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Guidelines for Improvements to Transit Accessibility for Persons with Disabilities

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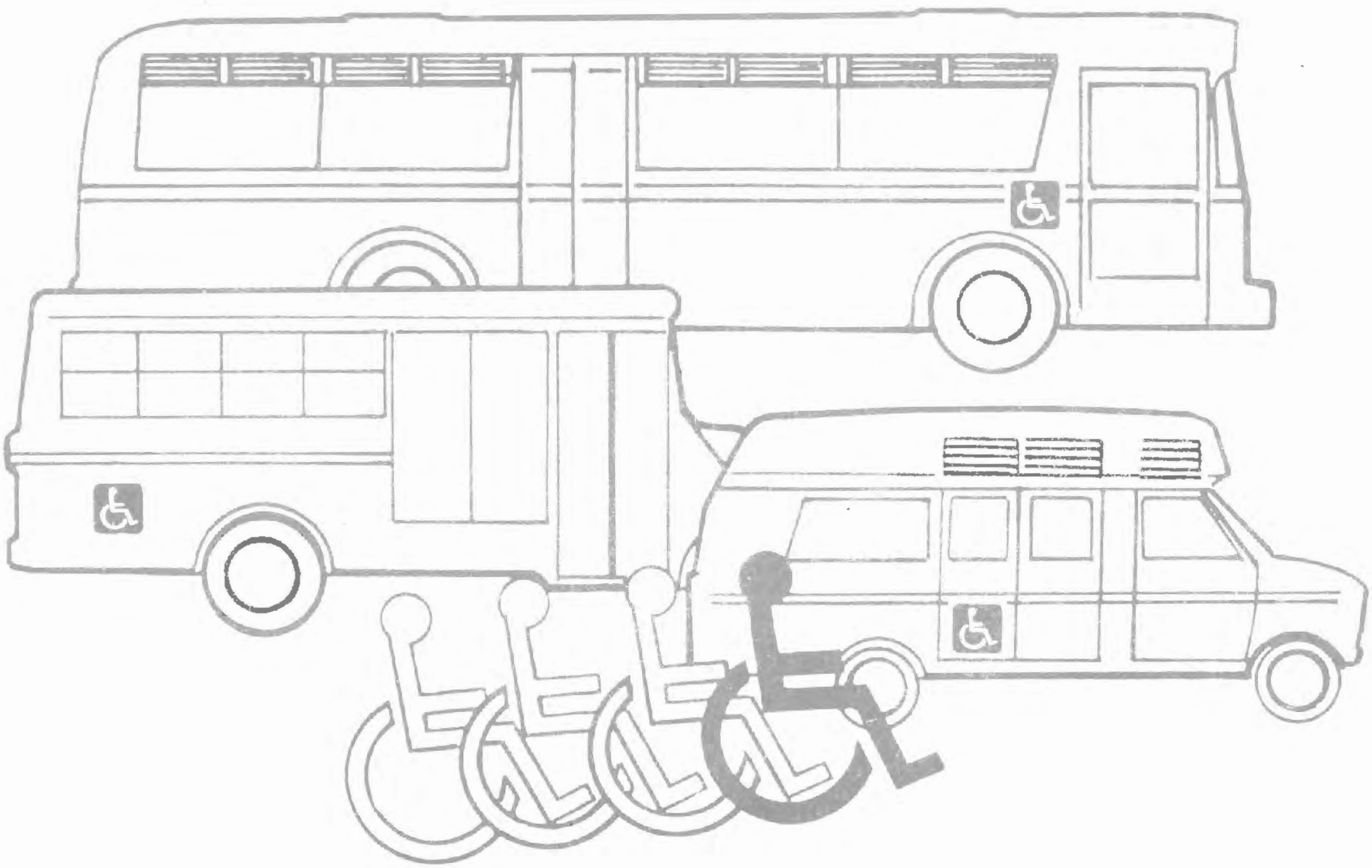

FEDERAL TRANSIT ADMINISTRATION

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Guidelines for Improvements to Transit Accessibility for People with Disabilities

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Technical Report
September 1992

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1.0 INTRODUCTION

1.1 Background

The Americans with Disabilities Act (ADA) of 1990 establishes a clear and comprehensive prohibition of discrimination on the basis of disability. It is a broad act directed toward eliminating discrimination against persons with disabilities relative to employment (Title I), public services (Title II), public accommodations and services operated by private entities (Title III), and telecommunications (Title IV). The requirements contained in Titles II and III address transportation including vehicles, systems, and facilities.

The Act requires the Secretary of Transportation to issue regulations necessary for carrying out specific parts of the Act pertaining to public transportation. It further requires that the resulting U.S. Department of Transportation (DOT) regulations be consistent with accessibility guidelines issued by the Architectural and Transportation Barriers Compliance Board (Access Board) (36 CFR Part 1191 and Part 1192, September 6, 1991).

On September 6, 1991, DOT issued a final rule implementing the ADA (49 CFR Parts 27, 37, and 38). The rule contains provisions on acquisition of accessible vehicles by private and public entities, requirements for complementary paratransit service by public entities operating a fixed route system, and provision of non-discriminatory accessible transportation service.

The rule's Part 37.7 states standards for accessible vehicles. The rule states that a vehicle shall be considered accessible if it meets the requirements of Part 38, which is DOT's promulgation of the accessible vehicle specifications developed by the Access Board. Vehicles are classified as Buses and Vans, Rapid Rail, Light Rail, Commuter Rail, Intercity Rail, Over-the-Road Buses, and Other (e.g., automated guideway transit vehicles, high speed rail cars and monorails, ferries and other vessels, and trams). The rule's Part 37.9 promulgates standards for accessible transportation facilities. A transportation facility is considered accessible if it meets the standards included in Appendix A to Part 37. The appendix reprints the guidelines developed by the Access Board for buildings and facilities in general, and specifically for transportation facilities. Both Part 38 and Appendix A focus substantially on guidelines relating to persons using wheelchairs; however, guidelines for such items as detectable warnings, alarms, signage, telephones, and public address systems are directed to the broad range of passengers with disabilities.

1.2 Purpose and Scope

The purposes of this report are to assist U.S. transit system operators in complying with the ADA and to review alternative techniques of providing accessibility for passengers with disabilities. The report:

- Examines barriers to the use of public transit by persons with disabilities.
- Provides information on techniques and devices that can improve transit access.
- Identifies and recommends areas for research and development that may help to overcome existing barriers to accessibility.

The scope of this report is to provide information related to the bus and transit rail accessibility needs of persons who are deaf or hard-of-hearing, persons with visual or cognitive impairments, or persons who are semi-ambulatory (having a mobility impairment that does not require the use of a wheelchair). The report addresses needs throughout the entire travel process on a bus or rail transit system, from obtaining basic route and schedule information to trip completion. Many of the techniques discussed in this report are applicable to commuter rail vehicles, intercity rail vehicle, over-the-road buses, and other vehicle systems (ferries, trams, etc.), although these systems are not the primary focus of this work.

This report does not address the needs of persons using wheelchairs.* While the needs of such persons are important, and are specifically addressed at length in the ADA, this area was excluded from the scope of this report because it is addressed by an associated research activity that has issued its findings in another report.** This report also does not address the special needs of persons with multiple disabilities, such as the deaf-blind.

1.3 Approach

The approach to conducting the research reported here consisted of two major thrusts. First, the requirements and needs of persons with disabilities related to their use of transit vehicles and facilities were reviewed. Next, information was sought on techniques and devices that could be used to overcome accessibility barriers (i.e., meet the requirements and needs). This interactive process involved examining both aspects concurrently, and was conducted following passage of the ADA, during the Federal rulemaking process, and after adoption of the DOT regulations.

The identification of accessibility requirements was primarily derived from the language of the ADA, its legislative history, and Access Board and DOT preliminary and final rulemakings. Accessibility needs, applicable to persons with disabilities, were also extracted from a variety of sources. Included were written submissions to the various dockets associated with the rulemakings, transcripts of testimony given at DOT's public hearings held to solicit comment on the proposed rules, and a review of research reports and papers addressing both general and transit-specific issues related to persons with disabilities.

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* Wheelchair means a mobility aid belonging to any class of three or four-wheeled devices, operated manually or powered, usable indoors, designed for and used by individuals with mobility impairments. This definition does not include walkers, crutches, or other similar devices. Persons utilizing such devices are included in the general class of semi-ambulatory persons that is addressed in this report.

** This report is Federal Transit Administration Guideline Specification for Passive Lifts, Active Lifts, Wheelchair Ramps, and Securement Devices," September, 1992.

While the sources cited above helped to identify potentially applicable techniques and devices, an emphasis was placed on research reports, data from manufacturers and the experience of persons with disabilities. Published materials as well as direct contact with disabled individuals and individuals and groups professionally involved with a wide range of persons with disabilities provided additional data. Information on technical products and innovations was current as of 1991. Since many of these products are developing rapidly, further improvements and adaptations may have already occurred.

1.4 Report Contents

Chapter 2 of this report presents an overview of the disabled populations of concern, including general demographic information. This chapter also provides an overview of the functional requirements associated with using public transit and of the relationship of these requirements to persons with various disabilities.

Chapter 3 reviews specific techniques and devices for improving transit access for persons with disabilities and discusses the status of techniques currently in use and their demonstrated effectiveness. Also, the potential for technological innovation or transfer of other techniques to the transit environment is examined. This information is presented in five separate sections that address techniques for 1) aiding general accessibility, 2) improving accessibility for persons who are deaf or hard-of-hearing, 3) improving accessibility for persons with visual impairments, 4) improving accessibility for persons with cognitive impairments, and 5) improving accessibility for semi-ambulatory persons. Chapter 4 proposes policy issues and research and development needs to improve transit access for persons with disabilities. Resources are listed in Appendix A.

2.0 OVERVIEW OF DISABLED POPULATIONS AND TRANSIT FUNCTIONS

2.1 Overview of Disabled Populations

It is difficult to quantify all the people who are protected against discrimination under the ADA. The intent of the Congress was to articulate clearly that no physical disability, sensory impairment, cognitive limitation, disease, or mental illness should restrict any person from equal access to every aspect of American society. Congress provided the following formal definition for the term "disability," with respect to an individual: (a) a physical or mental impairment that substantially limits one or more life activities of such individual, (b) a record of such an impairment, or (c) being regarded as having such an impairment (see Section 37.3 of 49 CFR 37 for a more explicit definition).

Based on this definition, four populations of persons who are disabled are explicitly addressed in this report: 1) persons who are deaf or hard-of-hearing, 2) persons with visual impairments, 3) persons who have cognitive impairments or a mental illness, and 4) persons who are semi-ambulatory (non-wheelchair users). These populations are defined as follows:

- **Persons Who are Deaf or Hard-of-Hearing**. A person who is deaf is one whose hearing disability precludes successful processing of linguistic information through audition, with or without a hearing aid. A further definition is that the sense of hearing is non-functional for the ordinary purposes of life. A person who is hard-of-hearing is one in whom the sense of hearing, although defective, is functional, with or without a hearing aid.[(1)] "Hearing impaired" is a more generic term, indicating a hearing disability that may range from mild to profound and including the subsets of deaf and hard-of-hearing. Some deaf or hard-of-hearing persons also have a communication disability or difficulty speaking understandably.

- **Persons with Visual Impairments**. This category includes all persons who are blind or have sufficiently diminished visual acuity and/or limited fields of vision. Blindness has been defined as visual acuity of 20/200 in the better eye with best correction, or visual acuity of greater than 20/200 if the widest diameter of the visual field subtends an angle no greater than 20 degrees. The definition for persons with low vision is those who fall within the range of 20/70 to 20/200, and more generally as an impairment in the visual system which interferes with normal daily functioning.[(2)]

- **Persons with Cognitive Impairments**. This population includes all persons with limited intellectual capacity, such as those with mental retardation, those who have lost intellectual ability due to traumatic brain injury, those whose ability to learn is compromised by any number of learning disabilities such as dyslexia, and those who cannot reason or process information due to the effects of mental illness (or the pharmaceutical(s) used to treat it). Persons with cognitive impairments also frequently have other impairments including low vision and balance problems.

- **Persons Who are Semi-Ambulatory**. This population includes all who have an impairment that adversely affects their mobility, but who do not require the use of a wheelchair (e.g., persons who are unsteady, who are unable to climb stairs or go up ramps, whose movements are abnormally slow). These persons often utilize walkers, crutches, canes, or other assistive devices.

Although this report does not directly address the needs of persons with disabilities other than those defined above or the needs of persons with multiple disabilities (e.g., persons who are deaf-blind), many of the techniques described in this report will be helpful to such persons, as well as to the general public.

The population of persons who are disabled is growing and will continue to grow in the future. Americans in general are living longer, and senior citizens make up a substantial portion of the population. As people get older, many acquire disabilities.

Further, while the incidence of birth or genetically related disabilities has decreased as a result of scientific advances and enhanced access to prenatal and neonatal care, the disabilities continue to be prevalent as improved health care enables people with previously fatal conditions to live long and productive lives. For example, the survival rate from severe traumatic injuries has increased dramatically. In 1975, 83 percent of all persons who suffered severe traumatic brain injuries died within 30 days of the trauma. Advances in emergency care and rehabilitation have reversed this trend. In 1985, nearly 85 percent survived.[(3)]

The distribution of persons who are disabled varies considerably within the United States. Concentrations of the elderly are found in Florida and other Sun Belt states. Within communities there are also highly localized clusters of persons who are disabled (group homes or employment centers are two examples). The dispersion and needs of persons who are disabled may be unequal.

