoming more defined. The type of product that fits best with a particular application is determined by frequency of operation, speed of operation required, new versus existing construction, traffic flow and cost. Products are available to address the full range of applications based on these factors.

Manufacturers believe that automated doors are the preferred means of access for all users, not only people with disabilities. However, when these doors malfunction, users are quick to complain which is not the case with manual doors.

### *3.3 Regulations and Standards*

The two key regulations are the ADA Accessibility Guidelines (ADAAG) and the Uniform Federal Accessibility Standard (UFAS). These are both based in large

part on the technical criteria in the national voluntary consensus standard, ANSI A117.1. A new version of the ANSI A117.1 standard has recently been approved (1992). The requirements related to doors in all these documents were identified and compared. With one exception, there are only a few minor differences between them. This is the requirement in ANSI A117.1 (1986) for a maximum opening force at exterior doors of 8.5 lbf. (37.8 N). Neither of the other three documents contains this requirement. Thus, with the advent of ANSI A117.1 (1992) none of the primary sources of accessibility criteria have requirements for opening force.

The states have several different approaches to accessibility regulations. Some states have adopted ANSI A117.1, UFAS, ADAAG or model building code requirements, all of which are relatively similar. Another group of states rely on one or another of these sources as a basis but that have not adopted them by reference. A third, smaller group includes states with their own codes. Several states have door design criteria that differ from ADAAG. One state, Wisconsin, recommends the use of automated doors where exterior doors have resisting forces greater than 8 lbf. (35.6 N). Two states, Massachusetts and New Hampshire, require automation at exterior doors with resistive forces exceeding 15 lbf. (66.6 N) and interior doors exceeding 8 lbf. (35.6 N). The states of Michigan and Connecticut require that at least one entrance to certain types of buildings have automated doors. The State of Washington recently enacted a change that requires all automated doors to stop and re-open automatically if they encounter a body or object in their path.

Of the 12 Canadian provinces and territories, all either have adopted in total or adapted the Canadian National Building Code. This code requires at least one automated door for certain types of buildings.

The most recent attempt by European countries to develop a consensus standard on accessibility is the European Manual for an Accessible Built Environment sponsored by a committee of the European community. The door design criteria are somewhat different than the U.S. regulations and standards. However, the manual does not require the use of automated doors. The only specific criteria for design of automated doors concerns door speed.

In the review of human factors research (Section 2.1) the findings of research are compared with the requirements of the ADAAG and The European Manual.

### *3.4 Constraints on the Use of Automated Doors*

We completed a survey of nine organizations whose facilities are equipped with automated doors. This survey was completed in two metropolitan area, Buffalo, NY. and Washington, DC. The survey provided insight into issues related to design, installation and use of automated door systems. We also completed a survey of automated door products including interviews with manufacturers.

All the organizations surveyed were generally satisfied with the products that they were using. There were few complaints about the door systems. They are also satisfied with the acquisition costs. Their greatest concern was about reliability and ease of maintenance. Durability, ease of installation, ease of repair, safety and security do not appear to be significant factors in decision making about automated door systems. Energy conservation due to heat loss is a major negative characteristic of automated door systems. However, it is basically a function of high traffic that leads to the need for such systems. Almost all installations surveyed in Buffalo used vestibules to reduce heat loss in winter.

From this survey and our product survey, we identified several constraints related to the use of automated doors: climate, traffic patterns, operating costs, emergency operation and safety.

### Climate

Wind loads and pressure differentials, both positive and negative, are design concerns that must be overcome in all exterior door design. Back checking devices stop doors from being damaged when the wind blows against open doors and forces them backwards. Power assist devices can reduce opening force where pressure differentials are required. Energy conservation (heat gain and heat loss) can be addressed through quicker timing of automated doors, or the use of revolving doors, vestibules and air curtains.

High prevailing winds can affect the performance of all types of automated doors. Sliding doors are particularly affected. High winds blowing perpendicular to the doors have a significant impact on the performance of the doors. Yet only a few of the facility managers interviewed reported problems with high winds. This is probably because it is a known factor and is considered in the selection and design of door entries.

The reliability of control mats can be affected by moisture. Snow, ice or heavy rainfall leads to moisture accumulation underneath mats and failure of door controls. Corrosion problems can develop in control mats caused by salt used to melt ice on the sidewalks outside. Cold weather also causes slow operation of exterior pneumatic door operators. In response to such problems, several facility managers in our survey indicated their organizations had abandoned control mats for motion detectors or other sensing systems.

### Traffic Patterns

Several organizations reported that pedestrians walking across the front of doors triggered motion detectors. At an airport, even cabs in the loading zone triggered detectors. These problems can be alleviated by adjustments of detection areas. In new construction, the location and orientation of doors can prevent this problem without a reduction in the minimal detection area.

## Operating Cost

In general, the cost of operating automated doors themselves is low. The principle operating cost associated with automated doors is due to increased energy costs. Costs increases result not only directly from heat loss or heat gain but also indirectly from additional space, such as vestibules, or equipment, such as air curtains, used to conserve energy at doors with high levels of traffic. However, the energy costs are primarily due to the traffic flow, not the automated doors themselves. Supermarket chains use large vestibules between two sets of doors to help reduce energy costs. One organization said that it had made a decision to utilize only revolving doors in an attempt to cut energy costs. It should be noted that such systems can cost as much as \$100,000 each. This commitment indicates the extent of the problem for that particular organization. Low energy door installations do not cause as severe an energy conservation problem because they have less traffic. Although these doors may remain open a long time, several people can pass through before they start closing. This reduces the traffic at adjoining doors.

Although facility managers were satisfied with maintenance costs, the maintenance cost associated with automated door equipment is significant. One organization reported the need to periodically adjust motion detectors. Vandals push them out of alignment. Another facility manager reported that their company (a large supermarket chain) has a full time position devoted to door maintenance. This individual continually visits stores for necessary adjustments and preventative maintenance. Most organizations contacted have a service contract to maintain the doors in working order.

Most organizations contacted are satisfied with the performance of their doors. They are generally considered very reliable. Most report that they have been switching from hydraulic systems to electro-mechanical systems. The later seem to be more reliable and require less maintenance. One organization (a university) reported that they selected sliding doors over swinging doors due to their ease of repair and reliability. For low cost installations, they use swinging doors and maintain them with their own staff. At least six to eight years of trouble-free operation can be expected from new installations. One organization argued that routine maintenance can extend the length of trouble free operation to 20 years, even for pneumatic and hydraulic door systems. They suggested that reports of dissatisfaction are due to a lack of proper maintenance.

In general, the selection of a particular automated door system is based on reliability and durability issues rather than cost concerns. Once the level of reliability and durability is established, cost then becomes an issue for competing systems of the same type.

## Emergency Operation

None of the organizations in our facility management survey reported a problem with emergency operation. On the other hand, several seem to have never considered the issue in the past. A few facility managers were prompted by our interview to wonder how their doors would perform under an emergency. They specifically voiced concern about the effect of smoke on motion detectors and infrared detectors. In an emergency when power is curtailed, doors at required exits must operate manually. Hinged, sliding and revolving doors are designed to "break-out" and swing away. However, break-out force must be set high enough to prevent this from happening during everyday operation.

## Safety

In general the organizations we surveyed were satisfied with the physical safety and security of automated door products for public use under general operating conditions. Only a few minor security problems were mentioned related to vandalism. There were some serious safety problems reported, however. It was noted that children can slip under the guardrails and step on control mats causing the door to open. Two supermarket chains with large numbers of doors both reported incidents. One had a number of incidents in which doors closed on the fingers of small children who inserted them along the hinged edge of the door. They now have installed guards along the hinge to prevent the doors from closing when an object is detected along that edge.

### *3.5 Trends in Product Development*

As described above in 3.1, the key problem in use of mechanical closers is providing enough force to overcome resistance to door closing. Since the design margins are small to begin with, there is little tolerance to work with. Compliance with an 8.5 lbf. (37.8 N.) maximum opening for opening doors thus cannot be assured until after construction or installation. The closing force required to ensure proper latching may require greater opening forces than this maximum limit.

There is no new technology being developed related to mechanical door closers that would alleviate the need for automated doors as an accessibility feature. The primary design problem for mechanical closers is that a reduced opening force means a reduced closing force. Since it always takes more force to open the door than close it, the lower the allowable limit on the opening force, the more difficult it is to get the door to close (i.e., higher efficiency). Lower closing force is a serious product liability issue for the closer manufacturer, especially as it relates to security.