The Congressional debates surrounding the ADA estimated the number of Americans who are disabled at approximately 43,000,000. A 1986 Harris survey of disabled Americans breaks out that number, as shown in Figure 1. These numbers are based on self-identification by people who were asked to choose "the most limiting condition" affecting their lives.

The number 43,000,000 is considered a conservative estimate of the disabled population in the United States. This number ignores persons with temporary disabilities (e.g., temporary mobility impairment due to a fractured ankle) and does not identify multiple disabilities. Further, data based on self-identification allow for varying definitions of disabilities. For example, The National Center for Health Statistics estimates that more than 20 million people in the United States are hard-of-hearing[(4)], while the 2.5 million figure in

Physical Disability	
Non-Paralytic Orthopedic Impairments	12,470,000
Neurologic Impairments	3,440,000
Brain Dysfunction	2,580,000
Other Physical Disabilities	860,000
Sensory Impairments	
Blindness/Significant Vision Loss	3,010,000
Hearing/Speech/Language Impairments	2,580,000
Cognitive Impairments	
Mental Retardation (moderate/severe/profound)	1,290,000
Other (traumatic brain injury, learning disability, etc.)	945,000
Mental Illness	
Chronic and Severe Mental Illness	1,290,000
Other Serious Health Impairments	
Heart Disease/Vascular Disease	6,880,000
Pulmonary/Respiratory Disease	2,150,000
Cancer/Diabetes/Renal/Other	4,730,000
Epilepsy/Seizure Disorders	1,204,000
TOTAL	43,429,000

Source: Harris Survey, 1986.

FIGURE 1. MOST LIMITING CONDITION OF SELF-DEFINED DISABILITIES

Figure I is an accurate tally of those persons who are profoundly deaf. While the Congress is clear in that perceiving oneself as having a disability protects the individual under the ADA, some subjects who could benefit from special assistance may not perceive themselves as having a disability.

Of the 43 million Americans with disabilities, 12.4 million are between the ages of 16 and 64 years. A 1987 follow-up Harris survey indicates that only 4.1 million of this group are working, while 8.2 million are willing and able to work. Of those not working, 44 percent cite the lack of accessible and affordable transportation as one of the main reasons they are not working.[5] Thus, public transit can play an important role by providing mobility and enhancing the lives of millions of persons.

2.2 Transit Functions and Related Needs of Persons with Disabilities

The basic functions that must be performed to use fixed route public transportation successfully involve understanding the system, accessing the correct vehicle, entering the vehicle, traveling on it, departing it, and leaving the stop, station, or terminal. The special needs, concerns, and/or problems of persons with disabilities using a transit system vary according to the disability and within disability groups. The transit functions and the related needs of the four major disabled populations considered in this report are discussed in this section.

2.2.1 Transit Functions

Making a trip on a fixed route public transit system entails performing a number of specific functions (see Figure 2). Figure 2 provides a composite representation of a trip by either transit bus or rapid rail. Those functions unique to bus or rail have been designated with a (b) or (r), respectively. Since light rail transit operations contain elements of both transit bus and rapid rail (e.g., high level or low level boarding platforms, fares collection on board or prior to boarding), the functions cited here are also applicable to this transit mode. Note that, while the first group of functions may occur throughout the trip, functional groups two through six are organized chronologically to represent a trip.

Understanding the System. Understanding the system involves passengers receiving information from the transit authority. Proper communication of this information is critical for successful completion of a trip. Before a trip begins, users of the system need

1. Understanding the System
    a. Learn routes, stops/stations, and transfer points
    b. Learn schedules
    c. Learn fare schedule and payment media
    d. Learn special services and provisions

2. Accessing the Correct Vehicle
    a. Locate the stop/station/terminal
    b. Locate and access fare system (r)
    c. Activate and pass through fare gate (r)
    d. Move to proper boarding area/platform (r)
    e. Identify correct incoming vehicle
    f. Identify and move to vehicle doorway

3. Entering the Vehicle
    a. Move through doorway/cross railcar gap (r)
    b. Ascend stairs/utilize lift (b)
    c. Pay fare (b)
    d. Identify vacant seat or standing space
    e. Reach seat/standing space

4. Traveling on Vehicle
    a. Accommodate motion of vehicle
    b. Accommodate entrance and egress movements of others
    c. Comprehend special announcements
    d. Respond to selected special announcements

5. Departing the Vehicle
    a. Identify desired stop/station/terminal
    b. Notify driver of desire to stop (b)
    c. Move to doorway
    d. Descend stairs/utilize lift (b)
    e. Exit vehicle and reach platform/pad

6. Exiting the Station/Terminal (r)
    a. Determine desired exit direction (r)
    b. Activate and pass through fare control gate (r)
    c. Exit station/terminal (r)

(b) = applicable only to bus transit systems
(r) = applicable only to rail transit systems

FIGURE 2. BASIC FUNCTIONS ASSOCIATED WITH USING TRANSIT

to know what services are provided and the basic conditions (routes, stops, schedules, fares) associated with the service. Included is information on special services such as the availability of wheelchair lifts, ramps, low-floor buses, etc. This information is usually provided through printed material or responses to telephone inquiries.

Such information is also necessary when a trip is in progress. For example, when entering a bus, a rider may be unaware of the correct fare, or a rapid rail car passenger may need to know the stop in order to disembark. Successful completion of the trip is dependent upon such information being provided on the vehicle or in stations. This information is acquired through signs and system maps or direct communication with transit operating personnel.

Accessing the Correct Vehicle. To access the correct vehicle, a rider must first locate the point at which a trip is to be initiated. Finding the appropriate bus stop is relatively straightforward (although a simple sign or pole can be obscure). Rail transit systems, however, often have underground stations, accessible from multiple, widely separated entrances. In some systems these entrances are specific to the rail direction of travel. Therefore, appropriate station entrance identification is essential.

In the case of bus systems, once the stop has been reached there is little to do except wait for the arrival of the bus. If the bus stop serves multiple routes, the rider must determine whether an approaching bus is the one desired. On certain routes, it is necessary to signal the bus to stop. Since buses often cannot stop directly in front of a waiting passenger, the passenger must be able to find the boarding door and move towards it.

Rail transit stations vary greatly in size and complexity from simple wayside stops to multi-line, multi-level, and even multi-modal terminals. Once a rider enters the station, it is necessary to pay the proper fare and proceed to the correct platform. This may entail traversing considerable distances and various levels. The rider must understand the station layout and system and make pathway decisions, especially if the station uses multiple platforms. Fare payment also requires an understanding of the rail system, especially when there are variable fares or the procedure is automated.

As with transit bus systems, users of the rail system must determine whether the approaching train is the one desired. While it is unnecessary to signal a train to stop, trains have only approximate stopping locations on the platform. Therefore, it is necessary to move along the platform until a doorway is encountered. Visually impaired persons may mistake the gaps between cars as doors. This improper identification must be avoided.

Entering the Vehicle. Upon reaching the doorway, the rider must step up from ground level to enter a bus and some rail systems (unless a lift, ramp, or level platform is utilized). This function may be facilitated by low floor or "kneeling" buses. Some light rail vehicles also require a step up. Fare payment commonly involves use of a fare box and may require an understanding of the system's fare structure. For example, a rider may need to be familiar with the additional cost and necessity of a transfer.

Rail systems may have level boarding from platforms into a rail car; however, riders must safely negotiate vertical and horizontal gaps. Vertical and horizontal gaps can vary considerably depending upon the specific transit system, the type of car, and the construction of the station, especially a station with curves. A rider also must be aware of station dwell time to avoid doors closing before boarding has been completed.

After entering either a bus or rail car, a rider must proceed to an available seat or standing position. The number of other riders and their relative positions on the vehicle will affect the difficulty of this function. For example, riders tend to congregate near rail car doorways, which impedes initial progress into the vehicle. Also, buses and rail cars commonly begin moving while passengers are still seeking seats. This movement can result in jerking effects making it necessary to hold on to a support such as a strap, stanchion, or seat back, to prevent falling.

Traveling on Vehicle. Traveling on a transit vehicle entails more than merely waiting to exit at the proper bus or rail stop. Riders must accommodate awkward motions of a vehicle, such as sudden starts and stops, acceleration, and deceleration. Accommodating the movement of other riders may require little or considerable response, depending upon relative positions and proximity to the movement.

A rider also must comprehend and respond to special announcements, such as a delay or an emergency. These situations are not always obvious to the rider. In a rail transit system, riders have limited knowledge of the operational status of a car. Riders must be able to respond to an emergency, including understanding and following directions and, possibly, evacuating the vehicle.

Departing the Vehicle. Identifying a desired bus stop while traveling can be difficult. A rider must rely on landmarks or street signs, which can be hard to read from a moving vehicle, to determine current and upcoming locations. Bus stop signs rarely include location information. On some systems drivers announce each stop, but this is not a routine practice. The DOT regulations (49 CFR 27.37-18) require drivers to announce stops at regular intervals, transfer points, major intersections, and upon request. Riders desiring a stop need to notify the bus driver before the bus reaches the stop. A common notification system entails pulling a cord or pressing a strip. This produces an audible sound and/or light to alert both the driver and other riders that a stop has been requested.

Departing riders must then proceed to an exit doorway. This activity can be initiated prior to the bus completing a full stop. A rider, therefore, must safely accommodate the motion of the stopping vehicle while moving toward the doorway.

Once a rider is at the doorway, and the vehicle has stopped, the rear doors must be pushed open on some buses. It is then necessary to descend the steps (or use the lift) to street level. Some light rail vehicles also require a step down. As with entering the bus, exiting may be facilitated by low floor or "kneeling" buses.

Rail transit operators commonly announce over the public address system the upcoming stations and indicate on which side of the vehicle exiting will take place. The names of rail stations are often placed in multiple locations on the walls behind the platforms. These can be seen as the trains enter the stations and come to a stop. Riders in the front cars have more opportunity to see these signs, and the view of the signs on crowded cars may be obscured.

The braking process associated with rail transit vehicles often concludes with an abrupt jerking action, which requires passengers to assume a stable position to avoid falling. Exiting a rail car is the reverse of entering; potential vertical and horizontal gaps exist at an otherwise level exit; and exiting must be completed prior to door closure.

Exiting the Station/Terminal. Most bus riders are not concerned with exiting a station or terminal, since buses commonly use simple stops. Upon reaching the bus stop, a rider is essentially out of the system. Some bus systems, however, arrive at a common terminal, possibly a space shared with other transport modes, which requires choosing the correct exit path. Rail stations can be very complex, with multiple levels and entrances/exits. Single line, single platform stops do not present difficulties in exiting, but in more complex terminals, an incorrect pathway decision may leave a rider very far from the final destination (whether that is transferring to another line or leaving the station).

2.2.2 Related Needs of Persons With Disabilities

In general, execution of the previously discussed transit functions is routine. Many public transit riders do not encounter any problems using a system. Even persons new to a particular system often adapt based on prior experience with similar transit system operations. While individual system operations vary in detail, there are many similarities in their nature and in the basic functions associated with their use.

For persons with disabilities, public transit is not always so straightforward. Many persons with disabilities routinely and successfully travel on public transit, but impaired vision, hearing, cognitive skills, or mobility may pose challenges in performing the basic functions associated with transit use. The degree of difficulty experienced by such persons varies with the nature and extent of their impairment, the specific functions involved, and the specific transit systems being used.

The following identifies the special needs of disabled passengers as they relate to these basic transit functions. The discussion has been separated into four parts corresponding to the four major disabled populations considered in this report.

Persons Who are Deaf or Hard-of-Hearing. In general, persons who are deaf or hard-of-hearing use public transportation with substantial independence. However, difficulties can arise in obtaining information in a timely manner and in responding to emergencies. Passengers who are deaf or hard-of-hearing, therefore, experience difficulties relative to two major functional activities:

1. Obtaining information (such as fare amounts, schedules, stops, and transfers) directly from transit personnel, either via telephone or conversations with transit operators and information booth attendants. Problems can occur prior to, or during, travel. General interactions with other passengers may also be adversely affected.

2. Obtaining information from announcements made in stations and on vehicles. These may be routine (upcoming stops, transfers, etc.), abnormal (such as information relative to delays on a line), or emergency (alarms or instructions in the case of an accident) announcements. Not understanding announcements can impact both ease of travel and safety of the passenger. In an emergency, while the actions of other passengers indicate that audible information has been provided, a passenger who is deaf or hard-of-hearing may be unaware of the necessary response.

Persons with Visual Impairments. Partial or total loss of vision affects the ease of using public transit. Although mobility training facilitates traveling independently, persons with vision impairments experience difficulties in three aspects of transit use:

1. Functions that entail receiving information by visual means. For example, information is provided visually on brochures, schedules, direction and location signs, and route/system maps.

2. Functions that entail locating and utilizing devices associated with carrying out a trip, such as ticket machines, turnstiles, and fare boxes.

3. Functions that entail physical movement throughout the system, including all activities related to entering, moving through, and exiting stations and vehicles. This includes accommodating the movements of others while

moving toward specific areas, such as entrances/exits, platforms, vehicle doorways, and seats.