In general the most common types of automated doors installed are swinging doors with electro-mechanical, pneumatic or hydraulic operators. Doors that are installed primarily to facilitate accessibility for people with disabilities are usually activated by a touch/pressure switch although some products have a feature that

activates power upon pushing the door. One organization surveyed had discovered, through statistical analysis, that their hydraulic and pneumatic doors actually had a longer trouble-free life expectancy, but a rigorous routine maintenance schedule had to be followed. Thus, the trend toward electro-mechanical systems may be due to a desire to reduce scheduled and preventive maintenance rather than improving reliability.

There is little that any manufacturer is willing to say about the development of new technology in automated doors. The focus of research and development seems to be in the areas of reduced sizes of components, aesthetics, activation devices, improved safety systems, and security improvements. The manufacturers as a group are most concerned about safety first.

There is a growing interest in the use of wireless remote units for installations. One idea would have the Federal Communications Commission provide reserved radio frequencies for all manufacturers of automatic doors and door openers. People with disabilities could receive a single small transmitter/receiver that they could then use through this universal protocol. This would enable the user to receive audio messages upon approach to a facility with an automatic or power assisted entry door, instructions as to its location, warning upon approach, and the means to activate the door. Such a system would be most beneficial to persons with visual impairments.

Three other innovative technologies identified include sensors that prevent revolving door wings from hitting a user, an add-on power wheel that rolls a door shut and smart technology that can recognize the difference between the wind and solid obstacles in the door path. The automated revolving door is a new technology that addresses a major short-coming of other automated door systems, poor performance with respect to energy conservation.

Although installation of automated doors can improve accessibility significantly to the point that all building users notice, existing buildings do present some difficulties in installation. Products that do not attach permanently to the door (i.e. "retrofit" applications) have some benefit related to historic property concerns. Apparently this is more acceptable than permanent alterations, even though the door opener is still a visual intrusion.

## **4.0 Recommendations**

### *4.1 Performance Criteria*

The findings of our research were used to develop the following performance criteria for accessible automated doors.

4.1.1. Required Automated Doors: All new buildings used by the public should have at least one automated door at an accessible entrance. There should be an exception for small buildings where adding such a door may be a financial hardship for building owners.

4.1.2. Automated Revolving Doors and Turnstiles: Where automated revolving doors are used at an accessible entrance, an alternative accessible means of access should also be available at the entrance.

4.1.3. Security Controls: Keyed switches, card readers or combination switches should be allowed as security devices at required automated doors. They should be used only at entrances that are kept locked and where access is restricted.

4.1.4. Door Width: Automated doors must be wide enough for use with wheeled mobility devices, walking aids or by very large individuals. Full powered or low energy bi-parting and telescoping doors should be allowed to meet this requirement based on the width of the entire opening rather than one panel, as with manual doors.

4.1.5 Door Width -- Emergency Use: Automated doors should be wide enough for emergency egress and there should be an alternative accessible means of egress.

4.1.6. Thresholds and Edges: Thresholds and control mats at automated doors should not have abrupt edges that would pose a barrier or safety hazard to those who use wheeled mobility devices or walking aids or those who are visually impaired.

4.1.7. Compartments in Revolving Doors: Automated revolving doors should have enough space within them for use of wheeled mobility devices and walking aids.

4.1.8. Door Timing: Automated doors should remain open long enough to allow people with disabilities to enter the opening and pass through the door.

4.1.9. Opening Force: The force required to open a manual door or an automated door when the building power is off should be limited to ensure that people with disabilities can escape a building during an emergency. An alternative is a back-up power supply to keep the door operating.

4.1.10. Bump Force: The force produced by a low energy door as it closes or opens should be limited to avoid knocking an individual off balance. Two options should be allowed, a maximum force threshold and sensor controlled variable forces.

4.1.11. Door Swing: Full powered doors that swing against the direction of travel should have protective features to ensure that they will not hit someone approaching the door.

4.1.12 Activating Controls: Controls switches should be easy to use by people who have difficulty forming a grip.

4.1.13. Activation Forces: Forces necessary to operate door controls should be within the capabilities of severely disabled people.

4.1.14 Control Location: Switches for operating low energy automated doors should be located as follows:

a. Within the reach range of people with severe disabilities who use wheeled mobility devices.

b. In a location that allows a direct approach to the door.

c. In close proximity to the door.

d. In standard locations.

f. Not on the door itself.