Persons with Cognitive Impairments. The varying abilities of persons with cognitive impairments result in a corresponding range in the degree of difficulty these persons will encounter in using public transportation. Passengers with cognitive impairments generally experience difficulty comprehending and/or applying basic transit information. The difficulty may be that the information is too complex, that it is presented too rapidly, or that there are too many distractions in a facility or vehicle. The result will be indecision and apprehension, a failure to act, or reactions that are incorrect or "socially inappropriate." In the context of the transit environment, impaired cognitive functions may cause difficulties in understanding the system in general, accessing the correct vehicle, departing the vehicle, and exiting the station or terminal. Again, mobility training facilitates traveling independently for many persons with cognitive impairments.

Passengers Who are Semi-Ambulatory. Persons who are semi-ambulatory, although not in wheelchairs, often confront difficulties similar to those who are in wheelchairs. Such persons will encounter difficulty walking or stepping up or down and may also have difficulty moving about inside a vehicle. They may have a hard time moving to and from the vehicle doorway or sitting and standing up. While using a lift, they must exercise caution to maintain their balance and not strike their head on the bus door frame. These difficulties arise both from the nature of the impairment, as well as from the assistive devices used, such as canes, crutches and walkers. These devices require room to maneuver, which can be difficult on a vehicle, and normally require the use of one or both hands, which may make it more difficult to maintain a stable posture in a moving vehicle. Also, care must be observed with devices such as canes and walkers so that their use or storage does not impede the movement of or injure others.

3.0 TECHNIQUES FOR IMPROVING ACCESS

The DOT regulations implementing the transportation provisions of the ADA do not prescribe exactly how a transit system must meet all accessibility requirements. Particularly in the areas of public information systems, a transit system has broad discretion. For example, most of the information needs of deaf passengers could be accommodated by an electronic message board displaying preprogrammed messages. An alternative approach that requires less technology but more employee involvement would be for a transit system to provide bus drivers with printed cards that could be shown to deaf riders. An even simpler but more time consuming approach would be to equip all drivers with message pads to write out answers to questions posed by deaf or hard-of-hearing riders. The techniques addressed in this chapter span a range of complexity.

In determining how to respond to the federal requirements, transit managers must find an acceptable balance among technological complexity, cost, the degree of human involvement required, and the needs of the disabled persons that the solution assists. As another example, large print, non-glare, high contrast signage will convey written information to a large percentage of person with low vision, but will not meet the needs of the profoundly blind. Providing announcements or auditory information whenever signage is present meets the needs of all persons with vision impairments, from the least impaired rider to the totally blind (unless the rider is deaf-blind). Announcements are likely to be helpful to non-disabled riders, as well. If the information needs of the most disabled riders are solved, in most cases the needs of the less disabled will also be solved, but perhaps with more complexity and cost.

A number of techniques will aid more than one group of persons with disabilities and persons with disabilities not addressed in this report. Many, in fact, may be beneficial to the non-disabled population as well. Rare situations may occur where a device beneficial to one population is detrimental to another. These situations are noted as appropriate.

3.1 Overview of Techniques

Techniques to assist disabled persons in using public transit relate to both the function(s) to be performed and the nature of the disability(ies) to be accommodated. Table 1 provides an overview, in matrix form, of such techniques. These techniques are cross-referenced with the transit functions previously presented in Figure 2 and disabled populations considered here (i.e., hearing, visual, cognitive, and mobility impaired). In addition, the general disability category lists those techniques broadly applicable to more than one of the populations. Some of these general techniques may need to be tailored to meet the specific needs associated with a given disability.

3.2 General Techniques for Aiding Accessibility

There is a broad array of techniques that transit systems can employ to enhance accessibility for persons with disabilities. Techniques that are of use to more than one disability group are discussed in this section. The suggestions in this chapter elaborate on the information in Table 1, and most of these techniques are common sense approaches that enhance the appeal of transit for all consumers—with or without disabilities. Many of the concepts discussed are already employed by some transit systems and some are under development as a result of the passage of the ADA.

3.2.1 Training of Transit Personnel

Description. The DOT regulations implementing the transit portions of the ADA require that

> Personnel are trained to proficiency, as appropriate to their duties, so that they operate vehicles and equipment safely and properly assist and treat individuals with disabilities who use the service in a respectful and courteous way, with appropriate attention to the difference among individuals with disabilities. (49 CFR 37.173)

TABLE I. TECHNIQUES TO IMPROVE TRANSIT ACCESSIBILITY FOR PERSONS WITH DISABILITIES

Transit Function	General	Visual	Hearing	Cognitive	Semi-Ambulatory (Non Wheelchair)
1. Understanding the System					
a. Learn routes, stops/stations, and transfer points b. Learn schedules c. Learn fare schedules and payment media d. Learn special services and provisions	Training of transit operations personnel in communication and assistance techniques* Electronic file on computer disk Electronic bulletin board FAX Mobility training Automated telephone information system	Orientation and mobility training Large print/high contrast written information Braille materials Tactile maps Auditory mapping Audio cassette information	Directional signage to assist in locating technical aids TDD* Assistive listening devices (infrared, FM, induction loop) Automatic speech recognition systems Manual communication Adjustable volume telephone Hearing aid compatible telephone	Simple text and graphics Standard symbols Training	

*Required by DOT regulation
(b) = applicable to bus transit systems
(r) = applicable to rail transit systems

TABLE 1. TECHNIQUES TO IMPROVE TRANSIT ACCESSIBILITY FOR PERSONS WITH DISABILITIES

Transit Function	General	Visual	Hearing	Cognitive	Semi-Ambulatory (Non Wheelchair)
2. Accessing the Correct Vehicle					
a. Locate the stop/station/terminal	Training of transit operations personnel in communications and assistance techniques* Maps Standard logos and symbols Uniform architectural features	Tactile paths Large print/high contrast lighted signage	Visual signs	Uniform features Training	
b. Locate and access fare system (r)	Training of transit operations personnel in communications and assistance techniques* Audio, visual, and textural circulation aids	Tactile/braille vending machines Standard illumination levels Large print, non-glare, high contrast instructional signage Audio instructions	Clearly written instructions for use	Training Standard signage and symbols	Accessible path*
c. Activate and pass through fare gate (r)	Pre-paid pass system "Smart" card	Standard illumination levels Audio signal	Visual signals	Training Audio and/or visual signals	Minimum 32-inch clear width opening*

*Required by DOT regulation
(b) = applicable to bus transit systems
(r) = applicable to rail transit systems

TABLE 1. TECHNIQUES TO IMPROVE TRANSIT ACCESSIBILITY FOR PERSONS WITH DISABILITIES

Transit Function	General	Visual	Hearing	Cognitive	Semi-Ambulatory (Non Wheelchair)
d. Move to proper boarding area/platform (r)	Training of transit operations personnel in communication and assistance techniques* Uniform signage Standardized symbols Horizontal signage (versus vertical)	Auditory pathways Electronic or tactile circulation aids Detectable platform edge warning*	Visual displays of announcements	Training Uniform signage Standard symbols Color coding system	Accessible level changes (ramps with railings, escalators with two contiguous treads, elevators)* Standard stair intervals* Contrast edges on steps*
e. Identify correct incoming vehicle*	Training of transit operations personnel in communication and assistance techniques* External PA announcements (r)* Front, side, and rear signs displayed for sufficient time (b) Uniform station lighting (r) Passenger information system signifying next train arrival (r)	PA announcements* Large print/high contrast signage "Talking" bus stop (b) Electronic signals Auditory vehicle identification system (r)	Visual signs of next bus arrival (b) Visual train approaching signal (r) Visual vehicle identification system	Training Color coding system Audio/visual vehicle identification system	

*Required by DOT regulation
(b) = applicable to bus transit systems
(r) = applicable to rail transit systems

TABLE 1. TECHNIQUES TO IMPROVE TRANSIT ACCESSIBILITY FOR PERSONS WITH DISABILITIES

Transit Function	General	Visual	Hearing	Cognitive	Semi-Ambulatory (Non Wheelchair)
f. Identify and move to vehicle doorway		Audio cue Fixed stopping point Between-car barriers (pantographs, chains, motion detectors, etc.)* system			
3. Entering the Vehicle					
a. Move through doorway/ cross railcar gap (r)	Minimized horizontal and vertical car - platform gaps (r)*	Standard illumination (r)* Auditory doors closing warning (r)*	Visual door opening signal (r) Visual door closing signal (r)*		Handrails and stanchions for boarding via steps (LRVs) (r)* Clear door openings of 32 inches (r)* Slip-resistant surfaces (r)* *Level change mechanisms (lift, ramp) (r)* Indications for standing on lifts (r)

*Required by DOT regulation
(b) = applicable to bus transit systems
(r) = applicable to rail transit systems

TABLE 1. TECHNIQUES TO IMPROVE TRANSIT ACCESSIBILITY FOR PERSONS WITH DISABILITIES

Transit Function	General	Visual	Hearing	Cognitive	Semi-Ambulatory (Non Wheelchair)
b. Ascend stairs/utilize lift/ utilize ramp (b)	Training of transit operations personnel in communication techniques* Lower entry step (b) Low floor buses (b)	Standard illumination (b)* Surface change on step edges (b)			Slip-resistant floors and steps (b)* Contrast edges on steps (b)* Level change mechanism (lift, ramp, or kneeling bus) (b)* Indicators for standing position on lifts (b) Low head clearance sign (b) Properly placed handrails and assists (b)
c. Pay fare (b)	Training of transit operations personnel in communication and assistance techniques* Pass system "Smart" card	"Talking" fare box Standard locations for fare collection equipment	Standard visual signals	Standard visual/audio signals Training	Farebox located/designed to facilitate use by persons with mobility aids*
d. Identify vacant seat or standing space	Uniformly located priority seating for disabled persons			Training	

*Required by DOT regulation
(b) = applicable to bus transit systems
(r) = applicable to rail transit systems

TABLE 1. TECHNIQUES TO IMPROVE TRANSIT ACCESSIBILITY FOR PERSONS WITH DISABILITIES

Transit Function	General	Visual	Hearing	Cognitive	Semi-Ambulatory (Non Wheelchair)
e. Reach seat or standing space	Training of transit operations personnel in communication techniques* Priority seating located near bus entrance* Hand grips*	Sufficient room for seeing eye dogs	Sufficient room for hearing ear dogs		Sufficient room for mobility aids, including support dogs Hand grips and arms to assist in sitting and standing up
4. Traveling on Vehicle					
a. Accommodate to motion of vehicle					Hand grips*
b. Accommodate entrance and egress movements of others	Uniformly located priority seating for disabled persons*	Sufficient room for seeing eye dogs	Sufficient room for hearing ear dogs		Hand grips* Sufficient room for mobility aids, including support dogs
c. Comprehend special announcements	Training of transit operations personnel in communication and assistance techniques* Standard symbols and directions On-board PA* General safety/emergency information in accessible formats	Orientation and mobility training Large print/high contrast written information PA announcements*	Directional signage to assist in locating technical aids Assistive listening devices (infrared, FM, induction loop) Manual communication Visual displays of announcements Emergency strobe light system	Training Simple and clear communication techniques	

*Required by DOT regulation
(b) = applicable to bus transit systems
(r) = applicable to rail transit systems

TABLE 1. TECHNIQUES TO IMPROVE TRANSIT ACCESSIBILITY FOR PERSONS WITH DISABILITIES

Transit Function	General	Visual	Hearing	Cognitive	Semi-Ambulatory (Non Wheelchair)
d. Respond to selected special announcements	Emergency evacuation procedures Standard safety features (non-slip flooring, stanchions, handrails, etc.)*	Orientation and mobility training	Training	Training	
5. Departing the Vehicle					
a. Identify desired stop/station/terminal	Training of transit operations personnel in communication and assistance techniques* On-board PA and visual announcements Uniform station lighting (r) Station signage visible from inside car (r)	PA announcements* Pre-dispatch check of PA system Large print/high contrast/non-glare signage	PA system compatible with assistive listening systems Visual displays of announcements Seating near on-board "next stop" display Pre-dispatch check of passenger information system	PA announcements* Training to look for landmarks	Audio and visual next stop announcements
b. Notify driver of desire to stop (b)	Auditory/visual stop request system (b)*	Uniformly located auditory signal system (buzzer, bell) (b)	Visual confirmation that signal system is operating (light) (b)	Uniform location and standard systems (b)	Reachable pressure operated signal system (b)*
c. Move to doorway	Training of transit operations personnel in communication and assistance techniques*	Auditory announcement of correct door	Visual indicator of correct door		Hand grips to assist in standing up

*Required by DOT regulation
(b) = applicable to bus transit systems
(r) = applicable to rail transit systems

TABLE 1. TECHNIQUES TO IMPROVE TRANSIT ACCESSIBILITY FOR PERSONS WITH DISABILITIES

Transit Function	General	Visual	Hearing	Cognitive	Semi-Ambulatory (Non Wheelchair)
d. Descend stairs/utilize lift/utilize ramp (b)	Training of transit operations personnel in communication techniques* Lower entry step (b) Low floor buses (b)	Standard illumination (b)* Surface change on step edges (b)			Slip-resistant floors and steps (b)* Contrast edges on steps (b)* Level change mechanism (lift, ramp, or kneeling bus) (b)* Indicators for standing position on lifts (b) Low head clearance sign (b) Properly placed handrails and assists (b)
e. Exit vehicle and reach platform/pad	Minimized horizontal and vertical car - platform gaps (r)*	Standard illumination*	Visual indication of door opening signal (especially for exiting)		Handrails and stanchions* Clear door openings of 32 inches* Slip-resistant surfaces* Level change mechanisms Indications for standing on lifts

*Required by DOT regulation
(b) = applicable to bus transit systems
(r) = applicable to rail transit systems

TABLE I. TECHNIQUES TO IMPROVE TRANSIT ACCESSIBILITY FOR PERSONS WITH DISABILITIES

Transit Function	General	Visual	Hearing	Cognitive	Semi-Ambulatory (Non Wheelchair)
6. Exiting the Station/Terminal (r)					
a. Determine desired exit direction (r)	Uniform signage Standard lighting	Orientation and mobility training Large print/ non-glare, high-contrast signage Electronic or tactile circulation aids Auditory pathways		Training	
b. Activate and pass through fare control gate (r)	Pre-paid pass system "Smart" card	Standard illumination levels Audio signal	Visual signals	Training Audio and/or visual signals	Minimum 32-inch clear width opening*
c. Exit station/ terminal (r)	Uniform external design (r) Standardized signage (r) Directional signage (r)	Large print, non-glare, high contrast signage (r)		Training	Accessible path*

*Required by DOT regulation
(b) = applicable to bus transit systems
(r) = applicable to rail transit systems

Discussion. Training should extend to all transit employees who interact with the public, including information operators. Persons with disabilities have differing information needs. Visually impaired individuals, for example, may need to know the number of stops from the beginning to the end of a rail transit trip and the direction of travel from station entrances to platforms. Special training is also important for any staff member using a text telephone which is a device that allows persons with hearing or speech impairments to send and receive typed messages via telephone*. Transit agencies should consult with persons with disabilities, human service agencies, and mobility training specialists in designing training programs for personnel.