4.1.15. Detection Zone: Sensors and control mats at the pull side of hinged doors should detect people approaching doors early enough to ensure that the door will open before the user reaches the sweep area.

4.1.16. Visual Instructions and Warnings: Warning signs should be in highly visible locations, have standardized symbols and be large enough to be read by people with visual impairments. Switches for low energy automated doors should be identified with the International Symbol of Accessibility.

4.1.17 Tactile Information: Tactile information should be provided to help visually impaired people become aware of low powered automated doors and help them find the location of switches.

4.1.18. Maneuvering Space: There should be enough maneuvering space in front of automated doors and controls to accommodate use of wheeled mobility devices.

4.1.19. Ground and Floor Surfaces: Floor and ground surfaces in the maneuvering clearances and at the control location should not have a slope exceeding the minimum required for drainage.

4.1.20. Background Noise: If audible warnings or instruction messages are provided; they should be distinguishable against the ambient background noise and be accompanied by visual warnings or instruction labels.

#### *4.2 Technical Criteria*

Specific recommendations for revising the ADAAG technical criteria based on the performance criteria above were then developed. The recommendations are as follows (ADAAG Paragraph numbers are in parentheses):

##### 4.2.1 Automated Doors (4.13.12)

a. Change the number of this paragraph to 4.13.3, as described above. Update references:

Full powered automated doors: comply with ANSI/BHMA A156.10 - 1991

Low energy and power assist doors: comply with ANSI/BHMA A156.19 - 1990

b. Delete the existing ADAAG requirements for door timing and "bump force."

c. Add a sentence as follows:

Where requirements of ADAAG differ from those of ANSI/BHMA A156.10 - 1991 and ANSI/BHMA A156.19 - 1990, then those of ADAAG shall be followed.

##### 4.2.2 Revolving Doors (new section)

a. An automated revolving door may be used at an accessible doorway. If such a door is used, an accessible swinging or sliding door shall be located to serve the same space and facilitate the same pattern of use. This alternative accessible door may be a manual door.

b. Accessible automated revolving doors shall comply with all the applicable requirements of Section 4.13.3, Automated Doors.

c. Accessible automated revolving doors shall be identified by the International Symbol of Accessibility, as in 4.30.7.

d. Automated turnstiles shall not be allowed as part of an accessible path of travel. Where an automated turnstile is provided, an accessible door or gate shall be located to serve the same space and facilitate the same pattern of use. This alternative accessible door or gate may be manually operated.

#### 4.2.3 Gates (new section)

Automated gates shall meet all applicable specifications of 4.13.3 when they are used at accessible entrances.

#### 4.2.4 Doorways with Multiple Panels (new section)

The minimum clear width for automated door systems with multiple door panels that open simultaneously shall be based on the clear opening provided by all panels in the open position.

#### 4.2.5 Clear Opening Width (new section)

- a. The minimum clear width of door openings shall be 32 in. (815 mm.) in power-on mode.
- b. The minimum clear width of door openings shall be 32 in. (815 mm) in power-off mode, or, an accessible door that also meets the requirements for a means of egress shall be provided immediately adjacent to the automated door.
- c. If an automated revolving door is used in an accessible path of travel each compartment shall be large enough to accommodate a person in a wheelchair.

#### 4.2.6 Maneuvering Clearances (new section)

a. Minimum maneuvering clearances at automated revolving doors shall be as follows:

- 1) Approach clearance: a clear floor space 48 in. (1220 mm.) deep and as wide as the door opening.
- 2) Control clearance: a clear floor space 48 in. (1220 mm.) deep extending at least 24 in. (610 mm.) beyond the edge of the doorway.

b. Minimum maneuvering clearances at sliding and swinging doors shall be as follows:

1) Front approach:

Push-side approach: a clear floor space as wide as the doorway and 48 in. (1220 mm.) deep measured from the face of the door in a closed position. This area may overlap a control mat or detection area.

Pull-side approach: a clear floor space as wide as the doorway and 48 in. (1220 mm.) deep starting beyond the swing of the door. This area may overlap a control mat or detection area.

## 2) Side approaches :

Length: a clear floor space as wide as the doorway plus 48 in. (1220 mm.) measured from the near edge of the door frame. This area may overlap a control mat or detection area.