3.2.2 Mobility Training

Description. Mobility training for the visually impaired is a well-known specialty. Orientation and mobility specialists are trained at the undergraduate or graduate level to teach blind and visually impaired individuals to travel independently. Rehabilitation counselors and other therapists based in community hospitals, independent living centers, or human service agencies also have expertise in teaching mobility skills to persons with cognitive disabilities, developmental disabilities, or other physical impairments that make transit use difficult. These specialists also have the skills to work with family members and caregivers who are reluctant to allow disabled persons to travel independently. Another approach for mobility training is peer-to-peer training where a skilled traveler with a disability assists a new transit user. This approach is particularly useful with the elderly or wheelchair users.

Discussion. Transit agencies interested in assistance in developing mobility training programs should consult with experts in the local community and should investigate successful approaches used by other transit systems. See the resources listed in Appendix A. An issue of particular concern is the need for ongoing training assistance to persons with

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* Text telephones is a newer term for "telecommunication display devices" or "telecommunication devices for the deaf" commonly referred to as TDDs. The term TDD is used throughout this report.

disabilities, particularly the developmentally disabled and persons with cognitive impairments. These persons may be trained by vocational education or rehabilitation counselors to use transit from home to work, but if the route changes for any reason (a new job or a new residence), the person will require additional training.

3.2.3 Transit Information in Accessible Formats

Description. Transit entities are required to make information about transit services available in accessible formats. Large print, braille, and TDD telephone service are familiar accessible formats. Other options include

- PC-Based Information—Fare and schedule information on electronic bulletin boards or electronic mail that could be accessed via modem from the home or work place would be a convenience for many riders. This information could be provided directly by a transit system or via computer network. Several computer networks target people with disabilities and programs that serve them. Networks for the general population are also available to persons with disabilities. Computerized information could be easily and inexpensively updated. It is also possible to provide schedules and other system information on disc upon request for persons who do not have modems.

- Automated Telephone Information Systems—Most transit systems provide fare, route, and schedule information over the telephone. Automated voice information systems are increasingly common in many businesses. Such systems are being used by some transit systems and have great potential for use by others. Particularly for the blind and for persons who have low literacy levels or other print handicaps and cannot use a printed schedule, an automated information system would be helpful. An additional enhancement would be if this system could easily be accessed within a rail system or at bus stops, and if the information could be repeated upon request to improve the ability of a rider to remember it. An auto-answer TDD for the deaf could be established with the same information.

- FAX Machines—FAX technology is also increasingly common. This approach to exchanging information is particularly helpful for the deaf, hard-of-hearing, and for persons who find it difficult to speak or hear over the telephone.

Discussion. Personal computers, automated telephone information systems, and FAX machines are proven technologies that can be used in the transit environment. Transit agencies should consider these technologies as part of an array of innovative solutions for providing transit information to persons with disabilities. Considerations should include the demand for the information and the ease of production and updating. Transit agencies should investigate the possibility of cooperating with community agencies and advocacy organizations in information production and dissemination. Working together will help ensure that the information is usable and reaches those who need it.

3.2.4 Standardization

Description. Incorporating standard design into transit system features and operations will be advantageous to all transit users, particularly people with visual impairments, blindness, cognitive impairments, developmental disabilities, and mental illness. Ideally, some items should be standardized nationwide, such as the shape of bus stop poles, but at a minimum standards within transit systems should be developed. Items to consider for standardization include

- Bus Stop Signs—The same shape, color, and height on an easily identified pole (e.g., a square or triangle shape) can help persons with visual impairments and print handicaps to confirm that they have located transit stops.

- Architectural Design—Uniform architectural design helps persons with limited vision become oriented. Familiarity with design features also can ease the anxiety that can be problematic to persons with mental illness.

- Lighting—Sufficient lighting is essential for enhancing visual contrast. Lighting is important for persons with low vision; for blind persons using guide dogs, since dogs, which are color blind, rely on contrast for cues; for persons with cognitive disabilities who frequently feel vulnerable and anxious in poorly lighted areas and who often also have balance problems when walking over uneven surfaces. Persons with hearing impairments also frequently experience balance problems in poorly lit areas.

- Emergency Alarm Systems (Audible and Visual)—A standard visual warning light is particularly important for persons who are deaf and hard-of-hearing. The ADA accessibility standards for transportation facilities are stated in Appendix A to Part 37 and include both audible and visual alarm requirements.

- Electronic Signs—Signs that scroll through information are increasingly common on transit buses. The moving characters are difficult to follow for persons with low vision, especially those who use a monocular, and persons who do not have the ability to combine the moving characters into understandable works. This includes persons with cognitive impairments and also many deaf persons who read slowly. These signs are also difficult to read in glaring, outdoor light. Information should be displayed in a static format for a sufficient time. Additional research is needed to determine a satisfactory time interval.

- Icons and Color Coding—The use of graphic icons and color coding eliminates the need to be able to read the printed word. Graphics and color can be incorporated on fare information, schedules, bus stops, rail stations, and on transit vehicles to provide a consistent visual linkage for persons with disabilities. This approach is particularly helpful for persons with cognitive impairments, low vision, and learning disabilities. The advantage is pronounced for persons with severe vision loss who use devices such as a monocular to identify objects in the distance. When scanning a moving target such as a bus, it is difficult to find vehicle identification, much less read it. Icons or color coding located in uniform places can facilitate easy identification. Icons should be bold with high contrast and should incorporate familiar shapes. They should be placed in a universal position on all vehicles and should be positioned so as to maximize the contrast. For example, icons placed just below the roof line on a bus can be obscured in the blur between the bus and the bright sky.

- Priority Seating—Priority seating near the front of a vehicle is stipulated in the Access Board guidelines for accessible vehicles. It is important that this seating is within view of the operator. The sense of personal security that comes from having the operator in sight can be beneficial to individuals with cognitive impairments and mental illness. Persons who are deaf and hard-of-hearing sometimes need to be able to see the operator to know when a desired stop has been reached. Seating near the operator will help the blind to hear announcements. The seating should also be designed to allow sufficient room for safe storage of mobility devices, including support dogs.

Discussion. The transit industry should begin to identify items that could and should be standardized. Input from persons with disabilities and mobility specialists should be solicited. Developing national standards will no doubt be a lengthy and difficult process, so steps should be initiated as soon as possible.

3.3 Techniques to Aid the Deaf or Hard-of-Hearing

Section 2.2.2 noted two primary difficulties the deaf or hard-of-hearing population has in utilizing public transit: obtaining information directly from transit personnel, either by telephone or conversation, and obtaining information from announcements made in stations and on vehicles.

The techniques outlined in Table 2 attempt to overcome these difficulties. These techniques fall into two categories. The first category involves providing visual information, which is helpful both to persons who are deaf and to persons who are hard-of-hearing. The second category applies only to persons who are hard-of-hearing, enhancing their ability to hear and understand information by increasing the volume of sound provided. The techniques reviewed here are uniform symbols for technical aids, telecommunication devices for the deaf (TDDs), hearing aid compatible telephones, automatic speech recognition systems, visual displays on vehicles, assistive listening systems, manual communication, and emergency warning signals.

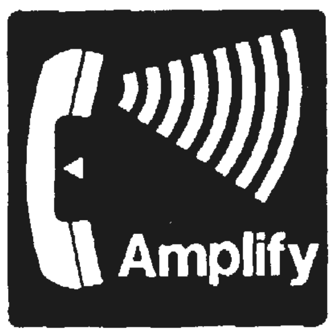
3.3.1 Uniform Symbols for Technical Aids

Description. Uniform symbols have been created to direct consumers within transportation facilities to the location of assistive equipment.

The ADA requires standard TDD signage in all public places. The uniform symbol for TDDs is:

The uniform symbol indicating facilities and services accessible to persons with a hearing loss:

The uniform symbol for adjustable volume telephones is:



Discussion. These uniform symbols are not always used. Use of different symbols can confuse persons who are deaf or hard-of-hearing. Printed words would be acceptable to identify telecommunication aids in addition to the icons given above. Transit agencies should use these standard symbols in conjunction with directional signage indicating where these devices can be found.

3.3.2 Text Telephone/TDDs

Description. Text telephone is a general term for machinery or equipment that employs interactive graphics (i.e., typed) communication through the transmission of coded signals across the standard telephone network. Text telephones include TDDs and computers. As previously noted, TDD is used in this report because it is the "common" text telephone in use at this time. In using TDDs, messages are sent back and forth over a telephone line by typing responses rather than by speaking. This provides visual rather than auditory information to the users. The device works by connecting a special keyboard to a telephone. It translates typed information into signals that can be carried by telephone lines. To use this technique, both the caller and the responder must have a TDD or TDD emulator. A TDD can be used in transit systems (and already is in many locations) to provide schedule and general information. A TDD is also essential for public use, so that persons who are deaf or hard-of-hearing may make personal calls to others with TDDs, or through TDD-relay services if the other party does not have a TDD.

TDD technology is rapidly improving. Several battery-powered portable models are available. These TDDs also have an AC converter. One of the most significant changes is the creation of a TDD keyboard that may be retrofitted to public telephones. This keyboard, contained in a metal drawer, slides out from underneath the telephone only when another TDD user has been called and has pressed several keys on their keyboard. Otherwise the keyboard is locked away and vandal resistant.

Discussion. One aspect of this technique that must be considered is the "language" that the TDD uses. To be carried by telephone wire, information must be translated into a signal or code that the receiver's TDD can understand and translate back into English. Baudot and ACSII are the two codes currently used. Baudot is the commonly used, and more limited, language. It has the option of only 32 characters—all 26 capital letters and six others. At this time, Baudot's speed is limited to about 60 words a minute, which is fast enough for most but not all users. The most significant problem with Baudot is that it is not compatible with personal computers. With the growing popularity of personal computers, it is important that TDDs be compatible. Modems that are TDD capable are available for personal computers. These devices are a better communication solution for PC users, because the modems offer both TDD capability and regular modem service. The user could have access to other services offered to modem users such as remote login to host computers (mainframe, work station, etc.), access to bulletin boards, etc.[6]

The greatest advantage of TDDs that can process information in ASCII is the ability to access personal computers. Their speed is also a benefit; ASCII-present modems with TDD capability can translate information at a rate of 300 words a minute, five times faster than present Baudot devices. (In fact, the modem's speed can be a problem. When accessing a bulletin board, the information is sent too fast to read on the screen, making a printer necessary.) Another benefit of ASCII is that it contains 128 characters, which allows a broader range of expression than is currently possible with Baudot.

Some TDDs have the ability to utilize both ASCII and Bandot. Advocacy groups for the deaf and hard-of-hearing are recommending that such technology be used on all public telephones.

The ADA has established requirements for the number, locations, and signage for text telephones and pay telephones that will accommodate portable text telephones. Subsection 4.31.9 of Appendix A of Part 37 states:

(1) Text telephones used with a pay telephone shall be permanently affixed within, or adjacent to, the telephone enclosure. If an acoustic coupler is used, the telephone cord shall be sufficiently long to allow connection of the text telephone and the telephone receiver.

(2) Pay telephones designed to accommodate a portable text telephone shall be equipped with a shelf and an electrical outlet within or adjacent to the telephone enclosure. The telephone handset shall be capable of being placed flush on the surface of the shelf. The shelf shall be capable of accommodating a text telephone and shall have 6 inch (152 mm) minimum vertical clearance in the area where the text telephone is to be placed.

The ADA requirements address the major areas of interest to transit TDD users, but the following additional points might be considered when making new installations.

- Installing credit card capability may make accessible phones more practical. Currently, many transit stations offer telephones that use credit cards instead of currency. This improvement benefits persons who are deaf or hearing impaired by eliminating the need to communicate with an operator regarding the correct change for a call.

- A TDD may be harder to use when it is placed among a bank of public telephones because of the activity and commotion common to public areas. There is also a concern about vandals destroying the keyboard of the TDD. Vandal-resistant drawers are available to house TDD keyboards.

It has become more common for transit operators to offer general information by TDD. On occasion these services are underutilized because transit personnel have not been properly trained to use the equipment or the TDD number is not well-publicized. Compounding this situation, the operator receiving a TDD call sometimes has difficulty understanding the message because the grammar is unclear. American Sign Language (ASL), used by many deaf persons, does not have the same grammatical rules as English. Consequently, it may be desirable for transit staff to become familiar with the language structure of ASL. Examples of the grammer of ASL users are as follows:

"Bus stadium stop where?" = Where does the bus stop at the stadium?
"Bus, how much cost, time?" = How much is the fare, and what time does the bus leave?

Videotapes to train people on how to use TDDs are available. They serve as excellent tools for learning the TDD technology at an individual pace. Community centers for the deaf can also provide assistance in using TDDs. Some resources are listed in Appendix A.

3.3.3 Hearing Aid Compatible/Amplified Telephones

Description. Hearing aid compatible telephones produce sufficient levels of magnetic energy so that, when used with a properly equipped hearing aid, the user can converse on the telephone. Hearing-aid compatible telephones are essential for public use in the transit environment. For a telephone to be hearing-aid compatible, both the telephone and the hearing aid must be properly equipped. A compatible hearing aid contains an induction coil that is sensitive to the telephone's magnetic energy, and the aid converts that energy back into sound. Such hearing aids contain a t-switch, that allows the aid to magnify only the sound coming from the coil and not other sounds. To contain this coil and t-switch, a hearing aid must be fairly large. Behind-the-ear hearing aids usually can be adapted; inner-ear aids and smaller aids usually cannot. Currently, 30 percent of all hearing aids sold contain a coil and t-switch.

Amplified telephones or amplified telephone handsets with adjustable volume control are another consideration. This equipment amplifies sound by twenty decibels and reduces background noise. The equipment is compatible with the hearing aid t-switch.

Discussion. The technology related to hearing-aid compatible telephones is not new. Previously, all telephones were compatible. In recent years, technological advances have allowed telephone manufacturers to reduce these levels of energy, making their equipment less expensive. As a result, to ensure that telephones remained accessible for persons who are hard-of-hearing, Congress enacted the Telecommunications for the Disabled Act of 1982, which requires all coin operated and all essential phones to be hearing-aid compatible. A 1989 law further requires all corded telephones sold in the United States to be compatible. Full compatibility has yet to be achieved, however. Transit agencies should have one amplified telephone/handset installed in each cluster of telephones.

3.3.4 Automatic Speech Recognition

Description. Automatic speech recognition (ASR) technology enables persons to talk to computers. Current applications include voice-driven word processing and data entry. The technology has the potential to be extremely useful for deaf and hard-of-hearing persons because it automatically converts speech to text. In effect, the ASR system acts as an interpreter, allowing persons who are deaf or hard-of-hearing to converse with hearing persons. The hearing impaired persons's response may then be written or spoken.

The basic techniques that ASR systems employ in interpreting spoken words are: (1) the systems work on a matching system, in which their memory patterns represent word sounds; when a sound is made that closely approximates a pattern, the corresponding word is chosen, and (2) some devices go further and include statistical information on words in their database to enhance the word selection process. Such devices utilize both matching sound information and an understanding of sentence structure and syntax to estimate what word is intended by a given sound.

Discussion. ASR technology is rapidly evolving and commercial applications are increasing; however, application to mass transit requires further development. The latest machines still rely on speaking in discrete utterances (words or phrases spoken singly with a pause before and after each word or phrase), as compared to continuous speech (words spoken fluently and rapidly, as in conversational speech). They also are only capable of providing something closer to speaker dependent recognition (a procedure for speech recognition that depends on enrollment data from the individual speaker who is to use the device) than they are to being speaker independent.

In one of the latest systems, each person who wishes to use the device must be registered by way of a voice mailbox. Although enrollment data is not required for every word from each user, the device must recognize each voice. Through repeated use, the device begins to recognize the voice pattern of an individual and can extrapolate to other discrete utterances made by that individual. Beyond this, even after a machine recognizes a specific voice, it will still only interpret 30 to 40 words a minute. This does not even closely approximate real-time speech recognition.

With future advances, ASR may be applicable for providing transit information where there is a limited number of employees and where the types of information provided are similar so that an appropriate vocabulary could be built up. For example, such a device may be used at an information counter in a rail station.

Technology is being developed to allow TDDs to interface with computerized voice technology, such as automated voice mail, transaction processing, etc. This may hold some potential for better providing schedule and fare information.

3.3.5 Visual Signs

Description. One of the easiest ways to help both the deaf and the hard-of-hearing population is through improved signage in transit vehicles, in stations, and at bus stops. Providing more information in this format will benefit most riders.

A possible approach is to use dynamic electronic signs inside buses, employing technology similar to that currently used outside buses. There is also a need for bus signs that indicate the correct fare and how to obtain a transfer. These signs could provide information such as which stop is approaching and emergency messages. There are two variables to consider; first, which type of electronic signage to use and, second, the manner in which the sign information gets changed to match the changing information needs.

There are several basic types of signs, including flip dot, reflective disc, liquid crystal display (LCD), and light emitting diode (LED). Flip dot signs have been used on the exterior of buses because of the problems that natural light poses for the other technologies. LED and LCD have proven to be less visible in natural light. These technologies have more applicability inside a vehicle where they are not subject to direct sunlight.

Discussion. One way interior signs may be used is to preprogram a list of all stops on a fixed route. The transit operator would simply press a button that causes the next message (e.g., the next stop) to be displayed on the screen. At the writing of this report, no transit system was reported to be using visual sign technology in this fashion, although several manufacturers indicate that such use is possible.

An automatic vehicle locator system (e.g., Global Positioning System, transponder) could also provide location information to the sign. A device that sends out a signal indicating the upcoming stop could be attached to poles along a fixed route. The transit vehicle would be equipped with a receiver to pick up that signal and transmit it to the sign. This technology exists and is used by several transit systems for vehicle tracking. It could be modified to interact with signage.

A more remote possibility is using an automatic speech recognition system. When a transit operator announces the next stop over a PA system, the information is also translated and displayed on the sign. Because of the limitations of this technology, as described above, such a system requires further development.

Length of display for electronic signage on transit vehicles should be further evaluated. Field tests are also needed to evaluate the feasibility and cost of automatic visual message systems in the transit environment.

3.3.6 Assistive Listening Systems

Description. Assistive listening systems provide clear auditory information to persons who are hard-of-hearing. They may have applications both in transit facilities and on vehicles. The inherent difficulty in communicating with persons who are hard-of-hearing is compounded by environmental conditions. Reverberation in a room makes any sound harder to interpret, and background noise can make an already difficult auditory situation even more so. Assistive listening systems help overcome these difficulties. Such systems convey a specific amplified sound directly to the ear(s) without increasing the volume of background sounds, thus diminishing the problems that environmental conditions present. On transit vehicles, assistive listening systems could help hearing impaired persons comprehend driver announcements. Within transit facilities, such systems could be used at information booths or ticket counters to assist persons who are hard-of-hearing converse with transit personnel, or at specific waiting areas in stations to comprehend announcements.

Discussion. There are three main categories of assistive listening systems: FM, infrared light, and induction loop.

- **FM Systems**-FM systems transform an audio sound source into an FM radio signal that can be picked up by a receiver. The message being sent (by a person speaking into a microphone) is connected to a transmitter that sends out a signal on an assigned channel. Persons wishing to receive the information must have a portable receiver. Some newer FM receivers have the capacity to receive more than one channel, but most receive only one.

Earphones connected to the receiver relay the information directly to the individual. The user can control the volume as desired.

The transmitter can be portable (worn by a transit operator) or fixed (requiring installation). Portable transmitters run on batteries, while the installed types use an available power supply.

FM assistive listening systems use either wide band frequency or narrow band frequency broadcasting. Both are on the market. Narrow band transmitters provide the opportunity for more distinct channels. More channels provide better clarity if multiple frequencies are used in close proximity. Narrow bands also reduce the likelihood of interference from outside sources. Up to 32 channels are available with narrow band systems. Eight are available with wide bands.

Wide band systems provide better sound quality because they offer a greater dynamic range and a higher signal-to-noise ratio. They are also less expensive to produce than narrow band systems. However, wide band systems have some disadvantages. First, there is a greater chance of picking up extraneous signals. These systems require more power than narrow band systems, since more information is being transmitted. Finally, keeping wide band systems tuned to the proper frequency can be a problem, since it is more difficult to stay on a wider band, and environmental conditions (such as heat and humidity) can affect this capability.

Equipment from different manufacturers is generally not compatible since each company has the option to choose the frequency (within the band designated for this purpose by the FCC) and the band width to use. Therefore, to purchase compatible equipment for use in a transit environment, individuals would have to know the system being used by the local transit authority and the frequency on its lines.

One concern with FM systems is the potential for crossed signals. Since the signal is being sent into the atmosphere, signals from another source broadcasting at the same frequency could easily interfere. Each time buses using FM assistive listening device at the same frequency get too close to each other, there is the potential for interference. Passengers may not know what information is correct. While a transit operator also has the option of using different channels on different routes, the logistics involved may be very difficult.

However, several factors may prevent this from being a critical problem. First, the range of the FM systems is, on average, from 200 feet to 1,000 feet. This range can be adjusted by either altering the strength of the signal transmitted or by changing the size of the antenna. A manufacturer stated that one of their systems has an average range of only 100 feet. There is also a phenomenon known as "FM capture effect." Any time there are multiple signals, if one is more than twice as far away from another transmitter, only the closer signal would be picked up. Further, metal helps absorb and attenuate the FM signal. The use of metal in transit vehicles would help to ease the problem of crossed signals.

Some information suggests that FM assistive listening devices can be used in the transit environment. At least one manufacturer has already used them on tour buses with success, even when the buses were in close proximity.

FM systems have applications beyond aiding persons who are hard-of-hearing. Although FCC limits the use of the frequencies, they can be used to aid persons with disabilities. Systems could be used to provide directions for persons with visual impairments (for example, directional information for a visually impaired persons who has left the station, beyond the level of detail required by a hard-of-hearing person) or possibly for persons with cognitive impairments.

- **Infrared Light Systems**-Infrared light assistive listening systems operate on a principle similar to that of FM systems; a transmitter sends out signals that must be picked up by receivers. Instead of the signal being transmitted by FM radio, however, these signals are transmitted by infrared light.

  Users of infrared light systems do not have to be concerned that individual signals will intermix with other infrared light signals in other locations or that the signal will be picked up outside its application location. A receiver only picks up signals that it can "see." Most of these systems are used in large auditoriums and professional concert halls because of the high quality of transmission and the ability to keep a signal within the confines of the room. Thus, such a system may be very applicable to transit stations.

  One consequence of infrared light not going beyond the confines of an area is that manufacturers may all use the same frequency to transmit their signal. They have, in fact, agreed to do so, allowing people to purchase their own receivers and use them wherever infrared light systems exist. This only applies to systems that transmit one signal, however. Multiple signals have not been standardized by manufacturers. If more than one signal is transmitted, special dedicated receivers that can be tuned to the channel in use must be available. A personal receiver would no longer be effective.

The signal is limited to those in the direct line of "sight" of the transmitted infrared light limits its applicability to transit vehicles. If something blocks the path of the light, the signal will not get through, which could be a problem on a crowded vehicle or in certain seats. Some infrared light systems can be mounted on the ceiling of a vehicle, which may diminish this problem.

Another problem is that infrared light systems do not perform well in natural light, since sunlight contains infrared light. Windows minimize this problem to an extent, and tinted windows, now used more frequently on buses, may prevent sunlight from affecting the quality of the signal altogether. These systems need to be tested to determine how they will perform in above-ground rail systems and bus systems.

Manufacturers are currently trying to develop a coded infrared light system. These system transmitters would send infrared light signals in pulses. For example, the light would be transmitted in three quick, successive pulses. The receivers could then be programmed to receive only infrared light that fits this designated pattern or code. Even though the infrared light content of the sun is much higher, it would effectively be blocked out by such receivers. This technology is at least several years away from implementation.

Infrared light systems are typically more expensive than the two other systems (FM radio and induction loop), although one manufacturer claimed that upkeep costs are lower. The trend in the field of assistive listening systems is in the direction of FM systems, and at least one manufacturer has abandoned infrared light systems in favor of FM systems.

- **Induction Loop Systems**-The least expensive assistive listening system is the induction loop. The induction loop system is based on a premise similar to that which makes telephones hearing-aid compatible. A microphone provides input to a transmitter that has a closed loop of wire attached to it. The system is installed by looping this wire around the perimeter of a room or area. The wire creates a magnetic field around the loop that can be picked up by hearing aids that are t-switch equipped (the same t-switch that makes a hearing aid compatible with telephones). Thus, it is possible to transmit a signal directly into a hearing aid without a receiver or an earphone. Without this t-switch, or with a poor quality coil in the hearing aid, the user requires a receiver similar to the one used with FM and infrared light systems.

  Induction loop systems are basically hearing-aid compatible, which is one of the real advantages to this assistive listening system. Persons with hearing aids do not need to carry a receiver or remove their hearing aids to use the system. However, as mentioned earlier, approximately 30 percent of hearing aids sold have the necessary coil and t-switch.

  Another benefit of loop systems is that there is less problem with crossed signals, since the signal does not travel far from the loop. In fact, sometimes persons must be close to the loop to receive a sufficiently strong signal and may have to avoid certain shadow spots. These problems frequently can be dealt with through proper amplification or setup of the system. The relatively small size and narrow shape of buses and rail cars are conducive to producing a strong signal.