Width: a clear floor space at least 60 in. (1525 mm.) for latch side approaches, 72 in. (2100 mm.) for hinge side approaches. This area may overlap a control mat or detection area.

Door swing clearance for hinge side approaches: at least 36 in. (915 mm.). This area may overlap a control mat or detection area.

### Exception:

Clearances at power assisted doors do not have to comply with these requirements; however, they shall comply with the requirements for clearances at manual doors as in 4.13.2. 6.

### Note:

Minimum maneuvering clearances for required automated doors are not intended for design of workplace and home modifications. In these situations, clearances should be based on the abilities of individual workers and residents and/or the performance of their wheelchairs.

### 4.2.7 Two Doors in Series (new section)

- a. The minimum space between two doors in series: 48 in. (1220 mm) plus the width of any door swinging into the space.
- b. Doors in series shall swing either in the same direction or away from the space in between.
- c. If doors are not operated by automatic detection devices, controls for at least one door shall be located in the vestibule.
- d. A single automated detection device or switch is allowed to control both doors either from outside a vestibule or from within, as long as controls are available as in paragraph c. Where such control is provided, the opening cycle of the second door shall have a time delay equal to one second for each foot (30 mm) of space between the two doors.

### 4.2.8 Thresholds and Floor Mats

- a. Maximum threshold height at automated doors: 1/2 in. (13 mm.).

b. Edges of floor mats used in activation and safety areas of automatic doors: 1/4 in. (6 mm.) maximum or beveled with slope no greater than 1:4

#### 4.2.9 Automatic Detection and Safety Systems (new section)

a. Automatic detection and safety systems shall be provided for all full powered swinging and sliding automated doors as required by ANSI/BHMA A156.10.

b. Automated revolving doors shall have an automatic detection and safety system that stops the door without contact upon detection of a stationary object or person within the compartments of the door or within the door opening.

#### 4.2.10 Door Timing (new section)

a. Low energy doors shall have a hold open period and closing period as required by ANSI/BHMA A156.19 or be equipped with an automated detection and safety system. Such a system shall sense the approach of an individual, and open the door; if the door encounters a person or object in its path while opening or closing, it must stop and reverse direction without contact.

b. Automated revolving doors shall have a slow mode that reduces the speed of the door to two revolutions per minute, maximum. A sensing system that adjusts door speed automatically to the speed of door users is an acceptable method to comply with this requirement.

#### 4.2.11 Door Operating Forces (new section)

a. Low energy doors

ALT. 1: The force a closing door exerts on a person or object within its path shall be 15 lbf. (67 N.) maximum.

ALT. 2: The force a closing door exerts on a person or object within its path shall be 15 lbf. (67 N.) maximum. A sensing system shall also be provided that immediately stops the door upon contact and automatically reverses its direction.

ALT. 3: A sensing system shall be provided that detects an object in the path of the door, stops and reverses its direction without contact.

Note: The closing force shall be measured while the door is stopped to avoid momentary and inconsistent readings. This is the same approach used in the ANSI/BHMA A156 Standards. The opening force requirements for manual doors do not apply to low energy doors used in power-off mode.

b. Power assist doors shall have opening forces no greater than 5 lbf. (22.2 N.). Forces shall be measured at the handle or 30 in. (760 mm.) from the hinge if the door has a panic bar or has no operating hardware.

Note: Opening forces shall be measured with the power assist on. The opening force requirements for manual doors do not apply to power assist doors in manual mode.

c. Breakout forces for all automated doors under emergency conditions shall comply with one of the following options:

1) 25 lbf. (111.2 N.) maximum

2) 50 lbf. (222.4 N.) max. and emergency backup power supplied by a battery or an emergency power system that will operate the door for at least one hour in the event of power failure.