  A disadvantage of loop systems is that they are less applicable than other assistive listening systems to persons who have normal hearing (such as the visually impaired) because of their greater frequency response limitation.

Although the fidelity of loop systems is usually sufficient, FM systems are considered by some experts to be higher quality.

Another disadvantage is that extensive metal surroundings affect the strength of a signal. Further, magnetic interference from high voltage lines, weak fluorescent light ballasts, and TV and computer cathode ray tubes all may create a distracting hum and diminish the primary signal. The signal may also be affected by "noise" sources, such as automotive ignition systems, traffic signals, and other items common to the transit environment. Some of these problems have been addressed, but it is possible that negative sources could make induction loop use problematic for transit vehicles. Available information was anecdotal; induction loops have been successfully used on buses in several Scandinavian countries and in The Netherlands, which suggests that the difficulties can be overcome.

The induction loop is the least costly of the three types of assistive listening systems. They require more time for installation, however. The quality and range of the sound of loop systems depends to an extent on the way that the loop is shaped. For example, one way to strengthen a signal is to add some turns in the loop. Each unique environment potentially requires a different shaped loop.

The other two types of assistive listening systems offer the ability to broadcast simultaneously over several channels. Unfortunately, with the induction loop system, this option is not available. Only one signal can be sent out on the induction loop.

It should be noted that induction loop technology may be combined with an FM system. The FM receiver can drive a small loop worn around the neck. This allows an assistive listening system to be directly compatible with a hearing aid if the hearing aid is equipped with a coil and t-switch.

It is clear that assistive listening systems have the potential to be useful on buses or rail vehicles, and in limited circumstances in transit facilities. The logistics of installing any one of these systems present many questions that need to be resolved through a field test. It must be decided how passengers would obtain receivers for use with the system. Receivers potentially could be installed on the vehicles or in waiting areas in stations, provided upon entering the bus or station, or privately owned or otherwise held by disabled individuals. There may be concerns about stolen equipment, or equipment that must be sanitary, such as the earpieces. The costs and feasibility of the various systems should be systematically tested and evaluated.

3.3.7 Emergency Warning Systems

Description. In the case of an emergency, a person who is deaf or hard-of-hearing will miss the typical auditory cues and not know what is happening. One approach to this serious situation is to create a warning system that incorporates flashing lights.

Discussion. ADA requirements address visual alarms or warning systems. If single station audible alarms are provided then single station visual alarms signals shall be provided. The photometric and location features of the requirement are similar to those suggested by research performed for the Architectural and Transportation Barriers Compliance Board[5]. The requirements are that the lamp shall be a xenon strobe type or equivalent and shall be clear (unfiltered) or filtered white light. The maximum pulse duration is two-tenths of a second with a maximum duty cycle of 40 percent with a minimum intensity of 75 candela. The flash rate minimum is one cycle per second and a maximum of three cycles per second. The light must be placed 80 inches above the highest floor level within the space or 6 inches below the ceiling, whichever is lower. In general terms, the distance between visual alarms should be no more than 50 feet. More detailed requirements are in Appendix A of Part 37.

Emergency warning systems in the transit vehicles require further design, testing, and evaluation with substantial input from disability groups.

3.3.8 Manual Communication

Description. American Sign Language (ASL) is the predominant language used by the majority of persons who are deaf in the United States. Sign English is the use of signs from ASL within an English syntactic order.[7]

Discussion. Transit operators may choose to learn some very basic sign language. Listed below are some signs that would be particularly useful to learn. It is particularly important that there be regular refresher courses if American Sign Language is taught. A training videotape (or a series of videotapes) that teaches basic signs, thus allowing transit operators to learn at their own pace, would be very useful. Sign language manuals are available from the National Association of the Deaf, and other publishers.

Helpful Signs			
Fare	Stop	Driver	Numbers and Letters
Station	Help	Terminal	One-Way
Round-Trip	Emergency	Time	Trouble
Schedule	Ticket	O.K.	Transfer

Source: Edward E. Corbett, Jr., Ph.D., Ohio School for the Deaf

3.4 Techniques to Aid the Visually Impaired

Section 2.2.2 noted three primary difficulties of persons who are blind or have low vision in utilizing public transit: receiving information by visual means, locating and utilizing devices associated with carrying out a trip, and physical movement throughout the 7ystem.

The techniques outlined in Table 1 attempt to overcome these difficulties. Two categories are addressed. The first category is providing tactile information; and the second category involves providing auditory information. Both can be helpful to persons who are blind and to persons who have low vision. Tactile and auditory information can be provided through auditory pathways, auditory mapping, talking bus stops, talking buses, infrared sign systems, tactile paths, tactile maps, and braille information.*

It is important to note that, in addition to an accessible transit system, many visually impaired persons require orientation and mobility training to travel independently. Orientation and mobility trainers contacted as part of this study cautioned that audio and tactile systems alone will not ensure that visually impaired riders can use mass transit safely. Mobility training specialists should be involved in the design of general or special purpose orientation aids for the visually impaired to ensure that the technique is appropriate for facilitating independent travel.

3.4.1 Auditory Maps**

Description. Auditory maps consist of tape recorded information that guides a person through an environment by providing step-by-step directions. There are two types of auditory maps: route maps and area or district maps. Route maps provide a route to follow when going from one point to another. Area maps describe the area more broadly. For example, the route map may describe a path from a bus stop to a station entrance; the area map may describe the vicinity of the station.

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*It is important to note that only a small percentage of visually impaired persons use braille. The American Foundation for the Blind estimates that fewer than 15 percent of persons with significant vision loss read braille. The Association for the Education and Rehabilitation of the Blind states that approximately half of the people who are blind are over sixty years of age, and less than 5 percent ever take braille lessons.

**This information is excerpted from A Handbook Describing Low Cost Concepts and Techniques to Make Public Transportation More Accessible for Visually and Hearing Impaired Persons, prepared by Crain-Revis Associates, Inc., for the Urban Mass Transportation Administration, Washington, D.C., 1982. (UMTA-DC-06-0349-82-1).

Auditory maps can be very general or very detailed, depending on the needs and skill levels of the individual user. Specific route instructions can be designed for use during a trip; and general maps can be used as a resource for trip planning. A general auditory map of a transit system would include the name, direction, stops, and end points of each line. For rail systems, maps could be produced with detailed descriptions of each station (number of levels, side or center platform, direction to exits, and transfer points).

Discussion. There has been little research on auditory maps as orientation aids for visually impaired persons.[8] No auditory maps are known to be in use in transit facilities. It is estimated, however, that auditory maps have the advantage of being flexible. Information on the tape could be easily updated and the cost of maintaining the maps would be low. A second advantage is that the maps could be used while traveling. Transit riders could listen to the tapes using personal cassette recorders that are inconspicuous and not intrusive. Personal tape and radio systems are now very common, and many transit riders carry them to listen to music, books, etc. The maps would not have to be used only in personal recorder systems, however.

"Talking maps" could be incorporated in public areas of transit systems in conjunction with visual map displays. Potential disadvantages of such maps are the need for an effective notification system for temporary service changes and a distribution system for updated maps. A rider using an outdated map could face safety hazards.

Auditory maps should be designed, tested, and evaluated in cooperative programs involving a transit operator, orientation and mobility specialists, and visually impaired transit users. Factors to be considered are the type of maps that are most useful, the level of detail required, personal map systems and/or "talking maps" in public areas, cost of production, and maintenance.

3.4.2 Auditory Pathways*

Description. Auditory pathways consist of electronically activated speakers positioned throughout the station. Instructions from the first speaker lead disabled persons to the next location, thereby guiding them through the station. There are several methods by which a person desiring to use the auditory pathway could signal the loudspeakers along the way: the person could carry a device to activate the loudspeakers; the person could activate the system by depressing a button at the entrance to the station, and then announcements would automatically be activated once the person has entered a certain space; or the person could wear something that would be detected by a device on the speakers.

Discussion. Research conducted in a laboratory simulation of a real transit environment to test auditory pathways[9] found that these announcements are most helpful when given at points of change in the environment. For example, an announcement that one has reached an escalator is more helpful than an announcement that the escalator is 10 feet ahead. The study also confirmed that, even in a noisy transit environment, subjects were able to discern and follow pathway instructions. An advantage to auditory pathways is that they provide regular feedback to individuals that they are going the right way. Research suggests that confirmation that a person is correct considerably enhances performance.

As with auditory maps, a pathway message would need to be changed to accommodate changes in the transit environment. The need to keep messages updated is a potential disadvantage. An inaccurate message could pose a safety hazard (e.g., directions to a stairway that is closed for repairs). If the person gets lost and goes off the path, the auditory pathway can no longer direct them. Another disadvantage is that the noise level in stations and the auditory pathway could conflict with public address announcements.

Additional research needs to be conducted on using auditory pathways in transit systems. Design, testing, and evaluation should include transit operators, individuals

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*For more information about auditory pathways, see "Innovations for Improving System-wide Accessibility" by Alec F. Peck, in Access to Mass Transit for Blind and Visually Impaired Travelers, edited by Mark M. Uslan, Alec F. Peck, William R. Wiener, and Arlene Stern, American Foundation for the Blind, New York, 1990.

with visual impairments, and orientation and mobility specialists. Topics for further study include the technology (types of speakers, types of cuing devices), location of speakers, recommended volume in varying environments, and message content.

3.4.3 Talking Bus Stops*

Description. The British Department of Transport developed an experimental talking bus stop system that is in use in the town of Weston-Super-Mare in the west of England. The Electronic Speech Information Equipment, known as ELSIE, enables visually impaired travelers to locate a bus stop, manually activate audible route and schedule information, and be alerted to the arrival of any given bus. The ELSIE system was field tested using nine bus stops in and around the town center and 40 buses.

The ELSIE system involves three components: a talking element that uses digital** speech, a bus identification unit that reads the route numbers of approaching buses, and a coordinating system using a microcomputer that links the other two components. The bus identification technique involves use of a small, low-power radio transmitted mounted by the road, approximately 200 yards ahead of the bus stop. Each bus is equipped with a small receiver. An approaching bus picks up the signal from the roadside transmitter and responds by transmitting a signal back that is encoded with the bus route number. The microprocessor interprets the signal. The route number is set by a switch in the cab. A box mounted on the bus stop post or within the bus shelter includes a push button, that when operated initiates an announcement of bus number and timetable information for all buses using the stop,

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*For more information, see "ELSIE, the Talking Bus Stop in England," by Ann Frye, in Access to Mass Transit for Blind and Visually Impaired Travelers, edited by Mark M. Uslan, Alec F. Peck, William R. Wiener, and Arlene Stern, American Foundation for the Blind, New York, 1990.

**Digital speech is actual human speech that is digitized (each sound is coded). The codes are stored in the voice synthesizer in fast-operating memory units. When the synthesizer utters a phrase, the codes are fed rapidly to the unit, which generates sound signals equivalent to the codes. Synthetic speech is purely computer generated, and is of a lower quality.

including the arrival time of the next bus. The box emits a continuous audible clicking sound at the rate of about one click per second. The units also have a built-in microphone that adjusts the volume of the announcements depending on the ambient noise of the street.

Discussion: Based on the results of this one field test, the ELSIE system was technically feasible and well-received by passengers with visual impairments, the elderly, and visitors unfamiliar with the bus system. The clicking box helped visually impaired travelers in particular verify that they had located the bus stop. Like other automated vehicle tracking systems, the system also has potential as a management tool for monitoring and traffic control. Concerns about vandalism were unfounded. Potential disadvantages include the cost of the system and equipment maintenance.

No information was available about follow-up demonstrations using this technology. Additional research is required to determine the feasibility and cost of a talking bus system in larger transit systems. Topics for further study include equipment guidelines (transmitters, receivers, voice synthesis technology), system operations, and message content. Additional field tests designed for systematic data collection and evaluation are necessary.

3.4.4 Talking Buses/Trains

Description. Another application of digital speech technology is vehicles equipped with message systems that announce destination and stopping points. Currently, a number of manufacturers produce such systems, either through automatic messaging options or manual messaging. Automatic messages can be programmed to be activated through a variety of techniques including an open vehicle door, pole transmitters along the route, or other automatic vehicle locator devices. Manual messages are activated by an operator depressing a number-coded entry key (for example, messages can be coded 1 through 10). Another option is for messages to be sequentially placed into a system, so that before every stop the operator depresses a key and the next message is played. With this technique, however, there is a risk if the operator forgets to activate the system at the appropriate location.

Discussion. Current technology allows that the number of messages needed in a system can easily be accommodated by building in additional memory. With adequate computer power, these devices are capable of interfacing with visual signage, so that both auditory and visual messages can be provided simultaneously. Some systems may be installed into an existing PA system. The devices are low maintenance and there are no tapes or moving parts. The only additional accessory is the high speed duplicator, which is needed to change, add, or delete messages. Messages can be changed in real time.

One concern is the amount of physical space a system would occupy if a great deal of memory is required. Audible signals require approximately 100 times the memory needed to create visual signals. For a large bus system, the equipment needed would be comparatively large, although technological innovation is continually reducing the size of computer memory boards.

Additional data is needed to evaluate the use of these systems in transit systems of varying sizes and varying operating environments. Issues to be examined include number of messages, message content, operations (manual vs. automatic), and type of signaling systems for automatic messaging.

3.4.5 Tactile Signs

Description. Tactile signs have raised or incised letters or characters to enable visually impaired persons to read the signs by touch. Standards of the American National Standards Institute (ANSI A 11.7.1-1980.4.30-Signage) require that raised or incised letters or numerals for tactile signage shall consist of sans serif characters between 5/8 inch and 2 inches in height. Tactile characters are most commonly found on elevator panels. The Massachusetts Bay Transportation Authority (MBTA) has installed braille and raised print characters on some bus stop signs.

Discussion. Research sponsored by the Urban Mass Transportation Administration (now the FTA) into specifications for letters and numerals for touch reading[(2)] confirmed several design principals for tactile characters. The study found that raised characters conforming to ANSI standards could be accurately read by blind persons;

however, incised characters were very difficult to read. The study also found that tactile signs were desired by persons with visual impairments in elevators, offices, and restrooms on transit properties. A key problem with tactile signs in transit stations or at station entrances is that unless a person can find the sign, the sign is of no use. A sign for a station entrance in a predictable location is of use to travelers only to confirm their location once they have found the entrance.

Tactile signage using raised characters should conform to ANSI standards. The DOT regulations for raised characters are found in Appendix A Part 37. Incised letters cannot be used. Transit systems should consider the use of tactile signage on elevators or restrooms in stations or in offices. Bus stops or station pylons with route information or on fare vending equipment are other potential applications. Any use of tactile signage should be designed with cooperation from disabled individuals and orientation and mobility specialists. Tactile signage may be helpful if used in conjunction with audio tapes or tactile maps that give directions to the sign location.

3.4.6 Tactile Paths and Warning Strips

Description. Changes in pavement texture or color that can be detected by persons with visual impairments through the use of canes, or when approaching the surface on foot, assist navigating the transit environment. Tactile warning strips on the edges of rail platforms have been studied by the Access Board and by DOT. The final DOT rule implementing the ADA includes requirements for tactile warning strips. Tactile paths are an established feature in many Japanese transit systems. In Japan, the paths are in the form of light colored braille blocks that lead travelers from rail station entrances to platforms. The pathways also lead from major intersections to bus stops. A wide variety of materials and textures are available for creating tactile warning systems and pathways.

Discussion. There are a number of issues with tactile warning systems. They have been criticized as creating a tripping hazard for all pedestrians. There is no unanimity regarding appropriate textures and materials. In outdoor environments, especially in harsh climates, the textures can be obscured by snow and ice, or can be damaged by snow removal equipment. The width of platform edge tactile warnings is also the subject of debate. The DOT regulations mandate a 24-inch wide platform edge warning in new stations.

It is critical that the pattern used for the warning strip not be used for the tactile path. Serious problems may arise if these two warnings are confused. If there is more than one path in a station, it is critical that they be easily distinguishable. It has also been suggested that paths have a high visual contrast so that persons who have low vision can see them. Yellow is the preferred color, and orange is next best.

3.4.7 Tactile Maps

Description. Tactile maps are actual maps of a station, an area or a transit system route that use raised markings to replace the visual cues common to ordinary maps. They do however, typically provide written and color information so that persons who have low vision may use the maps, or so that persons with normal vision may aid persons with visual impairments as necessary. Tactile maps have been created for the Massachusetts Bay Transit Authorities (MBTA) and the Washington Metropolitan Area Transit Authority (WMATA). The WMATA maps, which were funded by the U.S. Department of Education and developed by the University of Maryland, are printed in color with large type and are embossed on white plastic. The unit price for the rail system strip maps is $5.00. The maps indicate the rail line color, the station elevation (surface or underground), the platform location (center or side), the number of station levels, and the use of the station as a transfer location. For more information on tactile maps, see Appendix B.

Discussion. Tactile maps have been tested in the transit environment. Some studies have been performed in which subjects were given tactile maps and a new destination. These persons found the maps to be helpful, and 77.5 percent of all visually impaired persons surveyed indicated an interest in using these maps. However, the subjects were young, well educated, experienced users of transit systems, and some were the better students of orientation and mobility trainers. It is unclear how well a more diverse group of blind transit users would do.

Tactile maps may be actually more helpful as a way to understand the relationship of one place to another, and as a way to generally understand the area considered in the map. They may not be as helpful for route planning as they are for these other purposes. Relationships between locations may be very difficult to understand when they cannot be visualized. Congenitally blind travelers had more difficulty using tactile maps than adventitiously blind persons. Often tactile maps require the ability to read braille to determine names of streets, etc. Raised letters may also be used.(2) Tactile maps used in conjunction with auditory information can be helpful. In Japan these maps are combined with an audio tape in transit systems.

Transit agencies interested in developing tactile maps should initiate cooperative projects with orientation and mobility specialists and advocacy groups for the blind. Manufacturers are listed in Appendix A.

3.4.8 Infrared Signage

Description. Smith-Kettlewell Eye Research Institute developed a unique application of infrared technology, specifically for persons who are visually impaired. Smith-Kettlewell manufactured infrared signage, which is used in everyday settings to provide basic information to persons in the area of the Institute. Like assistive listening systems, infrared signage employs personal receivers that must be carried with the person who wishes to use the system. Infrared signals are sent out from a pole or other fixed location, and the receiver must be aimed at the transmitter to pick up the signal. The closer the receiver is aimed at the transmitter, the stronger the signal.

Discussion. One advantage of infrared signage is that, by using the strength of the signal to locate the transmitter, the user also acquires directional information. For example, by working to aim their receiver directly toward the receiver, disabled persons can orient themselves within the environment. Another benefit is that of being non-intrusive. The only persons who hear the message are those with receivers. There is great potential for this type of technology; however, it only works when a person has a receiver.

3.5 Techniques to Aid Persons with Cognitive Impairments

It is particularly difficult to generalize about the abilities of persons with cognitive impairments, because this term encompasses a substantial number of conditions from mental retardation to Alzheimer's disease, and includes persons with mental illness. Some people in this population may have exceptional orientation and mobility skills, but may be unable to communicate to a bus driver where they want to go. Other persons may be able to tell an operator their destination, but may not recognize it when they get there. The common element among the differing categories included in this population is difficulty comprehending and/or applying information about a transit system. The other common element is that the most important technique to aid persons with cognitive impairments is training—training the disabled person to travel independently and training the transit employee to deal with the passenger courteously and effectively.

Table I listed a number of suggestions for assisting persons with cognitive impairments in making a transit trip. Most of these techniques were addressed in Section 3.2, General Techniques for Aiding Accessibility. Items such as design uniformity, improved lighting, use of simplified graphics and color coding, and priority seating within view of the driver are extremely helpful to persons with cognitive impairments. Redundant audio and visual announcements that aid persons with hearing or visual impairments also provide additional support to persons with cognitive impairments.

Transit systems need to work closely with advocacy groups and community agencies serving persons with cognitive impairments to understand the their needs better. Training programs should be developed cooperatively to help ensure that they are effective. Many of the medical professionals, therapists, and counselors contributing to this study emphasized that every client traveling independently on public transit needs individualized training. Most of the training that takes place is tailored to repeat trips, such as to work or to school. It is less common, mostly due to resource limitations, for persons with cognitive limitations to be trained to navigate a transit system independently for recreational or discretionary trips. Another key (and usually unmet) need is for periodic retraining, especially when there are transit system changes or if the life circumstances of an individual change.

Items to consider when designing training programs for transit employees and for cognitively impaired individuals include:

- Persons with cognitive impairments are able to learn. Those who are mentally retarded or developmentally disabled have different learning patterns or learn at different rates than the average population. Different teaching techniques that are known to professionals who work with these populations (patterned learning, repetitive approximation, peer support) are appropriate for these individuals.

- Many persons with cognitive impairments have difficulty generalizing or problem solving. While these persons function well in a secure routine, they may have inappropriate reactions to unexpected variations, such as detours. It is therefore important that these persons be alerted in advance if something about a transit trip will be different that usual (e.g., a route or schedule change) and be assured that they will get to their destination safely and on time.

- Verbal or one-time instructions are less effective than written instructions or notes that these persons can carry as reminders. Transit passes that are coded with colored icons that match particular routes are particularly effective for this reason.

- Persons with cognitive impairments often process information more slowly than the average person. Transit personnel should understand this situation and must be patient if these passengers need extra time.

- The functional limitations of most persons with cognitive impairments, particularly the mentally retarded and developmentally disabled, are dynamic. With appropriate training, these persons can acquire new skills. At the same time, unanticipated factors such as change in residence, family circumstances, or other normal life stresses can cause these individuals to temporarily regress and acquire functional limitations not previously acknowledged. Transit systems should be aware of this possibility, especially in making determinations about paratransit eligibility.

Training programs for transit personnel and for persons with cognitive impairments should be developed cooperatively involving specialists in mobility training and professionals who provide service to this population, including vocational or rehabilitation therapists. Much of this training is already occurring for individuals in local communities. Transit agencies should actively seek and identify those community resources.

3.6 Techniques to Aid Persons Who are Semi-Ambulatory

Semi-ambulatory persons comprise those who have a mobility impairment but who do not require the use of a wheelchair. This population includes persons who have an unsteady gait or who lack the flexibility or strength to climb stairs or use a ramp. These persons may use walkers, canes, crutches, or other mobility devices.

With f.w exceptions, if transit vehicles and facilities comply with DOT requirements for accessibility and are usable by persons in wheelchairs, persons who are semi-ambulatory will be able to travel independently as well. There are, however, some circumstances where additional measures are required for semi-ambulatory persons to safely and conveniently use public transit. The items discussed below are use of lifts on transit buses (or some rail vehicles) by standees, kneeling buses, and low floor buses.

3.6.1 Use of Lifts by Standees

Description. The DOT regulations implementing the ADA require that all new transit vehicles be accessible to individuals with disabilities. An accessible vehicle is one that meets the guidelines promulgated by the Access Board. These guidelines provide specifications for lifts or ramps to permit a mobility aid user to board the vehicle. The DOT regulations specifically require that transit entities permit persons who do not use wheelchairs, including standees, to use a lift (49 CFR part 37.165 (g). The lift platforms may be marked to indicate a preferred standing position and platforms must be equipped with handrails on two sides (49 CFR parts 38.23, 38.82, 38.95, and 38.125). The regulations also specify that for buses in excess of 22 feet in length there must be a minimum of 68 inches clearance between the top of the door opening and the raised lift platform. For smaller vehicles, the clearance must be at least 56 inches. Doorway height on rail vehicles is not specified.

Discussion. There are a number of concerns related to these requirements. Foremost is the concern that semi-ambulatory persons standing on lifts on buses be able to safely clear the vehicle door. Rehabilitation professionals contributing to this study provided anecdotal information indicating that semi-ambulatory persons using mobility aids would have sufficient flexion at the neck or knees to be able to duck if necessary to avoid hitting their heads on the door frame. Further, it could be expected that a person correctly balanced on a walker would stand at 90 to 95 percent of full height. Using an estimate of 92.5 percent of full stature would mean that a 73.2 inch man (the 95th percentile of height distributions) would measure 67.7 inches, and if able to duck slightly could fit through the 68 inch door on a bus if standing on a lift. These professionals also stated that a semi-ambulatory person using a walker would be expected to have trunk flexion of 20 to 30 degrees.

3.6.2 Kneeling Buses

Description. Kneeling buses have been manufactured for several years and are in service in many transit systems. Virtually all new heavy-duty buses can now be ordered with this feature, which enables the operator to lower the side of the bus where the entrance is located so that the height of the first step is reduced 3 to 4 inches, typically from 14 inches to 10 or 11 inches.

Discussion. Both transit systems and disabled individuals report problems with the kneeling buses. Several transit systems have experienced mechanical difficulties with the kneeling feature that interfere with the ride of the vehicle. In several cities, the kneeling feature has been disconnected. Disabled individuals and rehabilitation professionals report that lowering the first step 3 or 4 inches does not help persons who cannot climb steps. Persons who can climb steps, but with difficulty, also find that the kneeling feature is not low enough to overcome the barrier that steps pose. A 10-inch step is still too high for many semi-ambulatory persons.

3.6.3 Low-Floor Buses

Description. Low-floor buses in conjunction with ramps may offer the best alternative for improving accessibility for semi-ambulatory persons. Ramps used with standard bus floor heights must be extremely long to meet the ramp slope requirements promulgated by DOT. The floor height of standard heavy-duty buses is about 34 inches. Low-floor buses now in use or under consideration have floor heights typically about 14 inches.

Discussion. The development of the low-floor bus in Europe has been underway for about ten years. Most of this work has been directed towards developing an entrance step and adjacent area of about 12.6 inches in height. Within the bus itself, seats and standing areas are usually elevated on platforms, requiring passengers to step up an additional distance. The seats in the rear over the rear axle are substantially elevated from the entrance step level. This additional step requirement poses a tripping hazard that may not be acceptable to the U.S. transit industry and conflicts with the requirements of the ADA.

There is no heavy-duty low-floor bus available to the U.S. transit industry that meets DOT regulations and requirements for underbody clearance and number of seats. The present standard configuration of bus bodies, propulsion systems, drivelines, suspensions, and climate controls are not appropriate. None of the large U.S. transit bus manufacturers have introduced low-floor, standard size bus prototypes. The successful introduction of a low-floor heavy-duty bus that meets the needs of the U.S. transit industry will require the development of new bus designs and components that are not presently available in the marketplace. More information on low-floor buses in the U.S. can be found in the FTA report FTA-OH-06-0060-92-1, "Status of Low-Floor Transit Bus Development."