#### 4.2.12 Control Switches (new section)

a. If an automated door is not activated by an automatic sensing device or control mat, switches shall be located at each approach to the door. Switches shall be either push buttons, push plates or a detector that can be activated by a hand movement.

b. Push buttons and plates shall have a minimum width of .75 in. (20 mm.). The maximum force to activate a push button or plate shall be 3lbf. (13.3 N). If a push plate is 3 in. (75 mm.) wide or larger, the maximum force of activation may be increased to 5 lbf. (22.2 N.). In facilities for children, the maximum force of activation shall be 2 lbf. (8.9 N.) for all buttons and plates, regardless of size.

c. The usable surface of switches shall not be recessed below the surface in which they are installed.

d. Security devices such as keyed locks, keypads, card readers and swipes are allowed to limit access to door controls at entrances where doors are kept locked. Slots shall be at least 1/8 in. (3 mm.) wide or have guides wider than 1/8 in. (3 mm.) apart directing the card into the slot. Grip clearances around the card reader shall be at least 6 in.(150 mm.).

e. Self activation through movement of the door is allowed only on one way doors that are pushed to open and have no latch.

f. Control switches shall be located as follows:

Mounted no higher than 36 in. (915 mm.) on center, measured from the floor.

With a wheelchair maneuvering clearance.

Outside the arc of the door swing.

No more than 72 in. (1830 mm.) from the door it operates.

For side approaches on the pull side, positioned opposite the door.

#### 4.2.13 Signage (new section)

a. Labels and warning for all automated doors shall be provided as required in ANSI/BHMA A156.10.

b. Instructional signage shall comply with 4.30.2 and 4.30.5.

c. Controls for automated doors shall be identified by the International Symbol of Accessibility (4.30.7). The symbol shall be located on the switch or immediately adjacent to it.

#### 4.2.14 Warning Signals (new section)

Wherever audible warning sounds and messages are provided, comparable signs or illuminated warning signals shall also be provided.

#### 4.2.15 One Way Traffic (New Section)

Where two adjacent doors are each designated for one way traffic, the stream of traffic in the direction of the door shall be on the right.

Detailed rationales for each recommendation were included, including cost implications. Several Figures were developed to illustrate the requirements.

## 5.0 Conclusion

Automated door products are a significant aid to accessibility. Many groups of people with disabilities can benefit significantly from the installation of these products at building entrances. Not only do they assist people with the most severe disabilities, those who use electric wheelchairs and have limited use of their arms and hands, but, they also provide assistance to the frail elderly with limited strength to open a manual door with a mechanical closer. In fact, automated doors are clearly a great benefit to the general population as well. They are a good example of universal design.

Our review of products and survey of existing applications demonstrated that there are many reliable products on the market. Technology is improving steadily

at both the high end and low end. Although automated doors require more maintenance and service than manual doors, this is partly due to the fact that when they do not operate properly, it is more noticeable and has a greater impact on the building user than a malfunctioning manual door does. Full powered automatic doors are available in a wide range of options to suit the needs of all applications where there is a high volume of pedestrian traffic. Low energy automated doors provide accessibility at a relatively low cost. Low energy "retrofit" controls can be added to existing manual doors with ease.

The human factors research on door use by people with disabilities clearly demonstrates a need for requiring automated doors as part of accessibility standards and regulations. Some state codes and the Canadian National Building Code already require automated doors for some types of buildings. However, a human factors analysis also demonstrates that there are many design issues related to the accessibility and safety of automated door systems. Automated door control systems, in particular, must be designed with the capabilities and anthropometrics of the users in mind. Although automated doors are similar in many respects to manual doors, in others they are quite different, not only in how they operate, but also in who uses them. Some existing accessibility criteria for manual doors, for example, maneuvering clearances, have to be re-considered for automated doors. Although the existing consensus standards for automated doors address many safety concerns, they do not take into account some important accessibility issues and also do not cover some types of doors, such as automated revolving doors. Therefore, it is necessary to develop accessibility standards to ensure that these products will be usable for people with disabilities.

Through an analysis of the door use task, this research identified accessibility requirements and specific recommendations for improving the coverage of automated doors in accessibility standards and regulations. The recommendations are prepared in a way that makes them easy to add to the ADAAG document. Each one is accompanied by a detailed rationale with cost implications for building design and operation. The research documented in this report will assist those who write standards and codes in improving the coverage that those documents give to automated door products.

Although there was much information available for making informed recommendations, there are some gaps in the knowledge base about automated doors and doors in general. The areas where additional research would be useful include:

1. Door maneuvering clearances for scooters.
2. Door opening force for manual doors.
3. Use of automated revolving doors and turnstiles.

4. Use of dual panel swinging doors.
5. The impact of "bump" force on door use.
6. Use of remote controls.
7. Identification of controls for people with visual impairments.
8. Usability of ANSI/BHMA A156 signage requirements.