CONCLUSIONS

The overall conclusions of these guidelines for improvement of transit accessibility for persons with disabilities are that:

1. Many techniques employing proven technology could be readily applied by the transit industry.
2. Opportunities for standardization and/or development and testing exist that would assist both persons with disabilities and other passengers.
3. Promising techniques require additional development, testing, and evaluation.
4. Some techniques for improving accessibility will require substantial development.
5. The application of existing technology and techniques and the development of new and improved methods and equipment should be a continual activity during the immediate and long-term future.

While some techniques can be readily implemented, most will require new technology or the application of existing technology in a new environment. All will require the training of both transit personnel and disabled passengers to take full advantage of new systems and methods.

The following is a list of techniques employing proven technology that could be readily applied by the transit industry.

- TDD - installation and use
- Automated telephone information system
- Hearing aid compatible telephones
- Manual communication techniques
- Tactile signs
- Tactile maps

- Orientation and mobility training programs
- Improved PA announcements (station and on board)
- Auditory vehicle identification
- Braille material
- Audio cassette information
- Visual display of announcements
- FAX
- Electronic file on computer disc for understanding transit system.

The following is a list of opportunities for standardization and/or development and testing that would assist both persons with disabilities and other passengers.

- Uniform signage
- Horizontal signage
- Universal use of symbols for technical aids for the hard-of-hearing
- Audio and visual "next stop" information
- Large print/high contrast signage
- Directional signage
- Bus stop signs
- Emergency alarm/warning systems
- Electronic/dynamic signage
- Icons and color coding
- Priority seating location
- Room for seeing-eye and hearing-ear dogs
- Fare box location
- Prepaid fare system
- Door opening and closing warnings
- Visual vehicle identification system
- Uniform architectural features
- Surface change at step edge
- Standing location on lifts

The following is a list of promising techniques of improving accessibility that will require substantial development.

- Simple text and graphics for those with cognitive impairment
- PC-based transit information
- Assistive listening systems in transit vehicles
- Auditory maps
- Auditory pathways
- Smart card use
- "Talking" fare box
- Tactile paths
- Infrared signage.

The following is a list of techniques of improving accessibility that will require substantial development.

- Automatic speech recognition
- Automatic visual message systems
- Platform edge warning
- Between car barriers
- Low-floor buses

RECOMMENDATIONS

It is recommended that the industry begin using available techniques and technology that can be currently adapted to transit use. Technologies that require further development will need cost and value analysis before being applied in transit.

Basic training programs should be developed for both transit personnel and persons with disabilities. This could be the most important step to assuring safety and effectiveness in providing accessibility. The training program could make it possible for a disabled passenger to use more than his or her "home" transit system safely.

The development of technology that has been identified in this report should be monitored to determine when and how it can be used effectively in the transit industry.

The development of a heavy-duty, low-floor bus for transit use in the United States is an undertaking that will require a large investment of both time and money.

ENDNOTES

(1) As defined by the Conference of Executives of American Schools for the Deaf (CEASD), 1938. Information provided by Edward E. Corbett, Jr., Ph.D., Superintendent, The Ohio School for the Deaf, Columbus, Ohio.

(2) B. L. Bentzen, R. M. Jackson, and A. F. Peck. Solutions for Problems of Visually Impaired Users of Rail Rapid Transit. Volume I. Improving Communications with the Visually Impaired in Rail Rapid Transit Systems, UMTA-MA-11-0036-81-1, August, 1981.

(3) Ohio Head Injury Study Commission, Report to the Governor and General Assembly, Columbus, Ohio, 1988.

(4) National Center For Health Statistics, data from the National Health Survey, Series 10, Number 166, Tables 57, 62, 1988.

(5) The International Center for the Disabled and the National Council on the Handicapped, ICD Study of Disabled Americans: Bringing Disabled Americans into the Mainstream, March 1986.

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(7) Ohio School for the Deaf. "301 Essential Signs Sign Language Book," Columbus, Ohio.

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(9) A. F. Peck, Enhancing Access to Rail Rapid Transit via an Auditory Pathway. U.S. Department of Transportation, Urban Mass Transportation Administration, Washington, D.C., 1989.

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APPENDIX A

REFERENCE LIST

1. **National Disability Organizations**

Association of Late-Deafened Adults, 2445 West Cuyler Street, Chicago, IL 60618, TDD (312) 604-4192, FAX (312) 604-5209

National Information Center on Deafness, Gallaudet University, 800 Florida Avenue, NE, Washington, D.C. 20002

National Association of the Deaf, 814 Thayer Avenue, Silver Spring, MD 20910

Self Help for Hard-of-Hearing People, Inc., 7800 Wisconsin Avenue, Bethesda MD 20814, (301) 657-2248 (voice), (301) 657-2249 (TDD)

American Speech-Language-Hearing Association, 10801 Rockville Pike, Rockville, MD 20852, (301) 897-5700 (voice or TDD)

American Foundation for the Blind, 1615 M Street, N.W., Suite 250, Washington, D.C. 20036, (202) 457-1487

American Council of the Blind, 1010 Vermont Avenue, N.W., Suite 1100, Washington, D.C. 20005, (202) 393-3666

Association for Retarded Citizens, 1522 K Street, N.W., Suite 516, Washington, D.C. 20005

National Association for the Mentally Ill, 2101 Wilson Boulevard, Suite 320, Arlington, VA 22209

National Easter Seal Society, 1350 New York Avenue, N.W., Suite 915, Washington, D.C. 20005

National Council on Independent Living, Troy Atrium, 4th Street and Broadway Troy, NY 12180

2. **Training Video on TDD Use**

Telecommunications for the Deaf, Inc., 8719 Colesville Road, Suite 300, Silver Spring, MD 20910, (301) 589-3786 (voice), (301) 589-3006 (TDD)

3. **Speech/Text Synthesis Information**

Dr. Judith E. Harkins, Director, Technology Assessment Program, Gallaudet University, 800 Florida Avenue, NE, Washington, D.C. 20002, (202) 651-5257

4. **Manual Communication Catalogues**

National Association of the Deaf, 814 Thayer Avenue, Silver Spring, MD 20910

TJ Publishers, 817 Silver Spring Avenue #206, Silver Spring, MD 20910

Harris Communications, 6541 City West Parkway, Eden Prairie, MN 55344-3248

Dawn Sign Press, 9080-A Activity Road, San Diego, CA 92162

5. **Computer Networks for Persons with Disabilities**

a. SERIES

The SERIES Network is available to paid staff, Board Members, or volunteers of Independent Living Centers, rehabilitation agencies, state vocational rehabilitation programs, or other projects funded by the National Institute for Disability and Rehabilitation Research (NIDRR) or the Rehabilitation Services Administration (RSA) of the U.S. Department of Education.

The SERIES Network has several bulletin boards available to subscribers where information on accessible transit services can be posted. Located at Eastern Washington University, the SERIES Network can be contacted by calling (503) 347-3534.

At present, there is no subscription fee for the SERIES Network.

b. SPECIALNet

SPECIALNet is operated by the National Association of State Directors of Special Education (NASDSE). At this time, SPECIALNet does not have a specific bulletin board for transit information but, according to the network coordinator, would be willing to set one up if there provided to be enough interest.

The National Association of State Directors of Special Education is located in Alexandria, VA, and can be reached at (703) 519-3800.

c. National Council on Independent Living

The National Council on Independent Living (NCIL), which represents independent living centers, is upgrading its data base to make information on access to local transit agencies available on its bulletin boards. The goal would be to enable a person traveling for one city to another to access information on the out-of-town transit system.

Currently, under a foundation grant, NCIL is developing a software package to enable local centers to have schedule information available through electronic mail. As the local center completes its data base, the information would be shared with NCIL to build the national base. Expected date of availability of this service is summer 1992.

6. Manufacturers

a. Manufacturers of TDDs

Krown Research, Inc., 10371 W. Jefferson Blvd., Culver City, CA 90232 (800/833-4968)

Telephone Interface Equipment (see information enclosed)

DIRAD Technologies, Inc., 21 Aviation Road, Albany, NY 12205, (800/93-DIRAD), (518) 438-6000

ULtratec Inc., 450 Science Drive, Madison, WI 53711, (800/482-2424), (608) 239-5400 (voice/TDD), (608) 238-3008 (FAX)

AT&T Special Needs Center

b. Manufacturers of Assistive Listening Systems

FM Systems

Audio Enhancement (COM-TEK), 8 Winfield Point Ln., St. Louis, MO 63141 (314/567-6141)

Devilbiss Development Co. Ltd., 3056 Hazelton St., Falls Church, VA 22004 (703/534-1681)

Earmark, Inc., 1125 Dixwell Ave., Hamden, CT 06514 (203/777-2130)

Phonic Ear, Inc., 3880 Cypress Dr., Petaluma, CA 94954 (800/227-0735)

Telex Communications, Inc., 9600 Aldrich St., Minneapolis, MN 553344 (800/328-6190)

Williams Sound, 10399 West 70th St., Eden Prairie, MN 55344 (800/328-6190)

Infrared Light Systems

Audex, 713 N. Fourth St., Longview, TX 75601 (800/237-0716)

Devilbiss Development Co. Ltd., 3056 Hazelton St., Falls Church, VA 22004 (703/534-1681)

Nady Systems, 1145 65th St., Oakland, CA 94609 (415 652-2411)

Siemans Hearing Instruments (Sennheiser) 685 Liberty Ave., Union, NJ 07083 (800/766-4500)

Sound Associates, Inc., 424 West 45th St., New York, NY 10036

Unex, 5 Lyberty Way, Westford, MA 01886 (508/256-8222)

Audio Induction Loop Systems

Acoustiguide Corp., Clearbrook Rd., Elmsford, NY 10523 (914/347-3607)

Audex, 713 N. Fourth St., Longview, TX 75601 (800/237-0716)

Centrum Sound (Oticon), 10234 Miner Pl., Cupertino, CA 95014 (408/996-7112)

Devilbiss Development Co. Ltd., 3056 Hazelton St., Falls Church, VA 22004 (703/534-1681)

Oval Window Audio, 78 Main St., Yarmouth, ME 04096 (207/846-6250)

Radio Shack, components at local stores

Rastronics USA, 768 Foster Ave., Bensenville, IL 60106 (800/624-5955)

Sutherland Industries, 2137 Coley Forest Pl., Raleigh, NC 27607 (919/782-7354)

c. Manufacturers or Researchers of Automatic Speech Recognition Systems

Dragon Systems, Inc., Chapel Bridge Park, 90 Bridge Street, Newton, MA 02158 (617/965-5200)

IBM Thomas J. Watson Research Center, P.O. Box 218, Route 134 East, Yorktown Heights, NY 10598

Kurzweil Applied Intelligence, 411 Waverly Oaks Road, Waltham, MA 02154

SRI International, 333 Ravenswood Avenue, Menlo Park, CA 94025

Speech Systems, Inc., 18356 Oxnard Street, Tarzana, CA 91356

d. Manufacturers of Signs

Vultron, Inc.

Luminator, 1200 E. Plano Parkway, Plano, TX 75074 (214/424-6511)

e. Manufacturers of Voice Message Systems

Transit Communications Systems, 4900 Prospectus Drive, Suite 1000, P. O. Box 14068, Research Triangle Park, NC 27709, (919) 361-2155

APPENDIX B

ADDITIONAL INFORMATION ON TACTILE MAPS

Research in this area has been extensive, and there is substantial data on what features are necessary in making a helpful tactile map.* There are four salient aspects to be considered: information content, scale, shape recognition, and symbols.

- **Information Content**. Too much information is confusing, so it is better to err on the side of not enough rather than too much information. Although highly skilled users of tactile maps prefer to have too much over too little, the majority of users are not highly skilled. If a lot of information is to be presented, it is suggested that a series of maps be created, with each map providing progressively more information. In this way, persons using the maps may work through them, collecting more detail with each map.

- **Scale**. The rule of thumb is that the scale of tactile maps should be consistent, but it is not absolutely necessary. There may be instances where this is impossible, however. For example, when two lines are very close together they may be perceived as being part of the same feature on the map. To make features discriminable, there must be a certain distance between them, which may entail slightly inaccurate scaled representations of the distances between features. Slight variations in scale, in some instances, may also aid perception. Consistency in geometrical patterns is very helpful, and may be even more helpful than perfectly scaled representations of objects on the map.

- **Shape Recognition**. A central issue with shape recognition is that objects should be no larger than necessary and as simple as possible. It is estimated that a 25 to 30 percent variation in characters is needed to optimize recognition and that, again, consistency in geometrical patterns may aid this process.

- **Symbols**. There are three basic types of symbols: point, line, and areal. They all have the common requirement that, to be discriminable, they should be as distinct as possible from each other and at least 0.125 inches apart.

    - Point. These represent a specific location, but they tell nothing about its shape or dimension. Their shape, size, and elevation all may be altered to make them more discriminable, but minimally they must be 0.2 inches to be perceived through touch.

    - Line. These indicate direction and location, and they can convey information on width and height if necessary by attempting to use scale in creating the lines. It seems that the most discriminable lines are single narrow lines. It has also been suggested that double lines are most easily traced, but they also may cause confusion.

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*This summary was compiled mostly from Foundations of Orientation and Mobility, Chapter 10.

Areal. These symbols are ways of defining specific locations or objects in the map. Such symbols provide information on location, shape, and size, as seen from above. This is accomplished through varied textures and patterns. For example, these symbols may vary in the density of the pattern (many dots close together, as compared to an irregular, more spread out pattern), in the direction of lines or figures, or in relative heights in the texture (for example, smooth vs. rough).

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